AQUEOUS ETHANOL *Ananas comosus* PEEL EXTRACT AS THE BIOACTIVE INGREDIENT IN AN OIL-IN-WATER NANOCREAM FOR TOPICAL DELIVERY

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DEDICATION

This thesis is dedicated to my special one, papa and mama.

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ABSTRACT

The polyphenols-rich *Ananas comosus* peels extract (*Ac*PE) can be developed as an alternative topical nanocream for the cosmeceutical industry. Also, active ingredients of nano formulated products are proven more effective in penetrating the stratum corneum of the human skin. However, there are yet no published works or known formulations of the *Ac*PE for topical skin use. Therefore, the present study proposed the formulation of an *Ac*PE nano cream (*Ac*PENc) to explore further applications of the pineapple biomass to benefit humankind. This study optimized an integrated high-energy method using ultrasonic assisted extraction (UAE) for responses, high yield, and high total phenolic content (TPC) of *Ac*PE. While the UAE gave an insignificant effect on the extraction yield ($p > 0.05$), the optimum conditions for the highest TPC extracted from *Ac*PE were successfully identified, namely ultrasonication time (5 min), solvent ratio (50 %), amplitude (65 %), and liquid-solid ratio (35:1 mL/g). The characterization of *Ac*PE revealed an adequate antioxidant capacity for the total flavonoid content (TFC), 1,1- diphenyl-2-picrylhydrazyl (DPPH), and ferric reducing antioxidant power (FRAP) with corresponding values of 1146.86 mg QE/g, 11.83 mg/mL, and 1578.07 ± 25.96 µM Fe^{2+}/100g DW. High-Performance Liquid Chromatography (HPLC) analysis showed the presence of polyphenols in *Ac*PE, with catechin as the major flavonoid, followed by quercetin and gallic acid. Next, the study successfully formulated the oil-in-water (O/W) *Ac*PENc using integrated low- and high-energy methods of phase inversion temperature (PIT) and ultrasonication. The D-Optimal Mixture design (MED)-assisted optimization of *Ac*PENc yielded a stable formulation comprising olive oil (1 %), grapeseed oil (12 %), Tween 80 (12.63 %), and water (74.37 %). The particle size and polydispersity index (PDI) of the optimized nano-cream (OPT-*Ac*PENc) were 187.37 ± 0.81 nm and 0.248 ± 0.017, respectively. Most importantly, the OPT-*Ac*PENc formulation exhibited characteristics that supported its long-term stability for storage, with a zeta potential value of −35.40 ± 2.71 mV, with a pH value of 4.56 ± 0.01. These attributes agree well with the recommended range for effective topical delivery of the active ingredients through human skin. The high conductivity (1346.67 ± 5.77 µS/cm) of the OPT-*Ac*PENc verified its O/W characteristics, while the rheological data proved the cream's shear-thinning (pseudoplastic) behavior. The OPT-*Ac*PENc transmission electron microscopy micrograph revealed spherically shaped nano-sized particles of < 350 nm. The OPT-*Ac*PENc was stable against high centrifugal force, mechanical shock, light test, and heating-cooling cycles in the stability study. Results of the accelerated stability test under three different incubation temperatures (4 ± 2, 25 ± 2, 50 ± 2 °C) for 6 weeks revealed 25 ± 2 °C to be the best storage temperature for the OPT-*Ac*PENc. The suitability was evident from OPT-*Ac*PENc's stability in pH, particle size, and PDI, without phase separation. Relevantly, the OPT-*Ac*PENc was safe from microorganisms and heavy metal contamination and fulfilled the prerequisite of the National Pharmaceutical Regulatory Agency (NPRA) Malaysia for cosmetic products. Sensory evaluation by 47 consumer panelists through the scoring method revealed that the OPT-*Ac*PENc was well accepted. The cream was favored for its color, fragrance, spreadability, adsorption, film/coating, and non-irritancy, as proven in the radar plot. Thus, the present study conclusively demonstrated the potential of *A*cPE as a nano cream for topical human skin use in the cosmeceutical industry.

ABSTRAK

Ekstrak kulit *Ananas comosus* (*Ac*PE) yang kaya dengan polifenol boleh dibangunkan sebagai nanokrim topikal alternatif untuk industri kosmetik. Bahan aktif produk nano yang diformulasikan juga terbukti lebih berkesan untuk menembusi stratum korneum kulit manusia. Walau bagaimanapun, masih belum ada kerja yang diterbitkan atau formulasi *Ac*PE yang diketahui untuk kegunaan topikal di kulit. Oleh itu, kajian ini mencadangkan formulasi nanokrim *Ac*PE (*Ac*PENc) untuk meneroka penggunaan lanjutan biojisim nanas untuk memberi manfaat kepada manusia. Kajian ini mengoptimumkan kaedah tenaga tinggi bersepadu menggunakan pengekstrakan berbantukan ultrasonik (UAE) untuk tindak balas, hasil yang tinggi, dan kandungan fenolik total (TPC) *Ac*PE yang tinggi. Sementara UAE memberikan kesan yang tidak ketara terhadap hasil pengekstrakan ($p > 0.05$), keadaan optimum untuk penghasilan TPC tertinggi yang diekstrak dari *Ac*PE telah berjaya dikenal pasti iaitu masa ultrasonikasi (5 min), nisbah pelarut (50 %), amplitud (65 %), dan nisbah cecair-pepejal (35:1 mL/g). Pencirian *Ac*PE menunjukkan keupayaan antioksidan yang mencukupi untuk kandungan flavonoid total (TFC), 1,1- difenil-2-pikrilhidrazil (DPPH), dan kuasa antioksidan penurunan ferrik (FRAP) dengan nilai sepadan 1146.86 mg QE/g, 11.83 mg/mL, dan 1578.07 ± 25.96 µM Fe^{2+}/100g DW. Analisis kromatografi cecair prestasi tinggi (HPLC) menunjukkan kehadiran polifenol di dalam *Ac*PE dengan katekin sebagai flavonoid utama, diikuti oleh quercetin dan asid galik. Seterusnya, kajian ini berjaya memformulasi *Ac*PENc minyak-di dalam-air (O/W) menggunakan kaedah bersepadu tenaga rendah dan tinggi bagi suhu penyongsangan fasa (PIT) dan ultrasonikasi. Pengoptimuman *Ac*PENc berbantukan reka bentuk D-Optimal Mixture (MED) menghasilkan formulasi stabil yang terdiri daripada minyak zaitun (1 %), minyak benih anggur (12 %), Tween 80 (12.63 %) dan air (74.37 %). Saiz zarah dan indeks polipenyerakan (PDI) nanokrim yang dioptimumkan (OPT-*Ac*PENc) masing-masing adalah 187.37 ± 0.81 nm and 0.248 ± 0.017. Yang paling penting, formulasi OPT-*Ac*PENc mempamerkan ciri yang menyokong kestabilannya untuk penyimpanan jangka masa panjang, dengan nilai keupayaan zeta −35.40 ± 2.71 mV dan nilai pH 4.56 ± 0.01. Sifat-sifat ini sangat sesuai dengan julat yang disyorkan untuk penyampaian topikal bahan aktif melalui kulit manusia dengan berkesan. Kekonduksian tinggi (1346.67 ± 5.77 µS/cm) OPT-*Ac*PENc mengesahkan ciri O/W bahan itu, sementara data reologi membuktikan kelakuan penipisan ricih (pseudoplastik) krim. Mikrograf mikroskopi elektron penghantaran OPT-*Ac*PENc mendedahkan zarah bersaiz nano berbentuk sfera < 350 nm. OPT-*Ac*PENc stabil terhadap daya empar yang tinggi, kejutan mekanikal, ujian cahaya, dan kitaran pemanasan-penyejukan dalam kajian kestabilan. Hasil ujian kestabilan dipercepatkan di bawah tiga suhu inkubasi yang berbeza (4 ± 2, 25 ± 2, 50 ± 2 °C) selama 6 minggu menunjukkan 25 ± 2 °C sebagai suhu penyimpanan terbaik untuk OPT-*Ac*PENc. Kesesuaiannya terbukti daripada kestabilan OPT-*Ac*PENc dalam pH, saiz zarah, dan PDI, tanpa pemisahan fasa. Berkaitan dengan itu, OPT-*Ac*PENc adalah bebas daripada pencemaran mikroorganisma dan logam berat serta memenuhi prasyarat Agensi Peraturan Farmasi Nasional (NPRA) Malaysia untuk produk kosmetik. Penilaian deria oleh 47 ahli panel pengguna melalui kaedah penilaian skor menunjukkan bahawa OPT-*Ac*PENc diterima dengan baik. Krim ini digemari kerana warna, keharuman, kemampuan penyebaran, penjerapan, filem/salutan, dan tiada kerengsaan, seperti terbukti dalam plot radar. Dengan demikian, kajian ini secara muktamad menunjukkan potensi *Ac*PE sebagai nanokrim untuk kegunaan topikal kulit manusia dalam industri kosmetik.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BTX	-	Botulinum Toxin
HRT	-	Hormone Replacement Therapy
*Ac*P	-	*A. comosus* Peels
*Ac*PE	-	*A. comosus* Peels Extracts
*Ac*PP	-	*A. comosus* Peels Powder
*Ac*PENc	-	*Ac*PE Nano Cream
OPT-*Ac*PE	-	Optimized *Ac*PE
OPT-*Ac*PENc	-	Optimized *Ac*PENc
UAE	-	Ultrasonic-Assisted Extraction
O/W	-	Oil-in-Water
W/O	-	Water-in-Oil
TPC	-	Total Phenolic Content
RSM	-	Response Surface Optimization
TFC	-	Total Favonoid Content
DPPH	-	1,1-Diphenyl-2-Picrylhydrazyl Radical Scavenging Activity
FRAP	-	Ferric Reducing Antioxidant Power
HPLC	-	High-Performance Liquid Chromatography
PIT	-	Phase Inversion Temperature
PDI	-	Polydispersity Index
TEM	-	Transmission Electron Microscopy
DW	-	Dry Weight
SC	-	Stratum Corneum
SG	-	Stratum Granulosum
SS	-	Stratum Spinosum
SB	-	Stratum Basale
UV	-	Ultraviolet
BTX-A	-	BTX- subtype A
MU	-	Mouse Units
FDA	-	Food and Drug Administration

LD_{50}	-	50 % Lethal Dose
RF	-	Radiofrequency
CPI	-	Consumer Product Inventory
HLB	-	Hydrophilic-Lipophilic balance
T80	-	Tween 80
XG	-	Xanthan Gum
RAPEX	-	Rapid Alert System
EC	-	European Commission
Phy-Et	-	Phenoxyethanol
US-EPA	-	US Environmental Protection Agency
SCCS	-	Scientist Committee on Consumer Safety
ANSM	-	French National Agency for Safety of Medicines and Health Products
GA	-	Gallic Acid
GRAS	-	Generally Recognized as Safe
USFDA	-	United States Food and Drug Administration
HPH	-	High-Pressure Homogenizer
DLS	-	Dynamic Light Scattering
SEM	-	Scanning Electron Microscopy
AFM	-	Atomic Force Microscopy
COLIPA	-	European Cosmetic Toiletry and Perfumery Association
CTFA	-	The Cosmetic, Toiletry and Fragrance Association
ANVISA	-	Brazil National Health Surveillance Agency
NPRA	-	National Pharmaceutical Regulatory Agency
Fe	-	Iron
Zn	-	Zinc
Pb	-	Lead
Hg	-	Mercury
As	-	Arsenic
Cd	-	Cadmium
ASTM	-	American Society of Testing and Material
BBD	-	Box-Behnken Design
CCD	-	Central Composite Design

MED	-	Mixture Design
TPTZ	-	2,4,6-Tri(2-pyridyl)-s-triazine
GSO	-	Grapeseed Oil
OO	-	Olive Oil
ANOVA	-	Analysis of Variance
CV	-	Coefficient of Variation
LOF	-	Lack of Fit
Na_2CO_3	-	Sodium Carbonate
$NaNO_2$	-	Sodium Nitrite
$AlCl_3$	-	Aluminum Chloride
NaOH	-	Sodium Hydroxide
PPE	-	Percentage Prediction Error
MLB	-	Modified Letheen Broth
MLA	-	Modified Letheen Agar
PDA	-	Potato Dextrose Agar
TSB	-	Trypticase Soy Broth
HCl	-	Hydrochloric Acid
EY	-	Extraction Yield
MRA	-	Multiple Regression Analysis
LA	-	Linoleic Acid
3D	-	Three-Dimensional
ACD	-	ASEAN Cosmetic Directive
TEWL	-	Transepidermal Water Loss

LIST OF SYMBOLS

%	-	Percentage
w/w	-	Weight by weight
α	-	Alpha
β	-	Beta
nm	-	Nanometre
°C	-	Degree of Celsius
ft	-	Feet
g	-	Gram
kg	-	Kilogram
µg	-	Microgram
µm	-	Micrometre
µS/cm	-	Micro siemens per Centimetre
mV	-	Millivolt
cfu/g	-	Colony-Forming Unit per Gram
mL	-	Millilitre
ppm	-	Parts per Million
h	-	Hour
kHz	-	Kilohertz
W	-	Watt
rpm	-	Revolutions per minute
s	-	Seconds
min	-	Minute
mL/g	-	Millilitre per Gram
mg/mL	-	Milligram per Millilitre
w/v	-	Weight per Volume
v/v	-	Volume per Volume
µL	-	Microliter
mM	-	Millimolar
mg GAE/g	-	milligrams of gallic acid equivalent per gram
mg QE/g	-	milligrams of quercetin equivalent per gram

μM of Fe^{2+}/100 g	-	micromolar of Fe^{2+} equivalent to 100 grams
keV	-	Kiloelectron Volt
kcal	-	Calorie

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Aging is a natural phenomenon that transpires over every growing human being. The aging process of the human skin involves a complex biological progression where it is prejudiced by a combination of endogenous or intrinsic (genetic, cellular metabolism, hormone, and metabolic processes) and exogenous or extrinsic (chronic light exposure, chemicals, toxin) factors (Ganceviciene *et al.*, 2012, Baumann, 2018). Thus, to remain in an ageless beauty may prove a little challenging for the large population, considering the surrounding environment is becoming increasingly polluted. The elevated existence of pollutants in the environment, the consumption of unhealthy foods, and the sedentary lifestyle are causes of major concerns. The two are much to be blamed for the accelerated aging process in humans (Hirlekar and Patil, 2013).

Many consumers have since turned to various commercial over the counter skin rejuvenating creams or serums. In contrast, certain people have even resorted to more drastic measures such as plastic surgery, Botox shots, injection of Botulinum Toxin (BTX), Hormone Replacement Therapy (HRT) (Ganceviciene *et al.,* 2012). Even certain unscrupulous manufacturers take advantage of the high consumer demand by incorporating questionable synthetic skin rejuvenating active ingredients in their cosmeceutical formulations. Such chemicals are favored as they are considerably cheaper than the natural ones. This is a particularly disturbing trend in the cosmeceutical industry as it appears that consumer safety has become secondary over profit-making. Some reports even claimed that certain substances have contributed to unusual bouts of poor health among certain users. There are claims that some substances are carcinogenic and increase the possibility of contracting breast cancer in women, trigger allergic reactions, and hazardous to the ecology (Chen, 2009, Rasanayagam *et al.*, 2015).

Given the undesirable effects of synthetic active compounds on human skin, the quest for safer, naturally sourced alternatives as ingredients in skin rejuvenating cosmeceutical products warrants commercial consideration. Moreover, the ever-growing market for skin rejuvenating products would resonate well with the increasing consumer demand for natural plant-based bioactive compounds as the main ingredients to maintain good skin conditions (Aburjai and Natsheh, 2003, Mukherjee *et al.*, 2011). In this perspective, the study believes that the search for novel skin rejuvenating bioactive compounds can first be explored in agricultural or food-based industrial biomass. The amount of discarded biomass in Malaysia has substantially risen to ~1.2 million tonnes/year, consistent with brisk developments in the agricultural sector alongside growth in the global population. The high biomass turnover from the manufacturing processes contributes to the high volume of waste. It poses serious environmental challenges, such as requiring larger landfills and eventually contributing to the greenhouse effect as the biomass decomposes. Rather than scouring the depths of forests for exotic plants and exacerbating the fragile ecosystems' overexploitation, the biowastes accrued from agricultural biomass may be a promising and sustainable source of skin rejuvenating bioactive compounds.

In this milieu, such a source is the peels of pineapple that are discarded by food manufacturers. The scientific name for pineapple, the *Ananas comosus* (L.) Merr is a herbaceous and perennial monocot of the Bromeliaceae family. Generally, ~50 % (w/w) of pineapple's total weight comes from pineapple wastes *viz.* peel, core steam, crown, and leaves. The *A. comosus* peels (*Ac*P), in particular, is inherently loaded with polyphenols, specifically catechin, quercetin, and gallic acid, likely useful as the active ingredients in skin rejuvenating formulations (Li *et al.*, 2014). These are groups of substances with excellent extractable radical scavenging capability (Ribeiro *et al.*, 2015b). For instance, Freitas *et al.* (2015) reported eight different carotenoids *viz.* α-carotene, β-carotene, β-cryptoxanthin, lutein, lycopene, neoxanthin, violaxanthin, zeaxanthin. Li *et al.* (2014) also stated gallic acid, catechin, epicatechin, and ferulic acid are the major polyphenolic compounds in *Ac*P. Hence, the *A. comosus* peels extracts (*Ac*PE) may have useful application as an active ingredient in skin rejuvenating formulation, justifiable by their reported biological activities of phenolic compounds *viz.* anti-inflammatory and anti-cancer (Murakami *et al.*, 2015). Thus, the extraction of *Ac*PE can be improved through an ultrasonic-assisted extraction (UAE) technique. The UAE technique's versatility to extract plant-based extracts relies on the cavitation process, where bubbles generated by the acoustic waves shaped and imploded, then disintegrating the plant material's cells. Thus, more polyphenolic compounds are liberated from the cells and extracted, while advantageously reducing extraction time and requiring less use of organic solvents (Esclapez *et al.*, 2011, Gil-Chávez *et al.*, 2013, Živković *et al.*, 2018).

Nano formulated active ingredients in cosmeceuticals are proven more effective given their better penetrative power into the human skin. Aside from improving active ingredients' stability, the outlook of nano formulated products are also more appealing (Mu and Sprando, 2010, Lohani *et al.*, 2014, Garces *et al.*, 2018). While designing functional cosmetics that promote human health, it is necessary to examine the release of active ingredients to a specific location under the skin layer. Such nano-delivery systems have been developed to efficiently carry the active ingredients across the skin with reduced adverse effects on the human. As a matter of fact, plant-based ingredients in the form of nano cream-emulsified forms are more effective for topical transmission across the skin barrier (Tadros *et al.*, 2004, Solans *et al.*, 2005, Gutiérrez *et al.*, 2008, Rai *et al.*, 2018). Literature has shown that nanoemulsions, or in actual fact, are mini emulsions either comprised of fine oil-in-water (O/W) droplets or water-in-oil (W/O) dispersion with droplet sizes typically below 300 nm but can range up to 500 nm (Lovelyn and Attama, 2011, Hardas and Brin, 2017, Singh *et al.*, 2017). Most importantly, transmembrane delivery of active ingredients in the form of nano-cream is advantageously more practical. The minute size of the bioactive particulates promotes better penetration of the active ingredients through the skin (Zainol *et al.*, 2015).

1.2 Problem Statement

Considering that skin aging is an inevitable process in humans, and the long-term use of synthetic chemicals in skin rejuvenating beauty products could be hazardous to consumers' health. Hence, the development of alternative creams derived from natural, i.e., plant-based active ingredients, may prove useful in averting the above-said issue. Herein, the study proposed the preparation of an O/W nano formulated polyphenolic extract of *Ac*PE, containing catechin, quercetin, and gallic acid as anti-oxidants in the topical rejuvenation of the human skin.

The study believes the naturally anti-oxidants rich *Ac*PE can effectively scavenge the reactive oxygen chemical species in the human skin. In doing so, this can delay the effects of physiological aging on the human skin. The *Ac*PE is rich in different kinds of carotenoids and vitamins A and E, too (Erukainure *et al.*, 2011, Hossain and Rahman, 2011, Barbulova *et al.*, 2015). It is pertinent to indicate here that there are yet any studies on the nano formulated *Ac*PE, i.e., catechin, quercetin, and gallic acid, as active ingredients for skin rejuvenating cream. As a matter of fact, previous cosmeceutical formulations have focused mainly on the proteolytic enzyme bromelain (Ketnawa *et al.*, 2010, Ketnawa *et al.*, 2011, Spir *et al.*, 2015). Besides being highly loaded in natural anti-oxidants, information on the potential use of *Ac*PE remains rather limited (Ketnawa *et al.*, 2012).

There are a few questions regarding the formulation of active ingredients-loaded in cosmeceuticals products specifically in terms of stability, such as (i) chemical, (ii) physical, and (iii) microbiological, that needed clarification to ensure efficacy in delivering the active ingredients to the target skin layers. The study believes that reconstruction of the *Ac*PE into a nano cream carrier system may answer these questions. Hence, this is the first study detailing the applicability of *Ac*PE, i.e., catechin, quercetin, and gallic acid, particularly the hydrophilic fractions from *Ac*P biomass, for the purpose above. Notably, *Ac*PE-loaded nano cream of catechin, quercetin, and gallic acid would permit better topical and safer controlled release of the ingredients (Donsì *et al.*, 2011, Casanova and Santos, 2015).

1.3 Objectives of Study

The objectives of this research are as follows:

1. To identify the optimized UAE of *Ac*PE for improved extraction yield and total phenolic content (TPC) and characterize the optimum *Ac*PE (OPT-*AcP*E) for anti-oxidant properties.

2. To screen and optimize *Ac*PE nano cream (*Ac*PENc) formulation using a combination of high and low energy methods.

3. To perform physicochemical properties and stability evaluations on the optimized *Ac*PENc (OPT-*Ac*PENc).

4. To conduct a sensory evaluation on the OPT-*Ac*PENc using a scoring method.

1.4 Scopes of Study

This study has four phases, with the first phase involving the proximate analysis of the *Ac*P. The study then carried out the response surface optimization (RSM) of variables for the protocol of the UAE of *Ac*PE. In the optimization study, the response was to attain a high extraction yield and phenolic content of the anti-oxidants in *Ac*PE. Four relevant parameters, *viz.* effect of sonication time, solvent ratio (ethanol: water), amplitude, and liquid-solid ratio, were selected for the experimental UAE optimization assessment. Then, this study investigated polyphenolic compounds' anti-oxidative properties in the OPT-*Ac*PE. In this part of the work, the assessed parameters were total flavonoid content (TFC), 1,1-diphenyl-2-picrylhydrazyl radical scavenging activity (DPPH), and ferric reducing anti-oxidant power (FRAP). The characterization of OPT-*Ac*PE involved reverse-phase High-Performance Liquid Chromatography (HPLC).

In the second phase, the study screened and optimized the *Ac*PE nano-cream (*Ac*PENc) preparation via a combination of high and low energy methods, utilizing ultrasonic bombardment and phase inversion temperature (PIT). The screening process screened for oil amount, surfactant: water amount, and xanthan gum amount. The range of parameters was chosen by monitoring the quality of the formed *Ac*PENc for texture, particle size, polydispersity index (PDI), stability, and pH. D-optimal Mixture Design was used to optimize the protocol to prepare the AcPENc. The optimization was focused on optimizing four formulation relevant parameters, namely, the olive oil amount (A), grapeseed oil amount (B), surfactant amount (C), and water amount (D) for responses, particle size (R_1), and PDI (R_2).

The third phase encompassed the characterization of the physicochemical properties of the OPT-*Ac*PENc involving: organoleptic evaluation, zeta potential, pH value, conductivity, rheology study, and lastly, a morphological study by Transmission Electron Microscopy (TEM). In response, a stability study was done to affirm the above-said tests. Stability study involved three different tests: physical (centrifugal and mechanical shock test), light and chemical (shelf test conducted at four different conditions: (1) room temperature (2) oven, (3) refrigerator, and (4) heating-cooling cycle). Other than that, this study embarked on safety evaluations: (1) microbial test and (2) heavy metal test of OPT-*Ac*PENc.

In the final phase of the study, sensory evaluation was done on two sets of consumers, totaling 47 panelists, on the formulated OPT-*Ac*PENc through the scoring method. Here, this study apprised on preferable nano cream profile among consumers other than provide a parametric benchmark to improve the OPT-*Ac*PENc formulation. The outcome of the investigation was based on a given set of questionnaires to gauge consumer acceptance of the cream developed in this study.

1.5 Significance of the Study

Because this study aimed at developing an alternative O/W cream using plant-active ingredients from *Ac*PE, thus the study could establish the best UAE technique to extract high quantities of the bioactive compounds. Consequently, the O/W *Ac*PENc developed here could serve as a steppingstone for further improvements in the utilization of pineapple biomass, namely, the exploration of other valuable uses of the peels, preferably for the benefit of humankind. This research also highlights the *Ac*PE nano cream's topical applicability, containing catechin, quercetin, and gallic acid, as active ingredients to improve the human skin. It is pertinent to indicate that the findings on the physicochemical, safety evaluation, and sensory evaluation studies on the *Ac*PE nano cream can further add to the body of knowledge on existing natural-based cosmeceuticals while being mindful of the environment and ecosystem issues.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

In this present research, a stable bioactive compound from agricultural or food-based industrial biomass of *Ac*PE was successfully explored to develop an O/W nano cream formulation. Since this is the first attempt to develop a nanoemulsion containing *Ac*PE for topical human skin use, the extraction and screening of formulated *Ac*PE must be established. Herein, this research aimed to improve bioactive compounds extraction from *Ac*PE while fulfilling the cosmeceutical formulation guidelines. The objectives of this research included that of (1) optimization of UAE and *Ac*PE characterization, (2) screening of *Ac*PE formulation, (3) physicochemical and safety evaluation of OPT-*Ac*PENc as well as (4) sensory evaluation on *Ac*PENc among the panelists.

This study successfully optimized the parameters of UAE through RSM to extract a better amount of yield and TPC from *Ac*PE. While the UAE revealed successful extraction of *Ac*PE, the BBD displayed the insignificant effect of UAE's parameter on yield. In contrast, UAE showed a significant effect on TPC, revealing the optimum condition for *Ac*PE's extraction suggested by RSM was 5 min sonication time, 50 % solvent ratio, 65 % amplitude, and 35:1 mL/g liquid-solid ratio. On top of that, TFC, DPPH, and FRAP assay revealed an acceptable amount of antioxidant capacity, thereby supporting the feasibility of the probe-UAE technique for extracting phenolics from *Ac*PE. Besides, HPLC analysis revealed the presence of phenolic compounds in *Ac*PE with catechin as the major flavonoid, followed by quercetin and gallic acid.

Other than that, this research successfully screened and optimized the parameters to formulate a stable O/W nano cream. It was affirmed that a combination of high and low-energy techniques utilizing ultrasonic bombardment and PIT was appropriate to develop a stable O/W *Ac*PENc. Based on D-optimal MED, it could be construed that the optimum formulation comprised of OO amount (1 %), GSO amount (12 %), T80 (12.63 %), and water (74.37 %) with a constant value of 10% *Ac*PE, 2 % XG, 1 % phenoxyethanol and 2 % perfume oil. Regarding that, OPT-*Ac*PENc reported exhibit low particle size (187.37 ± 0.81 nm) with desirable PDI and zeta potential values of 0.248 ± 0.017 and 35.40 ± 2.71 mV, respectively. TEM analysis illustrated OPT-*Ac*PENc as a spherically shaped nano size. Also, the formulated nano cream demonstrated its suitability for human skin application with an acceptable pH value (4.56 ± 0.01). In contrast, a high conductivity value (1346.67 ± 5.77 µS/cm) was observed; hence, verifying its O/W nature. Likewise, OPT-*Ac*PENc proved its cosmeceutical suitability with a shear thinning and non-Newtonian behavior.

This study also completed the stability study, which consists of; (1) physical (centrifugal and mechanical shock), (2) light, and (3) chemical (heating-cooling cycle and accelerated test). The system displayed a stable appearance with no phase separation during the physical and light tests as well as the heating-cooling cycle. During the accelerated test, it was found that the changes in particle size as a function of time at 4 ± 2 °C were affected by Ostwald ripening destabilization phenomenon. The nanoemulsion was destabilized at a high temperature of 50 ± 2 °C, showing phase separation at the end of storage time. The effect seen here was plausibly due to dehydration of T80 in the system. This, consequently, changed the curvature of the surfactant, and the spherical-droplet shape of the encapsulated active ingredients was disrupted. Despite that, this test uncovered the optimum storage temperature of OPT-*Ac*PENc to be at room temperature (25 ± 2 °C). In fact, the suitability was evident from OPT-*Ac*PENc's stability in pH, particle size, and PDI, without phase separation in this investigation. Noteworthy to mention, OPT-*Ac*PENc was revealed to be safe from microorganism contamination and heavy metal exposure, fulfilling the requirement of NPRA Malaysia for any cosmetic products.

Additionally, the sensory evaluation revealed that OPT-*Ac*PENc was preferred among the panellists regarding its color, fragrance, spreadability, adsorption, film/coating, and irritancy, based on the attained scale of 7 to 8. However, attributes on consistency, skin feel, and residue were rated lower than the commercial cream, with a difference of 1.0. The findings revealed that the lowest evaluated factor on OPT-*Ac*PENc was the thickness of nanoemulsion, with a collective scale of 6.0. This effect was plausibly due to the emulsion after-effects of the formulated composition. Still, findings of the evaluation thus could be used as a benchmark to certain attributes of the O/W OPT-*Ac*PENc.

In view of the overall findings of this present research, the O/W *Ac*PENc developed here has the potential application in the cosmeceutical industry, which focus on naturally derived plant active ingredients. Thus, the study's focus on exploring the *Ac*PE's potential could further add to the body of knowledge on existing food by-products and natural-based cosmeceuticals.

5.2 Recommendations

Considering that this formulated of O/W *Ananas comosus* peels extract on skin rejuvenation is relatively nascent, the following recommendations for future research are suggested:

1. To determine the antioxidant capacity of the formulated nano cream. The test can gauge the capacity and stability of bioactive compounds after the formulation and prove to consumers what the products claimed in the research studies and marketing materials.

2. To incorporate stabilizer, polymer, and emollients in the formulation. As the present research discovered *Ac*PENcs' imperfection regarding stability at accelerated temperature and texture attributes through sensory evaluation, it is recommended to upgrade the formulation to improve the stability and texture properties (feel particularly smooth and light on the skin) as well as maximize the skin benefits to consumers.

3. To carry out a further in-vitro study on the formulation, as topical semisolid is a complex formulation must carry bioactive compounds to the skin and the

underlying tissue. Thus, the optimization of drug release and skin penetration measurements *viz.* Franz diffusion using synthetic membrane and human skin, respectively, is suggested.

4. To study the in-vivo by instrumental measurement. The efficacy of non-invasively changes in skin barrier function such as epidermal hydration levels and transepidermal water loss (TEWL) evaluated on human volunteers is suggested. Besides, the correlation between in-vivo measurement and sensory evaluation can be investigated to accomplish cosmetic products with consumer-satisfying sensory attributes.

5. To perform molecular modeling and dynamic simulation for the formulation design. The use of computational tools could help explore the interactions between nanoparticles and the biological component of *Ac*PE. It also could suggest avenues for understanding complex formulation design in less time with lower investments.

REFERENCES

"Why Fragrance-Free Products". (n.d.). Paula's Choice Skincare. Available at: https://www.paulaschoice.com/expert-advice/skincare-advice/sensitive-skin/why-fragrance-free-products-are-best-for-everyone.html.

Abraham, J., Sharika, T., Mishra, R. K. and Thomas, S. (2017). Chapter 14 - Rheological characteristics of nanomaterials and nanocomposites. *In:* Mishra, R. K., Thomas, S. andKalarikkal, N. (eds.) *Micro and Nano Fibrillar Composites (MFCs and NFCs) from Polymer Blends.* Sawston, United Kingdom: Woodhead Publishing, pp. 327-350.

Aburjai, T. and Natsheh, F. M. (2003). 'Plants used in cosmetics', *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, 17(9), pp. 987-1000.

Adejokun, D. A. and Dodou, K. (2020). 'Quantitative sensory interpretation of rheological parameters of a cream formulation', *Cosmetics,* 7(1), pp. 2.

Adetunji, L. R., Adekunle, A., Orsat, V. and Raghavan, V. (2017). 'Advances in the pectin production process using novel extraction techniques: a review', *Food Hydrocolloids,* 62, pp. 239-250.

Adiyaman, P., Kanchana, S., Usharani, T., Ilaiyaraja, N., Kalaiselvan, A. and Anila Kumar, K. R. (2016). 'Identification and qualification of polyphenolic compounds in underutilized fruits (star fruit and egg fruit) using HPLC', *Indian Journal of Traditional Knowledge,* 15(3), pp. 487-493.

Ahmed, I. A., Mikail, M. A., Zamakshshari, N. and Abdullah, A. H. (2020). 'Natural anti-aging skincare: role and potential', *Biogerontology,* 21(3), pp. 293-310.

Ajila, C. M., Brar, S. K., Verma, M., Tyagi, R. D., Godbout, S. and Valero, J. R. (2011). 'Extraction and analysis of polyphenols: recent trends', *Critical Reviews in Biotechnology,* 31(3), pp. 227-249.

Akgündüz, M. Ç., Çavuşoğlu, K. and Yalçın, E. (2020). 'The potential risk assessment of phenoxyethanol with a versatile model system', *Scientific Reports,* 10(1), pp. 1209.

Akhoond Zardini, A., Mohebbi, M., Farhoosh, R. and Bolurian, S. (2018). 'Production and characterization of nanostructured lipid carriers and solid lipid nanoparticles containing lycopene for food fortification', *Journal of Food Science and Technology*, 55(1), pp. 287-298.

Al-Maqtari, Q. A., Ghaleb, A. D. S., Mahdi, A. A., Al-Ansi, W., Noman, A. E., Wei, M., Al-Adeeb, A. and Yao, W. (2021). 'Stabilization of water-in-oil emulsion of *Pulicaria jaubertii* extract by ultrasonication: fabrication, characterization, and storage stability', *Food Chemistry*, 350, pp. 129249.

Al Arawi, W. A., Al Shaman, U. S., Albalawi, W. A. M., Siddhachettiar, P. A., El-kannishy, S. M. H., Bagalagel, A., Diri, R., Aljabri, A. and Hamdan, A. M. (2020). 'Association of demographic variables with the awareness of type 2 diabetes mellitus patients (T2DM) among the northwest population in Saudi Arabia', *Journal of Diabetes Research*, 2020, pp. 9408316.

Alam, M. F., Akhter, M., Mazumder, B., Ferdous, A., Hossain, M. D., Dafader, N. C., Ahmed, F. T., Kundu, S. K., Taheri, T. and Atique Ullah, A. K. M. (2019). 'Assessment of some heavy metals in selected cosmetics commonly used in Bangladesh and human health risk', *Journal of Analytical Science and Technology*, 10(1), pp. 2.

Ali, M. and Watson, I. A. (2014). 'Comparison of oil extraction methods, energy analysis and biodiesel production from flax seeds', *International Journal of Energy Research*, 38(5), pp. 614-625.

Almeida, I. F., Gaio, A. R. and Bahia, M. F. (2008). 'Hedonic and descriptive skinfeel analysis of two oleogels: comparison with other topical formulations', *Journal of Sensory Studies*, 23(1), pp. 92-113.

Almusallam, I. A., Mohamed Ahmed, I. A., Babiker, E. E., Al Juhaimi, F. Y., Fadimu, G. J., Osman, M. A., Al Maiman, S. A., Ghafoor, K. and Alqah, H. A. S. (2021). 'Optimization of ultrasound-assisted extraction of bioactive properties from date palm (*Phoenix dactylifera* L.) spikelets using response surface methodology', *LWT - Food Science and Technology*, 140, pp. 110816.

Alothman, M., Bhat, R. and Karim, A. A. (2009). 'Antioxidant capacity and phenolic content of selected tropical fruits from Malaysia, extracted with different solvents', *Food Chemistry*, 115(3), pp. 785-788.

Alvarez-Rivera, G., Llompart, M., Lores, M. and Garcia–Jares, C. (2018). Chapter 9 - Preservatives in cosmetics: regulatory aspects and analytical methods. *In:* Salvador, A. andChisvert, A. (eds.) *Analysis of Cosmetic Products (Second Edition)*. Boston: Elsevier, pp. 175-224.

Amar, A. T., Tong, P. S. and Ng, C. (2015). 'The MD2 'super sweet' pineapple (*Ananas comosus*)', *Utar Agriculture Science Journal*, 1, pp. 14-17.

Amnuaikit, T. and Boonme, P. (2013). 'Formulation and characterization of sunscreen creams with synergistic efficacy on SPF by combination of UV filters', *Journal of Applied Pharmaceutical Science*, 3(8), pp. 1.

ANSM. (2012). *Concentration of phenoxyethanol in cosmetic products –Information statement [French]* [online]. French National Agency for the Safety of Medicines and HealthProducts. Available at: https://ansm.sante.fr/S-informer/Points-d-information-Points-d-information/Concentration-de-phenoxyethanol-dans-les-produits-cosmetiques-Point-d-information.

ANVISA, T. B. H. R. A. (2004). *Cosmetic Products Stability Guide* [online]. Brazil. Available at: https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/cosmeticos/manuais-e-guias/guia-de-estabilidade-de-cosmeticos-ingles.pdf/@@download/file/guia-de-estabilidade-de-cosmeticos-ingles.pdf (Accessed: 1 January 2020).

Ares, G. and Varela, P. (2017). 'Trained vs. consumer panels for analytical testing: Fueling a long lasting debate in the field', *Food Quality and Preference*, 61, pp. 79-86.

Arshad, H., Mehmood, M. Z., Shah, M. H. and Abbasi, A. M. (2020). 'Evaluation of heavy metals in cosmetic products and their health risk assessment', *Saudi Pharmaceutical Journal*, 28(7), pp. 779-790.

Aryal, S., Baniya, M. K., Danekhu, K., Kunwar, P., Gurung, R. and Koirala, N. (2019). 'Total phenolic content, flavonoid content and antioxidant potential of wild vegetables from western nepal', *Plants (Basel, Switzerland)*, 8(4), pp. 96.

Ashaolu, T. J. (2021). 'Nanoemulsions for health, food, and cosmetics: a review', *Environmental Chemistry Letters*.

Assaf, H., Adly, M. A. and Hussein, M. R. (2010). 'Aging and intrinsic aging: pathogenesis and manifestations'. In Farage, M. A., Miller, K. W. andMaibach, H. I. (Eds.), *Textbook of Aging Skin* (pp. 129-138). Berlin, Heidelberg: Springer Berlin Heidelberg. [Online]. Available at: https://doi.org/10.1007/978-3-540-89656-2_13 (Accessed: 28 August 2021).

ASTM E1490. (2003). 'ASTM Standard E1490 – 03: Standard Practice fo Descriptive Skinfeel Analysis of Creams and Lotions'.

Aswathanarayan, J. B. and Vittal, R. R. (2019). 'Nanoemulsions and their potential applications in food industry', *Frontiers in Sustainable Food Systems,* 3(95).

Azeem, A., Rizwan, M., Ahmad, F. J., Iqbal, Z., Khar, R. K., Aqil, M. and Talegaonkar, S. (2009). 'Nanoemulsion components screening and selection: a technical note', *AAPS PharmSciTech,* 10(1), pp. 69-76.

Aziz, Z. A. A., Mohd-Nasir, H., Ahmad, A., Mohd. Setapar, S. H., Peng, W. L., Chuo, S. C., Khatoon, A., Umar, K., Yaqoob, A. A. and Mohamad Ibrahim, M. N. (2019). 'Role of nanotechnology for design and development of cosmeceutical: application in makeup and skin care', *Frontiers in chemistry,* 7(739).

Azmi, N. A. N., Elgharbawy, A. A., Motlagh, S. R., Samsudin, N. and Salleh, H. M. (2019). 'Nanoemulsions: factory for food, pharmaceutical and cosmetics', *Processes,* 7(9), pp. 617.

Azmir, J., Zaidul, I. S. M., Rahman, M. M., Sharif, K. M., Mohamed, A., Sahena, F., Jahurul, M. H. A., Ghafoor, K., Norulaini, N. A. N. and Omar, A. K. M. (2013). 'Techniques for extraction of bioactive compounds from plant materials: a review', *Journal of Food Engineering,* 117(4), pp. 426-436.

Bag, G. C., Grihanjali Devi, P. G. and Bhaigyabati, T. (2015). 'Assessment of total flavonoid content and antioxidant activity of methanolic rhizome extract of three hedychium species of manipur valley', *International Journal of Pharmaceutical Sciences Review and Research,* 30(1), pp. 154-159.

Baite, T. N., Mandal, B. and Purkait, M. K. (2021). 'Ultrasound assisted extraction of gallic acid from Ficus auriculata leaves using green solvent', *Food and Bioproducts Processing,* 128, pp. 1-11.

Balasundram, N., Sundram, K. and Samman, S. (2006). 'Phenolic compounds in plants and agri-industrial by-products: antioxidant activity, occurrence, and potential uses', *Food Chemistry,* 99(1), pp. 191-203.

Barbulova, A., Colucci, G. and Apone, F. (2015). 'New trends in cosmetics: by-products of plant origin and their potential use as cosmetic active ingredients', *Cosmetics,* 2(2), pp. 82-92.

Barkat, S., Thomas-Danguin, T., Bensafi, M., Rouby, C. and Sicard, G. (2003). 'Odor and color of cosmetic products: correlations between subjective judgement and autonomous nervous system response', *International Journal of Cosmetic Science,* 25(6), pp. 273-283.

Baroni, A., Buommino, E., De Gregorio, V., Ruocco, E., Ruocco, V. and Wolf, R. (2012). 'Structure and function of the epidermis related to barrier properties', *Clinics in Dermatology,* 30(3), pp. 257-262.

Barradas, T. N. and de Holanda e Silva, K. G. (2020). Nanoemulsions as optimized vehicles for essential oils. *In:* Saneja, A., Panda, A. K. andLichtfouse, E. (eds.) *Sustainable Agriculture Reviews 44: Pharmaceutical Technology for Natural Products Delivery Vol. 2 Impact of Nanotechnology.* New York City: Springer International Publishing, pp. 115-167.

Barradas, T. N. and de Holanda e Silva, K. G. (2021). 'Nanoemulsions of essential oils to improve solubility, stability and permeability: a review', *Environmental Chemistry Letters,* 19(2), pp. 1153-1171.

Barros, B. S. and Zaenglein, A. L. (2017). 'The use of cosmeceuticals in acne: help or hoax?', *American Journal of Clinical Dermatology,* 18(2), pp. 159-163.

Barry, V., Winquist, A. and Steenland, K. (2013). 'Perfluorooctanoic acid (PFOA) exposures and incident cancers among adults living near a chemical plant', *Environmental Health Perspectives,* 121(11-12), pp. 1313.

Baş, D. and Boyacı, İ. H. (2007). 'Modeling and optimization I: usability of response surface methodology', *Journal of Food Engineering,* 78(3), pp. 836-845.

Bashir, A. and Lambert, P. (2020). 'Microbiological study of used cosmetic products: highlighting possible impact on consumer health', *Journal of Applied Microbiology,* 128(2), pp. 598-605.

Baumann, L. (2018). 'How to use oral and topical cosmeceuticals to prevent and treat skin aging', *Facial Plastic Surgery Clinics of North America,* 26(4), pp. 407-413.

Bernard, P., Bernard, F.-X. and Himbert, F. (2015). *Cosmetic And Pharmaceutical Applications of Gallic Acid And Gallic Acid Derivatives*. WO2015140470A2. Retrieved from Google Scholar.

Bezerra, M. A., Santelli, R. E., Oliveira, E. P., Villar, L. S. and Escaleira, L. A. (2008). 'Response surface methodology (RSM) as a tool for optimization in analytical chemistry', *Talanta,* 76(5), pp. 965-977.

Bilal, M. and Iqbal, H. M. N. (2019). 'An insight into toxicity and human-health-related adverse consequences of cosmeceuticals — A review', *Science of The Total Environment,* 670, pp. 555-568.

Bilal, M. and Iqbal, H. M. N. (2020). 'New insights on unique features and role of nanostructured materials in cosmetics', *Cosmetics,* 7(2), pp. 24.

Bilal, M., Mehmood, S. and Iqbal, H. M. N. (2020). 'The beast of beauty: environmental and health concerns of toxic components in cosmetics', *Cosmetics,* 7(1), pp. 13.

Blaak, J., Keller, D., Simon, I., Schleißinger, M., Schürer, N. Y. and Staib, P. (2018). 'Consumer panel size in sensory cosmetic product evaluation: a pilot study from a statistical point of view', *Journal of Cosmetics, Dermatological Sciences and Applications,* 08(03), pp. 97-109.

Bobaker, A. M., Alakili, I., Sarmani, S. B., Al-Ansari, N. and Yaseen, Z. M. (2019). 'Determination and assessment of the toxic heavy metal elements abstracted from the traditional plant cosmetics and medical remedies: case study of libya', *International Journal of Environmental Research and Public Health,* 16(11), pp. 1957.

Bogdan, C., Moldovan, M. L., Man, I. M. and Crișan, M. (2016). 'Preliminary study on the development of an antistretch marks water-in-oil cream: ultrasound assessment, texture analysis, and sensory analysis', *Clinical, Cosmetic and Investigational Dermatology,* 9, pp. 249-255.

Boligon, A. and Athayde, M. (2014). 'Importance of HPLC in analysis of plants extracts', *Austin Chromatography,* 1(3), pp. 2.

Bone, P. and Ellen, P. (1999). 'Scents in the marketplace: explaining a fraction of olfaction', *Journal of Retailing,* 75, pp. 243-262.

Borba, C. M., Tavares, M. N., Macedo, L. P., Araújo, G. S., Furlong, E. B., Dora, C. L. and Burkert, J. F. M. (2019). 'Physical and chemical stability of β-carotene nanoemulsions during storage and thermal process', *Food Research International,* 121, pp. 229-237.

Borhan, F. P., Abd Gani, S. S. and Shamsuddin, R. (2014). 'The use of D-Optimal mixture design in optimising okara soap formulation for stratum corneum application', *The Scientific World Journal,* 2014, pp. 173979.

Bosmans, A. (2006). 'Scents and sensibility: when Do (in)congruent ambient scents influence product evaluations?', *Journal of Marketing,* 70(3), pp. 32-43.

Bouarab-Chibane, L., Forquet, V., Lantéri, P., Clément, Y., Léonard-Akkari, L., Oulahal, N., Degraeve, P. and Bordes, C. (2019). 'Antibacterial properties of polyphenols: characterization and QSAR (quantitative structure-activity relationship) models', *Frontiers in Microbiology,* 10, pp. 829-829.

Bradford, K. D. and Desrochers, D. M. (2009). 'The use of scents to influence consumers: the sense of using scents to make cents', *Journal of Business Ethics,* 90, pp. 141-153.

Bradley, R. L. (2010). Moisture and total solids analysis. *In:* Nielsen, S., S. (ed.) *Food Analysis.* Berlin/Heidelberg, Germany: Springer, pp. 85-104.

Branco, I. G., Sen, K. and Rinaldi, C. (2020). 'Effect of sodium alginate and different types of oil on the physical properties of ultrasound-assisted nanoemulsions', *Chemical Engineering and Processing - Process Intensification,* 153.

Bruns, R. E., Scarminio, I. S. and de Barros Neto, B. (2006). *Statistical Design - Chemometrics (First Edition),* Amsterdam, Elsevier Science.

Cao, H., Martino, G. and Richardson, P. (2003). *Use of xanthan gum as a hair fixative.* US9072683B2. Retrieved from Google Scholar.

Cardoso-Ugarte, G. A., López-Malo, A. and Jiménez-Munguía, M. T. (2016). 'Application of nanoemulsion technology for encapsulation and release of lipophilic bioactive compounds in food'. In Grumezescu, A. M. (Ed.), *Emulsions* (pp. 227-255): Academic Press. [Online]. Available at: https://www.sciencedirect.com/science/article/pii/B9780128043066000076 (Accessed: 29 May 2021).

Carpenter, J. and Saharan, V. K. (2016). 'Ultrasonic assisted formation and stability of mustard oil in water nanoemulsion: Effect of process parameters and their optimization', *Ultrasonics Sonochemistry,* pp. 422-430.

Casanova, F. and Santos, L. (2015). 'Encapsulation of cosmetic active ingredients for topical application-a review', *Journal of Microencapsulation,* 33(1), pp. 1-17.

Chanamai, R. and McClements, D. J. (2002). 'Comparison of gum arabic, modified starch, and whey protein isolate as emulsifiers: influence of pH, $CaCl_2$ and temperature', *Journal of Food Science,* 67(1), pp. 120-125.

Che Marzuki, N. H., Wahab, R. A. and Abdul Hamid, M. (2019). 'An overview of nanoemulsion: concepts of development and cosmeceutical applications', *Biotechnology & Biotechnological Equipment,* 33(1), pp. 779-797.

Cheaburu-Yilmaz, C. N., Karasulu, H. Y. and Yilmaz, O. (2019). Nanoscaled dispersed systems used in drug-delivery applications. *In:* Vasile, C. (ed.)

Polymeric Nanomaterials in Nanotherapeutics. Amsterdam, Netherlands: Elsevier, pp. 437-468.

Chen, Q. (2009). 'Evaluate the effectiveness of the natural cosmetic product compared to chemical-based products', *International Journal of Chemistry,* 1(2), pp. 57-59.

Chen, S., Zeng, Z., Hu, N., Bai, B., Wang, H. and Suo, Y. (2018). 'Simultaneous optimization of the ultrasound-assisted extraction for phenolic compounds content and antioxidant activity of *Lycium ruthenicum* Murr. fruit using response surface methodology', *Food Chemistry*, 242, pp. 1-8.

Chen, W., Wang, W. P., Zhang, H. S. and Huang, Q. (2012). 'Optimization of ultrasonic-assisted extraction of water-soluble polysaccharides from *Boletus edulis* mycelia using response surface methodology', *Carbohydrate Polymers,* 87(1), pp. 614-619.

Chircov, C. and Grumezescu, A. M. (2019). Chapter 6 - Nanoemulsion preparation, characterization, and application in the field of biomedicine. *In:* Grumezescu, A. M. (ed.) *Nanoarchitectonics in Biomedicine.* William Andrew Publishing, pp. 169-188.

Choudhury, H., Gorain, B., Karmakar, S., Biswas, E., Dey, G., Barik, R., Mandal, M. and Pal, T. K. (2014). 'Improvement of cellular uptake, in vitro antitumor activity and sustained release profile with increased bioavailability from a nanoemulsion platform', *International Journal of Pharmaceutics*, 460(1-2), pp. 131-143.

Chung, C. and McClements, D. J. (2018). Chapter 17 - Characterization of physicochemical properties of nanoemulsions: appearance, stability, and rheology. *In:* Jafari, S. M. andMcClements, D. J. (eds.) *Nanoemulsions.* Academic Press, pp. 547-576.

Colgan, S. T., Mazzeo, T. and Orr, R. (2018). 'Chapter 2 - Regulatory expectations and industry practice on stability testing'. In Qiu, F. andScrivens, G. (Eds.), *Accelerated Predictive Stability* (pp. 15-32). Boston: Academic Press. [Online]. Available at: https://www.sciencedirect.com/science/article/pii/B9780128027868000024 (Accessed: 28 August 2021).

Connelly, L. M. (2013, July-August). Demographic data in research studies. *MedSurg Nursing, 22,* 269. Retrieved from https://link.gale.com/apps/doc/A341687270/AONE?u=anon~6e7a1d4a&sid=googleScholar&xid=7aa2c685 (Accessed: 13 August 2021).

Costa, A., Siqueira Talarico, A., Parra Duarte Cde, O., Silva Pereira, C., de Souza Weimann, E. T., Sabino de Matos, L., Della Coletta, L. C., Fidelis, M. C., Tannous, T. S. and Vasconcellos, C. (2013). 'Evaluation of the quantitative and qualitative alterations in the fatty acid contents of the sebum of patients with inflammatory acne during treatment with systemic lymecycline and/or oral fatty acid supplementation', *Dermatology Research and Practice,* 2013, pp. 1-14.

Costa, R. and Santos, L. (2017). 'Delivery systems for cosmetics - From manufacturing to the skin of natural antioxidants', *Powder Technology,* 322, pp. 402-416.

Cui, S. M., Li, T., Wang, Q., He, K. K., Zheng, Y. M., Liang, H. Y. and Song, L. Y. (2020). 'Antibacterial effects of *Schisandra chinensis* extract on *Escherichia coli* and its applications in cosmetic', *Current Microbiology,* 77(5), pp. 865-874.

Da Costa, S., Basri, M., Shamsudin, N. and Basri, H. (2014). 'Stability of positively charged nanoemulsion formulation containing steroidal drug for effective transdermal application', *Journal of Chemistry,* 2014, pp. 1-8.

da Silva, D. I., Nogueira, G. D., Duzzioni, A. G. and Barrozo, M. A. (2013). 'Changes of antioxidant constituents in pineapple (*Ananas comosus*) residue during drying process', *Industrial Crops and Products*, 50, pp. 557-562.

Dadashi, L. and Dehghanzadeh, R. (2016). 'Investigating incidence of bacterial and fungal contamination in shared cosmetic kits available in the women beauty salons', *Health promotion perspectives,* 6(3), pp. 159-163.

Dai, C.-Y., Liao, P.-R., Zhao, M.-Z., Gong, C., Dang, Y., Qu, Y. and Qiu, L.-S. (2020). 'Optimization of ultrasonic flavonoid extraction from *Saussurea involucrate*, and the ability of flavonoids to block melanin deposition in human melanocytes', *Molecules,* 25(2), pp. 313.

Danila, A., Ibanescu, S.-A., Zaharia, C., Muresan, E. I., Popescu, A., Danu, M. and Rotaru, V. (2021). 'Eco-friendly O/W emulsions with potential application in skincare products', *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* 612, pp. 125969.

Dario, M. F., Oliveira, C. A., Cordeiro, L. R., Rosado, C., Inês de Fátima, A. M., Maçôas, E., Santos, M. S. C., da Piedade, M. E. M., Baby, A. R. and Velasco,

M. V. R. (2016). 'Stability and safety of quercetin-loaded cationic nanoemulsion: *in vitro* and *in vivo* assessments', *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* 506, pp. 591-599.

Daudt, R. M., Back, P. I., Cardozo, N. S., Marczak, L. D. and Kulkamp-Guerreiro, I. C. (2015). 'Pinhao starch and coat extract as new natural cosmetic ingredients: Topical formulation stability and sensory analysis', *Carbohydrate Polymers,* 134, pp. 573-580.

Davidov-Pardo, G. and McClements, D. J. (2015). 'Nutraceutical delivery systems: Resveratrol encapsulation in grape seed oil nanoemulsions formed by spontaneous emulsification', *Food Chemistry,* 167, pp. 205-212.

Dewi, F. D., Sudjana, G. and Oesman, Y. M. (2011). 'Patient satisfaction analysis on service quality of dental health care based on empathy and responsiveness', *Dental research journal,* 8(4), pp. 172-177.

Dhukani, A. (2013). *Ananas comosus* (L.) Merr., Bromeliaceae *In:* Quave, C. L. (ed.) *Medicinal Plant Monograph.*

Dias, D. d. O., Colombo, M., Kelmann, R. G., Kaiser, S., Lucca, L. G., Teixeira, H. F., Limberger, R. P., Veiga, V. F. and Koester, L. S. (2014). 'Optimization of Copaiba oil-based nanoemulsions obtained by different preparation methods', *Industrial Crops and Products,* 59, pp. 154-162.

Djuris, J., Vasiljevic, D., Jokic, S. and Ibric, S. (2014). 'Application of D-optimal experimental design method to optimize the formulation of O/W cosmetic emulsions', *International Journal of Cosmetic Science,* 36(1), pp. 79-87.

Donsì, F., Sessa, M., Mediouni, H., Mgaidi, A. and Ferrari, G. (2011). 'Encapsulation of bioactive compounds in nanoemulsion- based delivery systems', *Procedia Food Science,* 1, pp. 1666-1671.

Dréno, B., Zuberbier, T., Gelmetti, C., Gontijo, G. and Marinovich, M. (2019). 'Safety review of phenoxyethanol when used as a preservative in cosmetics', *Journal of the European Academy of Dermatology and Venereology,* 33(S7), pp. 15-24.

Drozdz, P., Seziene, V. and Pyrzynska, K. (2017). 'Phytochemical properties and antioxidant activities of extracts from wild blueberries and lingonberries', *Plant Foods for Human Nutrition,* 72(4), pp. 360-364.

du Plessis, J. L., Stefaniak, A. B. and Wilhelm, K.-P. (2018). 'Measurement of Skin Surface pH'. In Surber, C., Abels, C. andMaibach, H. (Eds.), *pH of the Skin:*

Issues and Challenges. Basel, Switzerland: S. Karger AG. [Online]. Available at: https://books.google.com.my/books?id=dLJqDwAAQBAJ (Accessed: 23 May 2021).

Dubuisson, P., Picard, C., Grisel, M. and Savary, G. (2018). 'How does composition influence the texture of cosmetic emulsions?', *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 536, pp. 38-46.

Emeje, M., Isimi, C., Byrn, S., Fortunak, J., Kunle, O. and Ofoefule, S. (2011). 'Extraction and physicochemical characterization of a new polysaccharide obtained from the fresh fruits of *Abelmoschus esculentus*', *Iranian Journal of Pharmaceutical Research: IJPR*, 10, pp. 237-246.

EPA U. (2015). *Endocrine Dis-ruptor Screening Program (EDSP) Estrogen Receptor Bioactivity* [online]. United States Environmental Protection Agency. Available at: https://www.epa.gov/endocrine-disruption/endocrine-disruptor-screening-program-edsp-estrogen-receptor-bioactivity.

Epstein, H. (2014). 'Skin Care Products'. In Barel, A. O., Paye, M. andMaibach, H. I. (Eds.), *Handbook of Cosmetic Science and Technology*. Boca Raton, Florida, US: CRC Press. [Online]. Available at: https://books.google.com.my/books?id=RIvOBQAAQBAJ (Accessed: 4 June 2021).

Erukainure, O., Ajiboye, J. A., Adejobi, R. O., Okafor, O. Y., Kosoko, S. B. and Owolabi, F. O. (2011). 'Effect of pineapple peel extract on total phospholipids and lipid peroxidation in brain tissues of rats', *Asian Pacific Journal of Tropical Medicine*, pp. 182-184.

Esclapez, M. D., García-Pérez, J. V., Mulet, A. and Cárcel, J. A. (2011). 'Ultrasound-assisted extraction of natural products', *Food Engineering Reviews*, 3(2), pp. 108-120.

Espinosa-Andrews, H. and Páez-Hernández, G. (2020). 'Optimization of ultrasonication curcumin-hydroxylated lecithin nanoemulsions using response surface methodology', *Journal of Food Science and Technology,* 57(2), pp. 549-556.

Espitia, P. J. P., Fuenmayor, C. A. and Otoni, C. G. (2019). 'Nanoemulsions: synthesis, characterization, and application in bio-based active food packaging', *Comprehensive Reviews in Food Science and Food Safety*, 18(1), pp. 264-285.

Estanqueiro, M., Conceição, J., Amaral, M. H., Santos, D., Silva, J. B. and Lobo, J. M. S. (2014). 'Characterization and stability studies of emulsion systems containing pumice', *Brazilian Journal of Pharmaceutical Sciences,* 50(2), pp. 361-369.

Fakhry, K. R. and Mohammed Hassan, K. (2013). 'Formulation and evaluation of diphenhydramine HCL release from different semi-solid bases (cream, gel and ointment)', *World Journal of Pharmaceutical Research,* 2, pp. 1306-1324.

Farage, M. A., Hood, W., Berardesca, E. and Maibach, H. (2018). 'Intrinsic and extrinsic factors affecting skin surface pH'. In Surber, C., Abels, C. andMaibach, H. (Eds.), *pH of the Skin: Issues and Challenges* (Vol. 54, pp. 33-47). Basel, Switzerland: Karger. [Online]. Available at: https://pubmed.ncbi.nlm.nih.gov/30130773/ (Accessed: 28 August 2021).

Farage, M. A., Miller, K. W., Elsner, P. and Maibach, H. I. (2013). 'Characteristics of the aging skin', *Advanced Wound Care (New Rochelle),* 2(1), pp. 5-10.

Farahin, A. W., Yusoff, F. M., Basri, M., Nagao, N. and Shariff, M. (2019). 'Use of microalgae: *Tetraselmis tetrathele* extract in formulation of nanoemulsions for cosmeceutical application', *Journal of Applied Phycology,* 31(3), pp. 1743-1752.

Faria-Silva, A. C., Costa, A. M., Ascenso, A., Ribeiro, H. M., Marto, J., Gonçalves, L. M., Carvalheiro, M. and Simões, S. (2020). 'Nanoemulsions for cosmetic products'. In Nanda, A., Nanda, S., Nguyen, T. A., Rajendran, S. andSlimani, Y. (Eds.), *Nanocosmetics* (pp. 59-77): Elsevier. [Online]. Available at: https://www.sciencedirect.com/science/article/pii/B9780128222867000048 (Accessed: 29 May 2021).

Faruruwa, M. D. and Bartholomew, S. P. (2014). 'Study of heavy metals content in facial cosmetics obtained from open markets and superstores within Kaduna metropolis, Nigeria', *American Journal of Chemistry and Application,* 1, pp. 27-33.

Feng, J., Esquena, J., Rodriguez-Abreu, C. and Solans, C. (2020). 'Key features of nano-emulsion formation by the phase inversion temperature method', *Journal of Dispersion Science and Technology,* pp. 1-9.

Ferreira-Nunes, R., Angelo, T., Silva, S. M. M., Magalhães, P. O., Gratieri, T., Cunha-Filho, M. S. S. and Gelfuso, G. M. (2018). 'Versatile chromatographic method for catechin determination in development of topical formulations containing natural extracts', *Biomedical Chromatography,* 32(2), pp. e4062.

Ferreira, M. S., Magalhães, M. C., Oliveira, R., Sousa-Lobo, J. M. and Almeida, I. F. (2021). 'Trends in the Use of Botanicals in Anti-Aging Cosmetics', *Molecules,* 26(12), pp. 3584.

Ferreira, S. L., Bruns, R. E., Ferreira, H. S., Matos, G. D., David, J. M., Brandao, G. C., da Silva, E. G., Portugal, L. A., dos Reis, P. S., Souza, A. S. and dos Santos, W. N. (2007). 'Box-Behnken design: an alternative for the optimization of analytical methods', *Analytica Chimica Acta,* 597(2), pp. 179-186.

Figueroa-Robles, A., Antunes-Ricardo, M. and Guajardo-Flores, D. (2021). 'Encapsulation of phenolic compounds with liposomal improvement in the cosmetic industry', *International Journal of Pharmaceutics,* 593, pp. 120125.

Fiume, M. M., Heldreth, B., Bergfeld, W. F., Belsito, D. V., Hill, R. A., Klaassen, C. D., Liebler, D. C., Marks, J. G., Jr., Shank, R. C., Slaga, T. J., Snyder, P. W. and Andersen, F. A. (2016). 'Safety assessment of microbial polysaccharide gums as used in cosmetics', *International Journal of Toxicology,* 35(1 Suppl), pp. 5S-49S.

Franck, A. (2013). *Understanding Rheology of Structured Fluids* [online]. New Castle, Delaware, United States. Available at: http://www.tainstruments.com/pdf/literature/AAN016_V1_U_StructFluids.pdf (Accessed: 15 February 2021).

Freitas, A., Moldao-Martins, M., Costa, H. S., Albuquerque, T. G., Valente, A. and Sanches-Silva, A. (2015). 'Effect of UV-C radiation on bioactive compounds of pineapple (*Ananas comosus* L. Merr.) by-products', *Journal of the Science of Food and Agriculture,* 95(1), pp. 44-52.

Frost and Sullivan. (2017). *Global Personal Care Active Ingredients Market - Forecast to 2023* [online]. Available at: https://store.frost.com/global-personal-care-active-ingredients-market-forecast-to-2023.html#section6.

Fytianos, G., Rahdar, A. and Kyzas, G. Z. (2020). 'Nanomaterials in cosmetics: recent updates', *Nanomaterials (Basel),* 10(5).

Gahruie, H. H., Niakousari, M., Parastouei, K., Mokhtarian, M., Eş, I. and Mousavi Khaneghah, A. (2020). 'Co-encapsulation of vitamin D_3 and saffron petals' bioactive compounds in nanoemulsions: effects of emulsifier and homogenizer types', *Journal of Food Processing and Preservation,* 44(8), pp. e14629.

Galvão, K. C. S., Vicente, A. A. and Sobral, P. J. A. (2018). 'Development, characterization, and stability of O/W pepper nanoemulsions produced by high-pressure homogenization', *Food and Bioprocess Technology,* 11(2), pp. 355-367.

Ganceviciene, R., Liakou, A. I., Theodoridis, A., Makrantonaki, E. and Zouboulis, C. C. (2012). 'Skin anti-aging strategies', *Dermatoendocrinology,* 4(3), pp. 308-319.

Gao, J., Hu, J., Hu, D. and Yang, X. (2019). 'A role of gallic acid in oxidative damage diseases: a comprehensive review', *Natural Product Communications,* 14(8), pp. 1934578X19874174.

Garces, A., Amaral, M. H., Sousa Lobo, J. M. and Silva, A. C. (2018). 'Formulations based on solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC) for cutaneous use: a review', *European Journal of Pharmaceutical Sciences,* 112, pp. 159-167.

Gaynor, E. (2014). *Why It Can Be Bad That Your Products Smell Good* [online]. New York: Condé Nast. Available at: https://www.teenvogue.com/story/fragrance-free-products.

George, H. F. and Qureshi, F. (2013). Newton's law of viscosity, newtonian and non-newtonian fluids. *In:* Wang, Q. J. andChung, Y.-W. (eds.) *Encyclopedia of Tribology.* Boston, Massachusetts Avenue: Springer US, pp. 2416-2420.

Ghaderpoori, M., Kamarehie, B., Jafari, A., Alinejad, A. A., Hashempour, Y., Saghi, M. H., Yousefi, M., Oliveri Conti, G., Mohammadi, A. A., Ghaderpoury, A. and Ferrante, M. (2020). 'Health risk assessment of heavy metals in cosmetic products sold in Iran: the Monte Carlo simulation', *Environmental Science and Pollution Research*, 27(7), pp. 7588-7595.

Ghassemi, M. and Shahidian, A. (2017). Chapter 4 - Fluid mechanics. *In:* Ghassemi, M. andShahidian, A. (eds.) *Nano and Bio Heat Transfer and Fluid Flow.* Oxford: Academic Press, pp. 57-87.

Gil-Chávez, G. J., Villa, J. A., Ayala-Zavala, J. F., Heredia, J. B., Sepulveda, D., Yahia, E. M. and González-Aguilar, G. A. (2013). 'Technologies for extraction and production of bioactive compounds to be used as nutraceuticals and food ingredients: an overview', *Comprehensive Reviews in Food Science and Food Safety,* 12(1), pp. 5-23.

Gohtani, S. and Prasert, W. (2014). 'Nano-emulsions; emulsification using low energy methods', *Japan Journal of Food Engineering,* 15(3), pp. 119-130.

Gore, E., Picard, C. and Savary, G. (2020). 'Complementary approaches to understand the spreading behavior on skin of O/W emulsions containing different emollientss', *Colloids and Surfaces B: Biointerfaces,* 193, pp. 111132.

Gräbner, D. and Hoffmann, H. (2017). Chapter 27 - Rheology of cosmetic formulations. *In:* Sakamoto, K., Lochhead, R. Y., Maibach, H. I. andYamashita, Y. (eds.) *Cosmetic Science and Technology*. Amsterdam: Elsevier, pp. 471-488.

Gragnani, A., Cornick, S. M., Chominski, V., Ribeiro de Noronha, S. M., Alves Corrêa de Noronha, S. A. and Ferreira, L. M. (2014). 'Review of major theories of skin aging', *Advances in Aging Research,* 3(4), pp. 265-284.

Gulcin, İ. (2020). 'Antioxidants and antioxidant methods: an updated overview', *Archives of Toxicology,* 94(3), pp. 651-715.

Gutiérrez, J. M., González, C., Maestro, A., Solè, I., Pey, C. M. and Nolla, J. (2008). 'Nano-emulsions: new applications and optimization of their preparation', *Current Opinion in Colloid & Interface Science,* 13(4), pp. 245-251.

Guzmán, C., Rojas, M. A. and Aragón, M. (2021). 'Optimization of ultrasound-assisted emulsification of emollient nanoemulsions of seed oil of *Passiflora edulis* var. *edulis*', *Cosmetics,* 8(1), pp. 1.

Ha, E., Wang, W. and Wang, Y. J. (2002). 'Peroxide formation in polysorbate 80 and protein stability', *Journal of Pharmaceutical Sciences,* 91(10), pp. 2252-2264.

Halla, N., Fernandes, I. P., Heleno, S. A., Costa, P., Boucherit-Otmani, Z., Boucherit, K., Rodrigues, A. E., Ferreira, I. C. F. R. and Barreiro, M. F. (2018). 'Cosmetics preservation: a review on present strategies', *Molecules,* 23(7), pp. 1571.

Han, S. W., Song, H. Y., Moon, T. W. and Choi, S. J. (2018). 'Influence of emulsion interfacial membrane characteristics on Ostwald ripening in a model emulsion', *Food Chemistry,* 242, pp. 91-97.

Han, Y. L., Gao, J., Yin, Y. Y., Jin, Z. Y., Xu, X. M. and Chen, H. Q. (2016). 'Extraction optimization by response surface methodology of mucilage polysaccharide from the peel of *Opuntia dillenii* haw. fruits and their physicochemical properties', *Carbohydrate Polymers,* 151, pp. 381-391.

Hardas, B. and Brin, M. F. (2017). Topical botulinum toxin type A. *In:* Carruthers, A. andCarruthers, J. (eds.) *Botulinum Toxin: Procedures in Cosmetic Dermatology Series.* Elsevier Health Sciences, pp. 81-84.

Hatahet, T., Morille, M., Hommoss, A., Devoisselle, J. M., Muller, R. H. and Begu, S. (2016). 'Quercetin topical application, from conventional dosage forms to nanodosage forms', *European Journal of Pharmaceutics and Biopharmaceutics*, 108, pp. 41-53.

Hatambeygi, N., Abedi, G. and Talebi, M. (2011). 'Method development and validation for optimised separation of salicylic, acetyl salicylic and ascorbic acid in pharmaceutical formulations by hydrophilic interaction chromatography and response surface methodology', *Journal of Chromatography A*, 1218(35), pp. 5995-6003.

Hategekimana, J. and Zhong, F. (2015). 'Degradation of vitamin E in nanoemulsions during storage as affected by temperature, light and darkness', *International Journal of Food Engineering*, 11(2), pp. 199-206.

He, B., Zhang, L. L., Yue, X. Y., Liang, J., Jiang, J., Gao, X. L. and Yue, P. X. (2016). 'Optimization of ultrasound-assisted extraction of phenolic compounds and anthocyanins from blueberry (*Vaccinium ashei*) wine pomace', *Food Chemistry*, 204, pp. 70-76.

Herman, A. (2019). 'Antimicrobial ingredients as preservative booster and components of self-preserving cosmetic products', *Current Microbiology*, 76(6), pp. 744-754.

Herman, S. (2016). 'The use of fragrance in topically applied formulations'. In Dayan, N. (Ed.), *Handbook of Formulating Dermal Applications: A Definitive Practical Guide*. New Jersey, United States: John Wiley & Sons. [Online]. Available at: https://books.google.com.my/books?id=vMa7DQAAQBAJ (Accessed: 28 June 2021).

Hermann, A. (2004). *Guidelines on Stability Testing of Cosmetic Products* [online]. Brussels. Available at: https://www.cosmeticseurope.eu/files/5914/6407/8121/Guidelines_on_Stability_Testing_of_Cosmetics_CE-CTFA_-_2004.pdf (Accessed: 21 December 2020).

Hierrezuelo, J. M., Molina-Bolívar, J. A. and Ruiz, C. C. (2014). 'An energetic analysis of the phase separation in non-ionic surfactant mixtures: the role of the headgroup structure', *Entropy,* 16(8), pp. 4375-4391.

Hirlekar, R. and Patil, V. (2013). 'Novel anti-aging technologies and products', *International Journal of Pharmaceutical and Chemical Sciences,* 2(4), pp. 1756-1761.

Hong, I. K., Kim, S. I. and Lee, S. B. (2018). 'Effects of HLB value on oil-in-water emulsions: Droplet size, rheological behavior, zeta-potential, and creaming index', *Journal of Industrial and Engineering Chemistry,* 67, pp. 123-131.

Hossain, M. A. and Rahman, S. M. M. (2011). 'Total phenolics, flavonoids and antioxidant activity of tropical fruit pineapple', *Food Research International,* 44(3), pp. 672-676.

Houston, N. and Kimball, A. B. (2013). Green tea extract. *In:* Farris, P. K. (ed.) *Cosmeceuticals and Cosmetic Practice.* UK: Wiley Blackwell.

Hu, Y.-T., Ting, Y., Hu, J.-Y. and Hsieh, S.-C. (2017). 'Techniques and methods to study functional characteristics of emulsion systems', *Journal of Food and Drug Analysis,* 25(1), pp. 16-26.

Huang, J., Hitchins, A. D., Tran, T. T. and McCarron, J. E. (2017). 'Microbiological methods for cosmetics'. In *Bacteriological Analytical Manual (BAM)* Marland, USA: Food and Drug Administration. [Online]. Available at: https://www.fda.gov/food/laboratory-methods-food/bam-chapter-23-methods-cosmetics (Accessed: 30 May 2021).

Hülpüsch, C., Tremmel, K., Hammel, G., Bhattacharyya, M., de Tomassi, A., Nussbaumer, T., Neumann, A. U., Reiger, M. and Traidl-Hoffmann, C. (2020). 'Skin pH–dependent *Staphylococcus aureus* abundance as predictor for increasing atopic dermatitis severity', *Allergy,* 75(11), pp. 2888-2898.

Hwang, E., Park, S.-Y., Lee, H. J., Lee, T. Y., Sun, Z.-w. and Yi, T. H. (2014). 'Gallic acid regulates skin photoaging in UVB-exposed fibroblast and hairless mice', *Phytotherapy Research,* 28(12), pp. 1778-1788.

Ibrahim, N. A. and Ahmad Zaini, M. A. (2020). 'Chapter 2 - Nanomaterials in detergents and cosmetics products: the mechanisms and implications'. In Hussain, C. M. (Ed.), *Handbook of Nanomaterials for Manufacturing Applications* (pp. 23-49). Amsterdam, Netherlands: Elsevier. [Online]. Available at:

http://www.sciencedirect.com/science/article/pii/B9780128213810000028 (Accessed: 27 January 2021).

Isaac, V., Cefali, L., Chiari, B., Almeida, M., Ribeiro, H. and Corrêa, M. (2012). 'Effect of various thickening agents on the rheological properties of O/W emulsions containing nonIonic emulsifier', *Journal of Dispersion Science and Technology*, 34.

Jadoon, S., Karim, S., Asad, M. H. H. B., Akram, M. R., Kalsoom Khan, A., Malik, A., Chen, C. and Murtaza, G. (2015). 'Anti-aging potential of phytoextract loaded-pharmaceutical creams for human skin cell longetivity', *Oxidative Medicine and Cellular Longevity*, 2015, pp. 709628.

Jaslina, N. F., Faujan, N. H., Mohamad, R. and Ashari, S. E. (2020). 'Effect of addition of PVA/PG to oil-in-water nanoemulsion kojic monooleate formulation on droplet size: three-factors response surface optimization and characterization', *Cosmetics*, 7(4), pp. 73.

Jaswir, I., Noviendri, D., Hasrini, R. F. and Octavianti, F. (2011). 'Carotenoids: sources, medicinal properties and their application in food and nutraceutical industry', *Journal of Medicinal Plants Research*, 5(33), pp. 7119-7131.

Jiménez-Rodríguez, A., Heredia-Olea, E., Barba-Dávila, B. A., Gutiérrez-Uribe, J. A. and Antunes-Ricardo, M. (2021). 'Polysaccharides from *Agave salmiana* bagasse improves the storage stability and the cellular uptake of indomethacin nanoemulsions', *Food and Bioproducts Processing*, 127, pp. 114-127.

Jiménez, M., Domínguez, J. A., Pascual-Pineda, L. A., Azuara, E. and Beristain, C. I. (2018). 'Elaboration and characterization of O/W cinnamon (*Cinnamomum zeylanicum*) and black pepper (*Piper nigrum*) emulsions', *Food Hydrocolloids,* 77, pp. 902-910.

Jog, S. V., Bagal, S. A., Chogale, M. M. and Palekar-Shanbhag, P. (2012). 'Sensorial analysis in cosmetics: An overview', *Household and Personal Care Today*, pp. 23-24.

Johari, M. A. and Khong, H. Y. (2019). 'Total phenolic content and antioxidant and antibacterial activities of *Pereskia bleo*', *Advances in Pharmacological Sciences*, 2019, pp. 7428593.

John, J. J., Kuhn, S., Braeken, L. and Van Gerven, T. (2018). 'Effect of fluid properties on ultrasound assisted liquid-liquid extraction in a microchannel', *Ultrasonics Sonochemistry*, 42, pp. 68-75.

Jovanović, A. A., Đorđević, V. B., Zdunić, G. M., Pljevljakušić, D. S., Šavikin, K. P., Gođevac, D. M. and Bugarski, B. M. (2017). 'Optimization of the extraction process of polyphenols from *Thymus serpyllum* L. herb using maceration, heat- and ultrasound-assisted techniques', *Separation and Purification Technology,* 179, pp. 369-380.

Jovanović, M., Milutinović, M., Kostić, M., Miladinović, B., Kitić, N., Branković, S. and Kitić, D. (2018). 'Antioxidant capacity of pineapple (*Ananas comosus* (L.) Merr.) extracts and juice', *Lekovite sirovine,* (38), pp. 27-30.

Julian McClements, D., Henson, L., Popplewell, L. M., Decker, E. A. and Jun Choi, S. (2012). 'Inhibition of ostwald ripening in model beverage emulsions by addition of poorly water soluble triglyceride oils', *Journal of Food Science,* 77(1), pp. C33-C38.

Jun, L. Y., Khan, F. S. A., Mubarak, N. M., Yon, L. S., Bing, C. H., Khalid, M. and Abdullah, E. (2021). 'Importance of nanomaterials in engineering application'. In Mubarak, N. M., Khalid, M., Walvekar, R. andNuman, A. (Eds.), *Contemporary Nanomaterials in Material Engineering Applications* (pp. 1-20). Berlin, Germany: Springer. [Online]. (Accessed: 6 March 2021).

Kaneria, M. J. and Chanda, S. V. (2012). 'The effect of sequential fractionation technique on the various efficacies of pomegranate (*Punica granatum* L.)', *Food Analytical Methods,* 6(1), pp. 164-175.

Karjiban, R. A., Basri, M., Rahman, M. B. A. and Salleh, A. B. (2012). 'Structural properties of nonionic tween80 micelle in water elucidated by molecular dynamics simulation', *APCBEE Procedia*, 3, pp. 287-297.

Karsheva, M. and Georgieva, S. (2010). 'Flow properties of phytocosmetic formulations. effect of plant extracts and thickeners', *Comptes Rendus de l'Academie Bulgare des Sciences*, 63(12), pp. 1725-1732.

Karthik, P., Dutta, S. and Anandharamakrishnan, C. (2019). 'Nanoemulsions: preparation, stability and application in food'. In Anandharamakrishnan, C. andParthasarathi, S. (Eds.), *Food Nanotechnology: Principles and Applications*. Florida, United States: CRC Press. [Online]. Available at: https://books.google.com.my/books?id=feKEDwAAQBAJ (Accessed: 15 December 2019).

Kathe, K. and Kathpalia, H. (2017). 'Film forming systems for topical and transdermal drug delivery', *Asian Journal of Pharmaceutical Sciences,* 12(6), pp. 487-497.

Kaul, S., Gulati, N., Verma, D., Mukherjee, S. and Nagaich, U. (2018). 'Role of nanotechnology in cosmeceuticals: a review of recent advances', *Journal of Pharmaceutics,* 2018, pp. 3420204-3420204.

Kaur, B., Panesar, P. S. and Anal, A. K. (2021). 'Standardization of ultrasound assisted extraction for the recovery of phenolic compounds from mango peels', *Journal of Food Science and Technology-Mysore*.

Kerdudo, A., Burger, P., Merck, F., Dingas, A., Rolland, Y., Michel, T. and Fernandez, X. (2016). 'Development of a natural ingredient – natural preservative: a case study', *Comptes Rendus Chimie,* 19(9), pp. 1077-1089.

Kerwin, B. A. (2008). 'Polysorbates 20 and 80 used in the formulation of protein biotherapeutics: structure and degradation pathways', *Journal of Pharmaceutical Sciences,* 97(8), pp. 2924-2935.

Kesavan Pillai, S., Kleyi, P., de Beer, M. and Mudaly, P. (2020). 'Layered double hydroxides: An advanced encapsulation and delivery system for cosmetic ingredients-an overview', *Applied Clay Science,* 199, pp. 105868.

Ketnawa, S., Chaiwut, P. and Rawdkuen, S. (2011). 'Extraction of bromelain from pineapple peels', *Food Science and Technology International,* 17(4), pp. 395-402.

Ketnawa, S., Chaiwut, P. and Rawdkuen, S. (2012). 'Pineapple wastes: a potential source for bromelain extraction', *Food and Bioproducts Processing,* 90(3), pp. 385-391.

Ketnawa, S., Rawdkuen, S. and Chaiwut, P. (2010). 'Two phase partitioning and collagen hydrolysis of bromelain from pineapple peel *Nang Lae* cultivar', *Biochemical Engineering Journal,* 52, pp. 205-211.

Khan, B. A., Mahmood, T., Menaa, F., Shahzad, Y., Yousaf, A. M., Hussain, T. and Ray, S. D. (2018). 'New perspectives on the efficacy of gallic acid in cosmetics & nanocosmeceuticals', *Current Pharmaceutical Design,* 24(43), pp. 5181-5187.

Khan, H., Ali, M., Ahuja, A. and Ali, J. (2010a). 'Stability testing of pharmaceutical products-comparison of stability testing guidelines', *Current Pharmaceutical Analysis,* 6(2), pp. 142-150.

Khan, M. K., Abert-Vian, M., Fabiano-Tixier, A.-S., Dangles, O. and Chemat, F. (2010b). 'Ultrasound-assisted extraction of polyphenols (flavanone glycosides) from orange (*Citrus sinensis* L.) peel', *Food Chemistry,* 119(2), pp. 851-858.

Khorsandi, D., Moghanian, A. and Nazari, R. (2016). 'Personalized medicine: regulation of genes in human skin ageing', *Journal of Allergy & Therapy,* 7(06), pp. 1-9.

Kilfoyle, B. E., Kaushik, D., Terebetski, J. L., Bose, S. and Michniak-Kohn, B. B. (2011). 'The use of quercetin and curcumin in skin care consumer products'. In Dayan, N. andKromidas, K. (Eds.), *Formulating, Packaging, and Marketing of Natural Cosmetic Products* (pp. 259-286). Hoboken, New Jersey, US: John Wiley & Sons. [Online]. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118056806.ch14 (Accessed: 8 January 2019).

Kilic, S., Kilic, M. and Soylak, M. (2021). 'The determination of toxic metals in some traditional cosmetic products and health risk assessment', *Biological Trace Element Research,* 199(6), pp. 2272-2277.

Kim, H. W., Seok, Y. S., Cho, T. J. and Rhee, M. S. (2020). 'Risk factors influencing contamination of customized cosmetics made on-the-spot: evidence from the national pilot project for public health', *Scientific Reports,* 10(1), pp. 1561-1561.

Kishore, R. S. K., Pappenberger, A., Dauphin, I. B., Ross, A., Buergi, B., Staempfli, A. and Mahler, H.-C. (2011). 'Degradation of polysorbates 20 and 80: studies on thermal autoxidation and hydrolysis', *Journal of Pharmaceutical Sciences,* 100(2), pp. 721-731.

Klang, V., Matsko, N. B., Valenta, C. and Hofer, F. (2012). 'Electron microscopy of nanoemulsions: an essential tool for characterisation and stability assessment', *Micron,* 43(2-3), pp. 85-103.

Kudom, A. A. and Kwapong, P. K. (2010). 'Floral visitors of *Ananas Comosus* in Ghana: a preliminary assessment', *Journal of Pollination Ecology,* 2(5), pp. 27-32.

Kumar, A. and Dixit, C. K. (2017). '3 - Methods for characterization of nanoparticles'. In Nimesh, S., Chandra, R. andGupta, N. (Eds.), *Advances in Nanomedicine for the Delivery of Therapeutic Nucleic Acids* (pp. 43-58). Cambridge, United Kingdom: Woodhead Publishing. [Online]. Available at: http://www.sciencedirect.com/science/article/pii/B9780081005576000031 (Accessed: 2 February 2021).

Kumar, P. S., Pavithra, K. G. and Naushad, M. (2019). Chapter 4 - Characterization techniques for nanomaterials. *In:* Thomas, S., Sakho, E. H. M., Kalarikkal, N., Oluwafemi, S. O. andWu, J. (eds.) *Nanomaterials for Solar Cell Applications.* Elsevier, pp. 97-124.

Kundu, P., Arora, K., Gu, Y., Kumar, V. and Mishra, I. M. (2019). 'Formation and stability of water-in-oil nano-emulsions with mixed surfactant using in-situ combined condensation-dispersion method', *The Canadian Journal of Chemical Engineering,* 97(7), pp. 2039-2049.

Kuo, S.-H., Shen, C.-J., Shen, C.-F. and Cheng, C.-M. (2020). 'Role of pH Value in clinically relevant diagnosis', *Diagnostics,* 10(2), pp. 107.

Kurban, N. A., Altwaim, S. A., Altayeb, G. A., Somali, N. A., Almehmady, A. M. and Alharbi, W. S. (2020). 'Cosmeceutical awareness among community pharmacists in Jeddah, Saudi Arabia: The case of sunscreens and moisturizers', *Journal of Cosmetic Dermatology,* 19(9), pp. 2394-2400.

Lai-Cheong, J. E. and McGrath, J. A. (2021). 'Structure and function of skin, hair and nails', *Medicine*.

Li, H. and Borjas, R. (2018). Chapter 17 - ASAP applications in clinical development: prediction of degradation and dissolution performance. *In:* Qiu, F. andScrivens, G. (eds.) *Accelerated Predictive Stability.* Boston: Academic Press, pp. 369-382.

Li, T., Shen, P., Liu, W., Liu, C., Liang, R., Yan, N. and Chen, J. (2014). 'Major polyphenolics in pineapple peels and their antioxidant interactions', *International Journal of Food Properties,* 17(8), pp. 1805-1817.

Liew, S. Q., Ngoh, G. C., Yusoff, R. and Teoh, W. H. (2017). 'Microwave assisted extraction (MAE) and microwave-ultrasound assisted extraction (MUAE) of pectin from pomelo peels', *ETP International Journal of Food Engineering*.

Lilienblum, W. (2016). 'Opinion of the scientific committee on consumer safety (SCCS) – final version of the opinion on phenoxyethanol in cosmetic products', *Regulatory Toxicology and Pharmacology,* 82, pp. 156.

Lim, D. S., Roh, T. H., Kim, M. K., Kwon, Y. C., Choi, S. M., Kwack, S. J., Kim, K. B., Yoon, S., Kim, H. S. and Lee, B.-M. (2018). 'Non-cancer, cancer, and dermal sensitization risk assessment of heavy metals in cosmetics', *Journal of Toxicology and Environmental Health, Part A,* 81(11), pp. 432-452.

Lim, J. (2011). 'Hedonic scaling: a review of methods and theory', *Food Quality and Preference,* 22(8), pp. 733-747.

Lin, M.-H., Cross, S. N. N., Laczniak, R. N. and Childers, T. L. (2018). 'The sniffing effect: olfactory sensitivity and olfactory imagery in advertising', *Journal of Advertising,* 47(2), pp. 97-111.

Liu, Y., Wei, S. and Liao, M. (2013). 'Optimization of ultrasonic extraction of phenolic compounds from *Euryale ferox* seed shells using response surface methodology', *Industrial Crops and Products,* 49, pp. 837-843.

Löf, D., Schillén, K. and Nilsson, L. (2011). 'Flavonoids: precipitation kinetics and interaction with surfactant micelles', *Journal of Food Science,* 76(3), pp. N35-N39.

Lohani, A., Verma, A., Joshi, H., Yadav, N. and Karki, N. (2014). 'Nanotechnology-based cosmeceuticals', *ISRN Dermatology,* 2014, pp. 843687.

Loureiro Contente, D. M., Pereira, R. R., Rodrigues, A. M. C., da Silva, E. O., Ribeiro-Costa, R. M. and Carrera Silva-Júnior, J. O. (2020). 'Nanoemulsions of acai oil: physicochemical characterization for the topical delivery of antifungal drugs', *Chemical Engineering & Technology,* 43(7), pp. 1424-1432.

Lovelyn, C. and Attama, A. A. (2011). 'Current state of nanoemulsions in drug delivery', *Journal of Biomaterials and Nanobiotechnology,* 2(5), pp. 626-639.

Lu, W.-C., Huang, D.-W., Wang, C.-C. R., Yeh, C.-H., Tsai, J.-C., Huang, Y.-T. and Li, P.-H. (2018). 'Preparation, characterization, and antimicrobial activity of nanoemulsions incorporating citral essential oil', *Journal of Food and Drug Analysis,* 26(1), pp. 82-89.

Lukic, M., Jaksic, I., Krstonosic, V., Cekic, N. and Savic, S. (2012). 'A combined approach in characterization of an effective w/o hand cream: the influence of emollient on textural, sensorial and in vivo skin performance', *International Journal of Cosmetic Science,* 34(2), pp. 140-149.

Lukic, M., Pantelic, I. and Savic, S. (2013). 'Sensory profiling of cosmetic products: could it be easier? Use of rheology and textural analysis', *H&PC Today-Household and Personal Care Today,* 8(2).

Lundov, M. D., Moesby, L., Zachariae, C. and Johansen, J. D. (2009). 'Contamination versus preservation of cosmetics: a review on legislation, usage, infections, and contact allergy', *Contact Dermatitis,* 60(2), pp. 70-78.

Luque-García, J. L. and Luque de Castro, M. D. (2003). 'Ultrasound: a powerful tool for leaching', *Trends in Analytical Chemistry,* 22(1), pp. 41-47.

Ma, P., Zeng, Q., Tai, K., He, X., Yao, Y., Hong, X. and Yuan, F. (2018). 'Development of stable curcumin nanoemulsions: effects of emulsifier type and surfactant-to-oil ratios', *Journal of Food Science and Technology,* 55(9), pp. 3485-3497.

Ma, Z. and Boye, J. I. (2013). 'Advances in the design and production of reduced-fat and reduced-cholesterol salad dressing and mayonnaise: a review', *Food and Bioprocess Technology,* 6(3), pp. 648-670.

Magaia, T., Uamusse, A., Sjoholm, I. and Skog, K. (2013). 'Proximate analysis of five wild fruits of mozambique', *The Scientific World Journal,* 2013, pp. 601435.

Mahbubul, I. M. (2019). 5 - Rheological behavior of nanofluid. *In:* Mahbubul, I. M. (ed.) *Preparation, Characterization, Properties and Application of Nanofluid.* William Andrew Publishing, pp. 197-229.

Makarewicz, M., Drożdż, I., Tarko, T. and Duda-Chodak, A. (2021). 'The interactions between polyphenols and microorganisms, especially gut microbiota', *Antioxidants (Basel),* 10(2).

Manaia, E. B., Abuçafy, M. P., Chiari-Andréo, B. G., Silva, B. L., Oshiro Junior, J. A. and Chiavacci, L. A. (2017). 'Physicochemical characterization of drug nanocarriers', *International Journal of Nanomedicine,* 12, pp. 4991-5011.

Manikanika, Kumar, J. and Jaswal, S. (2021). 'Role of nanotechnology in the world of cosmetology: a review', *Materials Today: Proceedings*.

Mansoori, S., Bahmanyar, H., Jafari Ozumchelouei, E. and Najafipour, I. (2020). 'Investigation and optimisation of the extraction of carvone and limonene from the Iranian *Mentha spicata* through the ultrasound-assisted extraction method', *Indian Chemical Engineer*, pp. 1-10.

Maramaldi, G., Togni, S., Pagin, I., Giacomelli, L., Cattaneo, R., Eggenhöffner, R. and Burastero, S. E. (2016). 'Soothing and anti-itch effect of quercetin phytosome in human subjects: a single-blind study', *Clinical, Cosmetic and Investigational Dermatology,* 9, pp. 55-62.

Maran, J. P. and Priya, B. (2014). 'Ultrasound-assisted extraction of polysaccharide from *Nephelium lappaceum* L. fruit peel', *International Journal of Biological Macromolecules,* 70, pp. 530-536.

Martins, V. B., Bordim, J., Bom, G. A. P., Carvalho, J. G. D. S., Parabocz, C. R. B. and Mitterer Daltoé, M. L. (2020). 'Consumer profiling techniques for cosmetic formulation definition', *Journal of Sensory Studies,* 35(2), pp. e12557.

Marzuki, N. H. C., Hamid, M. A. and Wahab, R. A. (2018). 'Assessment of fatty acid composition and response surface optimization of ultrasonic-assisted extraction of phenolic compounds from *Pouteria campechiana* pulp', *Malaysian Journal of Fundamental and Applied Sciences*, 14(2), pp. 269-277.

Masoumi, H. R., Basri, M., Samiun, W. S., Izadiyan, Z. and Lim, C. J. (2015). 'Enhancement of encapsulation efficiency of nanoemulsion-containing aripiprazole for the treatment of schizophrenia using mixture experimental design', *International Journal of Nanomedicine,* 10, pp. 6469-6476.

Massadeh, A. M., El-Khateeb, M. Y. and Ibrahim, S. M. (2017). 'Evaluation of Cd, Cr, Cu, Ni, and Pb in selected cosmetic products from Jordanian, Sudanese, and Syrian markets', *Public Health,* 149, pp. 130-137.

Mat Hadzir, N., Basri, M., Abdul Rahman, M. B., Salleh, A. B., Raja Abdul Rahman, R. N. and Basri, H. (2013). 'Phase behaviour and formation of fatty acid esters nanoemulsions containing piroxicam', *AAPS PharmSciTech,* 14(1), pp. 456-463.

Mavani, H. A. K., Tew, I. M., Wong, L., Yew, H. Z., Mahyuddin, A., Ahmad Ghazali, R. and Pow, E. H. N. (2020). 'Antimicrobial efficacy of fruit peels eco-enzyme against *Enterococcus faecalis*: an *in vitro* study', *International Journal of Environmental Research and Public Health*, 17(14), pp. 5107.

McClements, D. J. (2015). *Food emulsions: principles, practices, and techniques*, CRC press.

Md, S., Gan, S. Y., Haw, Y. H., Ho, C. L., Wong, S. and Choudhury, H. (2018). 'In vitro neuroprotective effects of naringenin nanoemulsion against β-amyloid toxicity through the regulation of amyloidogenesis and tau phosphorylation', *International Journal of Biological Macromolecules,* 118, pp. 1211-1219.

Michalek, I. M., John, S. M. and Caetano dos Santos, F. L. (2019). 'Microbiological contamination of cosmetic products – observations from Europe, 2005–2018', *Journal of the European Academy of Dermatology and Venereology,* 33(11), pp. 2151-2157.

Michelutti, L., Bulfoni, M., Bolzon, V. and Nencioni, E. (2020). 'Preliminary evidence of a molecular detection method to analyze bacterial DNA as a quality indicator in cosmetics', *Cosmetics,* 7(3), pp. 54.

Miguel, M. G., Nunes, S., Dandlen, S. A., Cavaco, A. M. and Antunes, M. D. (2010). 'Phenols and antioxidant activity of hydro-alcoholic extracts of propolis from Algarve, South of Portugal', *Food and Chemical Toxicology,* 48(12), pp. 3418-3423.

Milotic, D. (2003). 'The impact of fragrance on consumer choice', *Journal of Consumer Behaviour,* 3(2), pp. 179-191.

Mohammed, A. N., Ishwarya, S. P. and Nisha, P. (2021). 'Nanoemulsion versus microemulsion systems for the encapsulation of beetroot extract: comparison of physicochemical characteristics and betalain stability', *Food and Bioprocess Technology,* 14(1), pp. 133-150.

Mohammed, N. K., Muhialdin, B. J. and Meor Hussin, A. S. (2020). 'Characterization of nanoemulsion of *Nigella sativa* oil and its application in ice cream', *Food Science & Nutrition,* 8(6), pp. 2608-2618.

Monteiro E Silva, S. A., Calixto, G. M. F., Cajado, J., De Carvalho, P. C. A., Rodero, C. F., Chorilli, M. and Leonardi, G. R. (2017). 'Gallic acid-loaded gel formulation combats skin oxidative stress: development, characterization and ex vivo biological assays', *Polymers,* 9(9), pp. 391.

Morais, D. R., Rotta, E. M., Sargi, S. C., Schmidt, E. M., Bonafe, E. G., Eberlin, M. N., Sawaya, A. C. H. F. and Visentainer, J. V. (2015). 'Antioxidant activity, phenolics and UPLC–ESI(–)–MS of extracts from different tropical fruits parts and processed peels', *Food Research International,* 77, pp. 392-399.

Morakul, B., Teeranachaideekul, V. and Buraphacheep Junyaprasert, V. (2019). 'Niosomal delivery of pumpkin seed oil: development, characterisation, and physical stability', *Journal of Microencapsulation*, pp. 1-10.

Morton, J. F. (1987). Pineapple. *In:* Morton, J. F. (ed.) *Fruits of Warm Climates.* Miami, Fluorida, pp. 18-28.

Mostafa, E. S., Maher, A., Mostafa, D. A., Gad, S. S., Nawwar, M. A. M. and Swilam, N. (2021). 'A unique acylated flavonol glycoside from *Prunus persica* (L.) var. florida prince: a new solid lipid nanoparticle cosmeceutical formulation for skincare', *Antioxidants,* 10(3), pp. 436.

Mu, L. and Sprando, R. L. (2010). 'Application of nanotechnology in cosmetics', *Pharmaceutical Research,* 27(8), pp. 1746-1749.

Mukherjee, P. K., Maity, N., Nema, N. K. and Sarkar, B. K. (2011). 'Bioactive compounds from natural resources against skin aging', *Phytomedicine,* 19(1), pp. 64-73.

Murakami, Y., Kawata, A., Ito, S., Katayama, T. and Fujisawa, S. (2015). 'Radical-scavenging and anti-inflammatory activity of quercetin and related compounds and their combinations against RAW264. 7 cells stimulated with porphyromonas gingivalis fimbriae. Relationships between anti-inflammatory activity and quantum chemical parameters', *In vivo (Athens, Greece),* 29(6), pp. 701-710.

Musa, S. H., Basri, M., Fard Masoumi, H. R., Shamsudin, N. and Salim, N. (2017). 'Enhancement of physicochemical properties of nanocolloidal carrier loaded with cyclosporine for topical treatment of psoriasis: in vitro diffusion and in vivo hydrating action', *International Journal of Nanomedicine*, 12, pp. 2427-2441.

Nagi, A., Iqbal, B., Kumar, S., Sharma, S., Ali, J. and Baboota, S. (2017). 'Quality by design based silymarin nanoemulsion for enhancement of oral bioavailability', *Journal of Drug Delivery Science and Technology*, 40, pp. 35-44.

Nagula, R. L. and Wairkar, S. (2019). 'Recent advances in topical delivery of flavonoids: a review', *Journal of Controlled Release*, 296, pp. 190-201.

Nakama, Y. (2017). 'Chapter 15 - Surfactants'. In Sakamoto, K., Lochhead, R. Y., Maibach, H. I. andYamashita, Y. (Eds.), *Cosmetic Science and Technology* (pp. 231-244). Amsterdam: Elsevier. [Online]. Available at: https://www.sciencedirect.com/science/article/pii/B978012802005000015X (Accessed: 6 August 2021).

Nakayama, Y. (2018). Chapter 2 - Characteristics of a fluid. *In:* Nakayama, Y. (ed.) *Introduction to Fluid Mechanics (Second Edition).* Oxford, United Kingdom: Butterworth-Heinemann, pp. 9-24.

Naseema, A., Lohitesh, K., Alok Kumar, B., Pramodh, K. K. P. and Priyanka, S. (2021). 'A critical review of synthesis procedures, applications and future potential of nanoemulsions', *Advances in Colloid and Interface Science,* 287, pp. 102318.

Nejadmansouri, M., Hosseini, S. M. H., Niakosari, M., Yousefi, G. H. and Golmakani, M. T. (2016). 'Physicochemical properties and oxidative stability of fish oil nanoemulsions as affected by hydrophilic lipophilic balance, surfactant to oil ratio and storage temperature', *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* 506, pp. 821-832.

Neza, E. and Centini, M. (2016). 'Microbiologically contaminated and over-preserved cosmetic products according rapex 2008–2014', *Cosmetics*, 3(1), pp. 3.

Nguyen, H. L. and Yiannias, J. A. (2019). 'Contact Dermatitis to Medications and Skin Products', *Clinical Reviews in Allergy & Immunology,* 56(1), pp. 41-59.

Nigro, F., Cerqueira, C., Rossi, A., Cardoso, V., Vermelho, A. B., Ricci-Júnior, E., dos Santos, E. P. and Mansur, C. R. E. (2020). 'Development, characterization and in vitro toxicity evaluation of nanoemulsion-loaded hydrogel based on copaiba oil and coenzyme Q10', *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* 586, pp. 124132.

Nikzade, V., Tehrani, M. M. and Saadatmand-Tarzjan, M. (2012). 'Optimization of low-cholesterol–low-fat mayonnaise formulation: effect of using soy milk and some stabilizer by a mixture design approach', *Food Hydrocolloids,* 28(2), pp. 344-352.

Nipornram, S., Tochampa, W., Rattanatraiwong, P. and Singanusong, R. (2018). 'Optimization of low power ultrasound-assisted extraction of phenolic compounds from mandarin (*Citrus reticulata* Blanco cv. Sainampueng) peel', *Food Chemistry*, 241, pp. 338-345.

Nirmal, N. P., Mereddy, R., Li, L. and Sultanbawa, Y. (2018). 'Formulation, characterisation and antibacterial activity of lemon myrtle and anise myrtle essential oil in water nanoemulsion', *Food Chemistry,* 254, pp. 1-7.

Nithiyanantham, S., Siddhuraju, P. and Francis, G. (2013). 'A promising approach to enhance the total phenolic content and antioxidant activity of raw and processed *Jatropha curcas* L. kernel meal extracts', *Industrial Crops and Products,* 43, pp. 261-269.

Nordin, F. N. M., Aziz, A., Zakaria, Z. and Wan Mohamed Radzi, C. W. J. (2021). 'A systematic review on the skin whitening products and their ingredients for safety, health risk, and the halal status', *Journal of Cosmetic Dermatology,* 20(4), pp. 1050-1060.

NPCB, N. P. R. A. (2017). *Guidelines for Control of Cosmetic Products in Malaysia (Revision 1st)* [online]. Malaysia. Available at: https://www.npra.gov.my/images/Guidelines_Central/Guidelines_on_Cosmetic/2017/feb2017/GUIDELINES_FOR_CONTROL_OF_COSMETIC_PRODUCTS_IN_MALAYSIA.pdf (Accessed: 24 May 2021).

Okihiro, G. Y. (2009). Pineapple diaspora. *In:* Okihiro, G. Y. (ed.) *Pineapple Culture: A History of the Tropical and Temperate Zones,*. University of California Press, pp. 76.

OpenStax. (2016). *Anatomy and Physicology* [online]. OpenStax. Available at: https://opentextbc.ca/anatomyandphysiology/chapter/5-1-layers-of-the-skin/.

Orisakwe, O. E. and Otaraku, J. O. (2013). 'Metal concentrations in cosmetics commonly used in Nigeria', *The Scientific World Journal,* 2013, pp. 959637.

Paderes, M., Ahirwal, D. and Fernández Prieto, S. (2017). 'Natural and synthetic polymers in fabric and home care applications', *Physical Sciences Reviews,* 2(9).

Panico, A., Serio, F., Bagordo, F., Grassi, T., Idolo, A., De Giorgi, M., Guido, M., Congedo, M. and De Donno, A. (2019). 'Skin safety and health prevention: an overview of chemicals in cosmetic products', *Journal of Preventive Medicine and Hygiene*, 60(1), pp. E50-E57.

Paraskevopoulou, A. (2005). 'Stabilization of olive oil - lemon juice emulsion with polysaccharides', *Food Chemistry,* 90(4), pp. 627-634.

Parente, M. E., Gámbaro, A. and Ares, G. (2008). 'Sensory characterization of emollients', *Journal of Sensory Studies,* 23(2), pp. 149-161.

Pavan, R., Jain, S., Shraddha and Kumar, A. (2012). 'Properties and therapeutic application of bromelain: a review', *Biotechnology Research International,* 2012, pp. 1-6.

Pavlačková, J., Egner, P., Polašková, J., Hojerová, J., Pinďáková, L., Mokrejš, P. and Varaďová, V. (2019). 'Transdermal absorption of active substances from cosmetic vehicles', *Journal of Cosmetic Dermatology,* 18(5), pp. 1410-1415.

Pavoni, L., Perinelli, D. R., Bonacucina, G., Cespi, M. and Palmieri, G. F. (2020). 'An overview of micro- and nanoemulsions as vehicles for essential oils: formulation, preparation and stability', *Nanomaterials (Basel, Switzerland),* 10(1), pp. 135.

Piekarska-Radzik, L. and Klewicka, E. (2021). 'Mutual influence of polyphenols and *Lactobacillus* spp. bacteria in food: a review', *European Food Research and Technology,* 247(1), pp. 9-24.

Pimentel, T. C., Gomes da Cruz, A. and Deliza, R. (2016). Sensory evaluation: sensory rating and scoring methods. *Encyclopedia of Food and Health.* pp. 744-749.

Pomeranz, Y. (2013). *Food Analysis: Theory and Practice*, Springer US.

Pongsumpun, P., Iwamoto, S. and Siripatrawan, U. (2020). 'Response surface methodology for optimization of cinnamon essential oil nanoemulsion with improved stability and antifungal activity', *Ultrasonics Sonochemistry,* 60, pp. 104604.

Preetz, C., Hauser, A., Hause, G., Kramer, A. and Mäder, K. (2010). 'Application of atomic force microscopy and ultrasonic resonator technology on nanoscale: distinction of nanoemulsions from nanocapsules', *European Journal of Pharmaceutical Sciences,* 39(1-3), pp. 141-151.

Preston, C. C. and Colman, A. M. (2000). 'Optimal number of response categories in rating scales: reliability, validity, discriminating power, and respondent preferences', *Acta Psychologica,* 104(1), pp. 1-15.

Prieto, C. and Calvo, L. (2013). 'Performance of the biocompatible surfactant tween 80, for the formation of microemulsions suitable for new pharmaceutical processing', *Journal of Applied Chemistry,* 2013, pp. 930356.

Proksch, E. (2018). 'Buffering capacity'. In Surber, C., Abels, C. andMaibach, H. (Eds.), *pH of the Skin: Issues and Challenges*. Basel, Switzerland: S. Karger AG. [Online]. Available at: https://books.google.com.my/books?id=dLJqDwAAQBAJ (Accessed: 18 July 2021).

Putri, D. A., Ulfi, A., Purnomo, A. S. and Fatmawati, S. (2018). 'Antioxidant and antibacterial activities of *Ananas comosus* peel extracts', *Mal. J. Fund. Appl. Sci.,* 14(2), pp. 307-311.

Pyrzynska, K. and Pękal, A. (2013). 'Application of free radical diphenylpicrylhydrazyl (DPPH) to estimate the antioxidant capacity of food samples', *Analytical Methods,* 5(17), pp. 4288-4295.

Qiu, F. (2018). 'Chapter 1 - Accelerated predictive stability: an introduction'. In Qiu, F. andScrivens, G. (Eds.), *Accelerated Predictive Stability* (pp. 3-14). Boston: Academic Press. [Online]. Available at:

https://www.sciencedirect.com/science/article/pii/B9780128027868000012 (Accessed: 28 June 2021).

Rachmawati, H., Budiputra, D. K. and Mauludin, R. (2015). 'Curcumin nanoemulsion for transdermal application: formulation and evaluation', *Drug Development and Industrial Pharmacy,* 41(4), pp. 560-566.

Rahimi, F., Tabarsa, M. and Rezaei, M. (2016). 'Ulvan from green algae *Ulva intestinalis*: optimization of ultrasound-assisted extraction and antioxidant activity', *Journal of Applied Phycology,* 28(5), pp. 2979-2990.

Rahman, Z. and Singh, V. P. (2019). 'The relative impact of toxic heavy metals (THMs) (arsenic (As), cadmium (Cd), chromium (Cr)(VI), mercury (Hg), and lead (Pb)) on the total environment: an overview', *Environmental Monitoring and Assessment,* 191(7), pp. 419.

Rai, V. K., Mishra, N., Yadav, K. S. and Yadav, N. P. (2018). 'Nanoemulsion as pharmaceutical carrier for dermal and transdermal drug delivery: formulation development, stability issues, basic considerations and applications', *Journal of Controlled Release,* 270, pp. 203-225.

Rai, V. R. and Bai, J. A. (2018). *Nanotechnology applications in the food industry,* Boca Raton, Florida, United States, CRC Press.

Rao, M. A. A. (2014). Intoduction: food rheology and structure. *In:* Rao, M. A. A. (ed.) *Rheology of Fluid and Semisolid Foods: Principles and Applications.* Springer, Boston, MA: Food Engineering Series, pp. 1-23.

Rapp, B. E. (2017). Chapter 9 - Fluids. *In:* Rapp, B. E. (ed.) *Microfluidics: Modelling, Mechanics and Mathematics.* Oxford: Elsevier, pp. 243-263.

Rasanayagam, S., Nudelman, J., Wolfson, R. and Engel, C. (2015). *Anti-aging secrets exposed: chemical linked to breast cancer in skin care* [online]. Available at: https://safecosmetics.org/wp-content/uploads/2015/10/Anti-aging-secrets-exposed-report.pdf (Accessed: 10 September 2018).

Ravera, F., Dziza, K., Santini, E., Cristofolini, L. and Liggieri, L. (2021). 'Emulsification and emulsion stability: the role of the interfacial properties', *Advances in Colloid and Interface Science,* 288, pp. 102344.

Ravichandran, K. S. and Krishnaswamy, K. (2021). 'Sustainable food processing of selected North American native berries to support agroforestry', *Critical Reviews in Food Science and Nutrition*, pp. 1-26.

Ray, S., Lalman, J. A. and Biswas, N. (2009). 'Using the Box-Benkhen technique to statistically model phenol photocatalytic degradation by titanium dioxide nanoparticles', *Chemical Engineering Journal,* 150(1), pp. 15-24.

Reed, S. J. B. (2005). *'Electron Microprobe Analysis and Scanning Electron Microscopy in Geology'.* In. [Online]. Retrieved from https://books.google.com.my/books?id=9-_v4YgpoVMC

Ren, J.-N., Dong, M., Hou, Y.-Y., Fan, G. and Pan, S.-Y. (2018). 'Effect of olive oil on the preparation of nanoemulsions and its effect on aroma release', *Journal of Food Science and Technology,* 55(10), pp. 4223-4231.

Reyes, Y., Hamzehlou, S. and Leiza, J. R. (2021). 'Ostwald ripening in nano/miniemulsions in the presence of two costabilizers as revealed by molecular dynamics simulations', *Journal of Molecular Liquids,* 335, pp. 116152.

Ribeiro, M. E. N. P., Vieira, Í. G. P., Cavalcante, I. M., Ricardo, N. M. P. S., Attwood, D., Yeates, S. G. and Booth, C. (2009). 'Solubilisation of griseofulvin, quercetin and rutin in micellar formulations of triblock copolymers E62P39E62 and E137S18E137', *International Journal of Pharmaceutics,* 378(1), pp. 211-214.

Ribeiro, R. C., Barreto, S. M., Ostrosky, E. A., da Rocha-Filho, P. A., Verissimo, L. M. and Ferrari, M. (2015a). 'Production and characterization of cosmetic nanoemulsions containing *Opuntia ficus-indica* (L.) mill extract as moisturizing agent', *Molecules,* 20(2), pp. 2492-2509.

Ribeiro, S. A., Estanqueiro, M., Oliveira, B. M. and Sousa Lobo, M. J. (2015b). 'Main benefits and applicability of plant extracts in skin care products', *Cosmetics,* 2(2), pp. 48-65.

Rodrigues, F., Sarmento, B., Amaral, M. H. and Oliveira, M. B. P. P. (2016). 'Exploring the antioxidant potentiality of two food by-products into a topical cream: stability, *in vitro* and *in vivo* evaluation', *Drug Development and Industrial Pharmacy,* 42(6), pp. 880-889.

Romanowski, P. and Schueller, R. (2001). Stability testing of cosmetic products. *In:* André O., B., Marc, P. andHoward I., M. (eds.) *Handbook of Cosmetic Science and Technology.* Florida, United States: CRC Press, pp. 115-130.

Roselan, M. A., Ashari, S. E., Faujan, N. H., Mohd Faudzi, S. M. and Mohamad, R. (2020). 'An improved nanoemulsion formulation containing kojic monooleate:

optimization, characterization and *in vitro* studies', *Molecules*, 25(11), pp. 2616.

Rostamabadi, H., Falsafi, S. R. and Jafari, S. M. (2020). 'Chapter Two - Transmission electron microscopy (TEM) of nanoencapsulated food ingredients'. In Jafari, S. M. (Ed.), *Characterization of Nanoencapsulated Food Ingredients* (Vol. 4, pp. 53-82). Cambridge, Massachusetts, US: Academic Press. [Online]. Available at: http://www.sciencedirect.com/science/article/pii/B978012815667400002X (Accessed: 24 January 2021).

Rusmadi, S., Ismail, S. and Praveena, S. (2017). 'A case study of selected heavy metals (lead, cadmium, and nickel) in skin-lightening creams and dermal health risk in Malaysia', *Annals of Tropical Medicine and Public Health,* 10(1), pp. 95-100.

Saary, M. J. (2008). 'Radar plots: a useful way for presenting multivariate health care data', *Journal of Clinical Epidemiology*, 61(4), pp. 311-317.

Saberi, A. H., Fang, Y. and McClements, D. J. (2013). 'Fabrication of vitamin E-enriched nanoemulsions: factors affecting particle size using spontaneous emulsification', *Journal of Colloid and Interface Science,* 391, pp. 95-102.

Saguy, I. S., Singh, R. P., Johnson, T., Fryer, P. J. and Sastry, S. K. (2013). 'Challenges facing food engineering', *Journal of Food Engineering*, 119(2), pp. 332-342.

Saharudin, S., Ahmad, Z. and Basri, M. (2016). 'Role of xanthan gum on physicochemical and rheological properties of rice bran oil emulsion', *International Food Research Journal*, 23(4).

Samiun, W. S., Ashari, S. E., Salim, N. and Ahmad, S. (2020). 'Optimization of processing parameters of nanoemulsion containing aripiprazole using response surface methodology', *International Journal of Nanomedicine*, 15, pp. 1585-1594.

Samson, S., Basri, M., Masoumi, H. R. F., Karjiban, R. A. and Malek, E. A. (2016). 'Design and development of a nanoemulsion system containing copper peptide by D-optimal mixture design and evaluation of its physicochemical properties', *RSC Advances*, 6(22), pp. 17845-17856.

Sang, J., Sang, J., Ma, Q., Hou, X.-f. and Li, C.-q. (2017). 'Extraction optimization and identification of anthocyanins from *Nitraria tangutorun* Bobr. seed meal and establishment of a green analytical method of anthocyanins', *Food Chemistry*, 218, pp. 386-395.

Sani, A., Gaya, M. B. and Abubakar, F. A. (2016). 'Determination of some heavy metals in selected cosmetic products sold in kano metropolis, Nigeria', *Toxicology Reports*, 3, pp. 866-869.

Santos, A. C., Morais, F., Simões, A., Pereira, I., Sequeira, J. A. D., Pereira-Silva, M., Veiga, F. and Ribeiro, A. (2019). 'Nanotechnology for the development of new cosmetic formulations', *Expert Opinion on Drug Delivery*, 16(4), pp. 313-330.

Sarheed, O., Dibi, M. and Ramesh, K. V. R. N. S. (2020a). 'Studies on the effect of oil and surfactant on the formation of alginate-based O/W lidocaine nanocarriers using nanoemulsion template', *Pharmaceutics*, 12(12), pp. 1223.

Sarheed, O., Shouqair, D., Ramesh, K. V. R. N. S., Khaleel, T., Amin, M., Boateng, J. and Drechsler, M. (2020b). 'Formation of stable nanoemulsions by ultrasound-assisted two-step emulsification process for topical drug delivery: effect of oil phase composition and surfactant concentration and loratadine as ripening inhibitor', *International Journal of Pharmaceutics*, 576, pp. 118952.

Savary, G., Gilbert, L., Grisel, M. and Picard, C. (2019). 'Instrumental and sensory methodologies to characterize the residual film of topical products applied to skin', *Skin Research and Technology*, 25(4), pp. 415-423.

Scalia, S., Franceschinis, E., Bertelli, D. and Iannuccelli, V. (2013). 'Comparative Evaluation of the Effect of Permeation Enhancers, Lipid Nanoparticles and Colloidal Silica on in vivo Human Skin Penetration of Quercetin', *Skin Pharmacology and Physiology*, 26(2), pp. 57-67.

Schwartz, N. O. (1975). 'Adaptation of the sensory texture profile method to skin care products', *Journal of Texture Studies*, 6(1), pp. 33-42.

Scrivens, G., Clancy, D. and Gerst, P. (2018). 'Chapter 3 - Theory and fundamentals of accelerated predictive stability (APS) studies'. In Qiu, F. andScrivens, G. (Eds.), *Accelerated Predictive Stability* (pp. 33-73). Boston: Academic Press. [Online]. Available at: https://www.sciencedirect.com/science/article/pii/B9780128027868000036 (Accessed: 15 August 2021).

Setyawati, A., Mardyaningrum, L. W. and Damayanti, T. (2020). 'Formulation, physical stability test and anti-bacterial test of nanoemulsion from water and n-hexane extract of *Cinnamomum burmanii*', *AIP Conference Proceedings,* 2229(1), pp. 030031.

Shafiq-un-Nabi, S., Shakeel, F., Talegaonkar, S., Ali, J., Baboota, S., Ahuja, A., Khar, R. K. and Ali, M. (2007). 'Formulation development and optimization using nanoemulsion technique: a technical note', *AAPS PharmSciTech,* 8(2), pp. 1-6.

Shanmugam, A. and Ashokkumar, M. (2014). 'Ultrasonic preparation of stable flax seed oil emulsions in dairy systems – physicochemical characterization', *Food Hydrocolloids,* 39, pp. 151-162.

Sharma, N., Bansal, M., Visht, S., Sharma, P. K. and Kulkarni, G. T. (2010). 'Nanoemulsion: a new concept of delivery system', *Chronicles of Young Scientists,* 1(2), pp. 2-6.

Sharma, S., Loach, N., Gupta, S. and Mohan, L. (2020). 'Phyto-nanoemulsion: an emerging nano-insecticidal formulation', *Environmental Nanotechnology, Monitoring & Management,* 14, pp. 100331.

Sharmeen, J. B., Mahomoodally, F. M., Zengin, G. and Maggi, F. (2021). 'Essential oils as natural sources of fragrance compounds for cosmetics and cosmeceuticals', *Molecules,* 26(3), pp. 666.

Sharmila, G., Nikitha, V. S., Ilaiyarasi, S., Dhivya, K., Rajasekar, V., Kumar, N. M., Muthukumaran, K. and Muthukumaran, C. (2016). 'Ultrasound assisted extraction of total phenolics from *Cassia auriculata* leaves and evaluation of its antioxidant activities', *Industrial Crops and Products,* 84, pp. 13-21.

Shende, P., Patel, D. and Takke, A. (2020). Chapter 24 - Nanomaterial-based cosmeceuticals. *In:* Mustansar Hussain, C. (ed.) *Handbook of Functionalized Nanomaterials for Industrial Applications.* Elsevier, pp. 775-791.

Shiau, S.-Y., Wu, M.-Y. and Liu, Y.-L. (2015). 'The effect of pineapple core fiber on dough rheology and the quality of mantou', *Journal of Food and Drug Analysis,* 23(3), pp. 493-500.

Siddiqui, A. and Hakim, M., A,. (1995). Format for the pharmacopoeial analytical standards of compound formulation. *Workshop on Standardization of Unani Drugs,(appendix),.* (pp. 24-25). Central Council for Research in Unani Medicine, New Delhi.

Singh, D. K., Singh, S. and Bajaj, S. (2018). Regulatory guidelines on stability testing and trending of requirements. *In:* Bajaj, S. andSingh, S. (eds.) *Methods for Stability Testing of Pharmaceuticals.* New York, NY: Humana Press, pp. 1-30.

Singh, S., Pandey, S. K. and Vishwakarma, N. (2020). Functional nanomaterials for the cosmetics industry. *In:* Mustansar Hussain, C. (ed.) *Handbook of Functionalized Nanomaterials for Industrial Applications.* Elsevier, pp. 717-730.

Singh, Y., Meher, J. G., Raval, K., Khan, F. A., Chaurasia, M., Jain, N. K. and Chourasia, M. K. (2017). 'Nanoemulsion: concepts, development and applications in drug delivery', *Journal of Controlled Release,* 252, pp. 28-49.

Singhvi, G., Hans, N., Shiva, N. and Kumar Dubey, S. (2019). Xanthan gum in drug delivery applications. *In:* Hasnain, M. S. andNayak, A. K. (eds.) *Natural Polysaccharides in Drug Delivery and Biomedical Applications.* Massachusetts, United States: Academic Press, pp. 121-144.

Sivakumar, M., Tang, S. Y. and Tan, K. W. (2014). 'Cavitation technology - a greener processing technique for the generation of pharmaceutical nanoemulsions', *Ultrasonics Sonochemistry,* 21(6), pp. 2069-2083.

Sklirou, A. D., Angelopoulou, M. T., Argyropoulou, A., Chaita, E., Boka, V. I., Cheimonidi, C., Niforou, K., Mavrogonatou, E., Pratsinis, H., Kalpoutzakis, E., Aligiannis, N., Kletsas, D., Trougakos, I. P. and Skaltsounis, A. L. (2021). 'Phytochemical Study and In Vitro Screening Focusing on the Anti-Aging Features of Various Plants of the Greek Flora', *Antioxidants,* 10(8), pp. 1206.

Smith, M. C., Crist, R. M., Clogston, J. D. and McNeil, S. E. (2017). 'Zeta potential: a case study of cationic, anionic, and neutral liposomes', *Analytical and Bioanalytical Chemistry,* 409(24), pp. 5779-5787.

Solans, C., Izquierdo, P., Nolla, J., Azemar, N. and Garciacelma, M. (2005). 'Nano-emulsions', *Current Opinion in Colloid & Interface Science*, 10, pp. 102-110.

Song, J., Yang, Q., Huang, W., Xiao, Y., Li, D. and Liu, C. (2018). 'Optimization of trans lutein from pumpkin (*Cucurbita moschata*) peel by ultrasound-assisted extraction', *Food and Bioproducts Processing,* 107, pp. 104-112.

Song, K.-W., Kim, Y.-S. and Chang, G.-S. (2006). 'Rheology of concentrated xanthan gum solutions: steady shear flow behavior', *Fibers and Polymers*, 7(2), pp. 129-138.

Sorourian, R., Khajehrahimi, A. E., Tadayoni, M., Azizi, M. H. and Hojjati, M. (2020). 'Ultrasound-assisted extraction of polysaccharides from *Typha domingensis*: structural characterization and functional properties', *International Journal of Biological Macromolecules,* 160, pp. 758-768.

Soto, M. L., Parada, M., Falqué, E. and Domínguez, H. (2018). 'Personal-care products formulated with natural antioxidant extracts', *Cosmetics,* 5(1), pp. 13.

Spagnuolo, C., Moccia, S. and Russo, G. L. (2018). 'Anti-inflammatory effects of flavonoids in neurodegenerative disorders', *European Journal of Medicinal Chemistry,* 153, pp. 105-115.

Spir, L. G., Ataide, J. A., De Lencastre Novaes, L. C., Moriel, P., Mazzola, P. G., De Borba Gurpilhares, D., Silveira, E., Pessoa, A., Jr. and Tambourgi, E. B. (2015). 'Application of an aqueous two-phase micellar system to extract bromelain from pineapple (*Ananas comosus*) peel waste and analysis of bromelain stability in cosmetic formulations', *Biotechnology Progress,* 31(4), pp. 937-945.

Stafoggia, M., Lallo, A., Fusco, D., Barone, A. P., D'Ovidio, M., Sorge, C. and Perucci, C. A. (2011). 'Spie charts, target plots, and radar plots for displaying comparative outcomes of health care', *Journal of Clinical Epidemiology,* 64(7), pp. 770-778.

Starostová, A., Zimmermann, P. and Stříteský, V. (2018). 'The effect of product colour and odour on consumers' perceived preference and intensity ratings', *Journal of International Studies,* 11(4).

Stone, H., Bleibaum, R. N. and Thomas, H. A. (2012). Chapter 7 - Affective testing. *In:* Stone, H., Bleibaum, R. N. andThomas, H. A. (eds.) *Sensory Evaluation Practices (Fourth Edition).* San Diego: Academic Press, pp. 291-325.

Sugumar, S., Ghosh, V., Nirmala, M. J., Mukherjee, A. and Chandrasekaran, N. (2014). 'Ultrasonic emulsification of eucalyptus oil nanoemulsion: antibacterial activity against *Staphylococcus aureus* and wound healing activity in Wistar rats', *Ultrasonics Sonochemistry,* 21, pp. 1044-1049.

Sulaiman, I. S. C., Basri, M., Masoumi, H. R. F., Ashari, S. E. and Ismail, M. (2016). 'Design and development of a nanoemulsion system containing extract of *Clinacanthus nutans* (L.) leaves for transdermal delivery system by D-optimal mixture design and evaluation of its physicochemical properties', *RSC Advances,* 6(71), pp. 67378-67388.

Surber, C., Humbert, P., Abels, C. and Maibach, H. (2018). 'The acid mantle: a myth or an essential part of skin health'. In Surber, C., Abels, C. andMaibach, H. (Eds.), *pH of the Skin: Issues and Challenges*. Basel, Switzerland: S. Karger AG. [Online]. Available at:

https://books.google.com.my/books?id=dLJqDwAAQBAJ (Accessed: 25 March 2021).

Sutradhar, K. B. and Amin, M. L. (2013). 'Nanoemulsions: increasing possibilities in drug delivery', *European Journal of Nanomedicine,* 5(2), pp. 97-110.

Tabor, J. (2016). The Challenges of Formulating Natural Products. *Happi*. Retrieved from https://www.happi.com/issues/2016-11-01/view_formulator-forum/the-challenges-of-formulating-natural-products/ (Accessed: 18 August 2021).

Tadros, T., Izquierdo, P., Esquena, J. and Solans, C. (2004). 'Formation and stability of nano-emulsions', *Advanced in Colloid and Interface Science,* 108-109, pp. 303-318.

Tadros, T. F. (2013). Emulsion formation, stability, and rheology *In:* Tadros, T. F. (ed.) *Emulsion Formation and Stability.* United Kingdom: Wiley-VCH, pp. 1-75.

Taha, A., Ahmed, E., Ismaiel, A., Ashokkumar, M., Xu, X., Pan, S. and Hu, H. (2020). 'Ultrasonic emulsification: an overview on the preparation of different emulsifiers-stabilized emulsions', *Trends in Food Science & Technology,* 105, pp. 363-377.

Takahashi, M., Wtanabe, H., Kikkawa, J., Ota, M., Watanabe, M., Sato, Y., Inomata, H. and Sato, N. (2006). 'Carotenoids extraction from Japanese persimmon (Hachiyakaki) peels by supercritical CO_2 with ethanol', *Analytical Science,* 22, pp. 1441-1447.

Talebpour, Z., Ghassempour, A., Abbaci, M. and Aboul-Enein, H. Y. (2009). 'Optimization of microwave-assisted extraction for the determination of glycyrrhizin in menthazin herbal drug by experimental design methodology', *Chromatographia*, 70(1-2), pp. 191-197.

Tamburic, S. (2009). The aging of polymer-stabilized creams : a rheological viewpoint. *In:* Schueller, R. andRomanowski, P. (eds.) *Beginning Cosmetic Chemistry: Practical Knowledge For The Cosmetic Industry.* Carol Stream, Illinois: Allured Books, pp. 189-198.

Tang, S. Y., Manickam, S., Wei, T. K. and Nashiru, B. (2012). 'Formulation development and optimization of a novel Cremophore EL-based nanoemulsion using ultrasound cavitation', *Ultrasonics Sonochemistry,* 19(2), pp. 330-345.

Teixeira, A., Vasconcelos, V., Teixeira, M., Almeida, V., Azevedo, R., Torres, T., Sousa Lobo, J. M., Costa, P. C. and Almeida, I. F. (2019). 'Mechanical properties of topical anti-psoriatic medicines: implications for patient satisfaction with treatment', *AAPS PharmSciTech,* 20(1), pp. 36.

Teófilo, R. F. and Ferreira, M. (2006). 'Chemometrics II: spreadsheets for experimental design calculations, a tutorial', *Química Nova,* 29(2), pp. 338-350.

Terescenco, D., Picard, C., Clemenceau, F., Grisel, M. and Savary, G. (2018). 'Influence of the emollient structure on the properties of cosmetic emulsion containing lamellar liquid crystals', *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* 536, pp. 10-19.

Thatai, P. and Sapra, B. (2017). 'Transungual gel of terbinafine hydrochloride for the management of onychomycosis: formulation, optimization, and evaluation', *AAPS PharmSciTech,* 18(6), pp. 2316-2328.

Tochi, B. N., Wang, Z., Xu, S. Y. and Zhang, W. (2008). 'Therapeutic application of pineapple protease (bromelain): a review', *Pakistan Journal of Nutrition,* 7(4), pp. 513-520.

Tseng, Y. P., Liu, C., Chan, L. P. and Liang, C. H. (2021). 'Coffee pulp supplement affects antioxidant status and favors anti-aging of skin in healthy subjects', *Journal of Cosmetic Dermatology*.

Turek, P. (2017). 'Color modification of the face cream and its general sensory quality', *Polish Journal of Commodity Science,* 53, pp. 139-147.

UNION, P. (2009). 'Regulation (EC) No 1223/2009 of the european parliament and of the council', *Official Journal of the European Union L,* 342, pp. 59.

van Smeden, J., Janssens, M., Gooris, G. S. and Bouwstra, J. A. (2014). 'The important role of stratum corneum lipids for the cutaneous barrier function', *Biochimica et Biophysica Acta,* 1841(3), pp. 295-313.

Vance, M. E., Kuiken, T., Vejerano, E. P., McGinnis, S. P., Hochella, M. F. J., Rejeski, D. and Hull, M. S. (2015). 'Nanotechnology in the real world: redeveloping the nanomaterial consumer products inventory', *Beilstein Journal of Nanotechnology,* 6, pp. 1769-1780.

Venkateshaiah, A., Padil, V. V. T., Nagalakshmaiah, M., Waclawek, S., Černík, M. and Varma, R. S. (2020). 'Microscopic techniques for the analysis of micro and nanostructures of biopolymers and their derivatives', *Polymers,* 12(3), pp. 512.

Wang, L., Dong, J., Chen, J., Eastoe, J. and Li, X. (2009). 'Design and optimization of a new self-nanoemulsifying drug delivery system', *Journal of Colloid and Interface Science,* 330(2), pp. 443-448.

Wang, W., Jung, J., Tomasino, E. and Zhao, Y. (2016). 'Optimization of solvent and ultrasound-assisted extraction for different anthocyanin rich fruit and their effects on anthocyanin compositions', *LWT - Food Science and Technology,* 72, pp. 229-238.

Wang, X., Wu, Y., Li, J., Wang, A., Li, G., Ren, X. and Yin, W. (2020). 'Ultrasound-assisted deep eutectic solvent extraction of echinacoside and oleuropein from *Syringa pubescens* Turcz', *Industrial Crops and Products,* 151, pp. 112442.

Wen, L., Yang, B., Cui, C., You, L. and Zhao, M. (2012). 'Ultrasound-assisted extraction of phenolics from longan (*Dimocarpus longan* Lour.) fruit seed with artificial neural network and their antioxidant activity', *Food Analytical Methods,* 5, pp. 1244-1251.

Wilde, P. J. (2019). 'Improving emulsion stability through selection of emulsifiers and stabilizers'. In Beddows, C. (Ed.), *Reference Module in Food Science*. Amsterdam, Netherlands: Elsevier. [Online]. Available at: https://www.sciencedirect.com/science/article/pii/B9780081005965223378 (Accessed: 9 January 2021).

Williams, H. (2018). 'Predictive stability testing utilizing accelerated stability assessment program (ASAP) studies'. In Bajaj, S. andSingh, S. (Eds.), *Methods for Stability Testing of Pharmaceuticals* (pp. 213-232). New York, NY: Springer New York. [Online]. Available at: https://doi.org/10.1007/978-1-4939-7686-7_10 (Accessed: 14 June 2021).

Wu, J., Lin, L. and Chau, F.-t. (2001). 'Ultrasound-assisted extraction of ginseng saponins from ginseng roots and cultured ginseng cells', *Ultrasonics Sonochemistry,* 8(4), pp. 347-352.

Xu, D. P., Zheng, J., Zhou, Y., Li, Y., Li, S. and Li, H. B. (2017). 'Ultrasound-assisted extraction of natural antioxidants from the flower of *Limonium sinuatum*: optimization and comparison with conventional methods', *Food Chemistry,* 217, pp. 552-559.

Yaar, M. and Gilchrest, B. (2001). 'Ageing and photoageing of keratinocytes and melanocytes', *Clinical and experimental dermatology,* 26(7), pp. 583-591.

Yahia, A., Mantellato, S. and Flatt, R. J. (2016). Chapter 7 - Concrete rheology: a basis for understanding chemical admixtures. *In:* Aïtcin, P.-C. andFlatt, R. J. (eds.) *Science and Technology of Concrete Admixtures.* Sawston, United Kingdom: Woodhead Publishing, pp. 97-127.

Yahya, N. A., Abdul Wahab, R., Abdul Hamid, M., Mahat, N. A., Mohamed Huri, M. A., Attan, N. and Hashim, S. E. (2020). 'Stastical optimization and characterization of acoustically extracted *Ananas comosus* peel powder with enhanced antioxidant capacity', *Jurnal Teknologi,* 82(4), pp. 1-10.

Yang, B., Zhang, M., Weng, H., Xu, Y. and Zeng, L. (2020). 'Optimization of ultrasound assisted extraction (UAE) of kinsenoside compound from *Anoectochilus roxburghii* (Wall.) Lindl by response surface methodology (RSM)', *Molecules,* 25(1), pp. 193.

Yang, L. and Du, K. (2019). 'A comprehensive review on the natural, forced, and mixed convection of non-Newtonian fluids (nanofluids) inside different cavities', *Journal of Thermal Analysis and Calorimetry,* 140(5), pp. 2033-2054.

Yeom, D. W., Song, Y. S., Kim, S. R., Lee, S. G., Kang, M. H., Lee, S. and Choi, Y. W. (2015). 'Development and optimization of a self-microemulsifying drug delivery system for atorvastatin calcium by using D-optimal mixture design', *International Journal of Nanomedicine,* 10, pp. 3865-3877.

Yoshino, S., Mitoma, T., Tsuruta, K., Todo, H. and Sugibayashi, K. (2014). 'Effect of emulsification on the skin permeation and UV protection of catechin', *Pharmaceutical Development and Technology,* 19(4), pp. 395-400.

Yu, L., Westland, S., Li, Z., Pan, Q., Shin, M. J. and Won, S. (2018). 'The role of individual colour preferences in consumer purchase decisions', *Color Research & Application,* 43(2), pp. 258-267.

Yukuyama, M. N., Ghisleni, D. D., Pinto, T. J. and Bou-Chacra, N. A. (2016). 'Nanoemulsion: process selection and application in cosmetics- a review', *International Journal of Cosmetic Science,* 38(1), pp. 13-24.

Yuliani, S., Muchtadi, T. R. and Syakir, M. (2018). 'Changes in characteristics of nanoemulsion of cinnamon oil and their relationships with instability mechanisms during storage', *Journal of Food Processing and Preservation,* 42(10), pp. e13745.

Yuris, A. and Siow, L.-F. (2014). 'A comparative study of the antioxidant properties of three pineapple (*Ananas comosus* L.) varieties', *Journal of Food Studies,* 3(1), pp. 40-56.

Yusoff, S. F., Haron, F. F., Asib, N., Mohamed, M. T. M. and Ismail, S. I. (2021). 'Development of *Vernonia amygdalina* leaf extract emulsion formulations in controlling gray mold disease on tomato (*Lycopersicon esculentum* Mill.)', *Agronomy*, 11(2), pp. 373.

Zainol, N. A., Ming, T. S. and Darwis, Y. (2015). 'Development and characterization of cinnamon leaf oil nanocream for topical application', *Indian Journal of Pharmaceutical Sciences,* 77(4), pp. 422-433.

Zeitoun, H., Kassem, M., Raafat, D., AbouShlieb, H. and Fanaki, N. (2015). 'Microbiological testing of pharmaceuticals and cosmetics in Egypt', *BMC Microbiology*, 15(1), pp. 275.

Zeng, L., Xin, X. and Zhang, Y. (2017). 'Development and characterization of promising Cremophor EL-stabilized o/w nanoemulsions containing short-chain alcohols as a cosurfactant', *RSC Advances*, 7(32), pp. 19815-19827.

Zhang, Y., Dong, Z., Ji, G. and Wang, S. (2015). 'Effect of spider-web-plot in MR brain image classification', *Pattern Recognition Letters,* 62, pp. 14-16.

Zhang, Z. and McClements, D. J. (2018). Overview of nanoemulsion properties: stability, rheology, and appearance. *In:* Seid Mahdi, J. andDavid Julian, M. (eds.) *Nanoemulsions: Formulation, Applications, and Characteriztion.* Massachusetts, United States: Academic Press, pp. 21-49.

Zhao, C., Shen, X. and Guo, M. (2018). 'Stability of lutein encapsulated whey protein nano-emulsion during storage', *PloS ONE,* 13(2), pp. e0192511.

Zillich, O. V., Schweiggert-Weisz, U., Eisner, P. and Kerscher, M. (2015). 'Polyphenols as active ingredients for cosmetic products', *International Journal of Cosmetic Science,* 37(5), pp. 455-464.

Živković, J., Šavikin, K., Janković, T., Ćujić, N. and Menković, N. (2018). 'Optimization of ultrasound-assisted extraction of polyphenolic compounds from pomegranate peel using response surface methodology', *Separation and Purification Technology*, 194, pp. 40-47.

LIST OF PUBLICATIONS

Journal with Impact Factor

1. **Yahya, N. A.**, Attan, N., Wahab, R. A. (2018). An overview of cosmeceutically relevant plant extracts and strategies for extraction of plant-based bioactive compounds. *Journal of Food and Bioproducts Processing. 112*, 69 – 85. https://doi.org/10.1016/j.fbp.2018.09.002. **(Q2, IF: 4.481)**
2. **Yahya, N. A.**, Wahab, R. A, Attan, N., Hashim, S. E., Hamid, M. A, Noor, N. M, Rahman, A. A. (2020). Optimization of oil-in-water nanoemulsion system of *Ananas comosus* peels extract by D-optimal mixture design and its physicochemical properties. *Journal of Dispersion Science and Technology*. 1-14. https://doi.org/10.1080/01932691.2020.1839485. **(Q3, IF: 2.262)**

Indexed Journal

1. **Yahya, N, A**., Wahab, R. A, Hamid, M. A., Mahat, N. A., Huri, M. A. M., Attan, N., Hashim, S. E. (2020). Statistical optimization and characterization of acoustically extracted ananas comosus peel powder with enhanced antioxidant capacity. *Jurnal Teknologi*, *82* (4). https://doi.org/10.11113/jt.v82.14486. **(Indexed by Web of Science)**
2. Yun, G. Y., **Yahya, N. A.**, Wahab, R. A., Hamid, M. A. (2020). Formulation and Characterization of a Kinetically Stable Topical Nanoemulsion Containing the Whitening Agent Kojic Acid. *Indonesian Journal of Chemistry*. https://doi.org/10.22146/ijc.56587. **(Indexed by Web of Science)**

Indexed Conference Proceedings

1. **Yahya, N. A.**, Wahab, R. A., Xine, T. L. S., Hamid, M. A. (2019). Ultrasound-assisted extraction of polyphenols from pineapple skin. *Proceedings of the 2nd International Conference on Biosciences and Medical Engineering (ICBME2019): Towards Innovative Research and Cross-Disciplinary Collaborations 2155. 020002* (2019) https://doi.org/10.1063/1.5125506. **(Indexed by Web of Science)**