Final Scientific Report

KoEF Research Cooperation Project

1. Project Overview	
Project Title	Phytocosmetics: Phytochemical Screening and Cosmetological Evaluation of the Medicinal Plants in Khyber Pakhtunkhwa, Pakistan and Innsbruck, Austria
Acronym	--
Project Number	KOEF 08/2019
Cooperating Countries	Pakistan and Austria
Coordinating Institution	Department of Chemistry, University of Swabi, Pakistan
Project Coordinator	Prof. Dr. Muhammad Nasimullah Qureshi
Email Coordinator	mnasimuq@uoswabi.edu.pk
Partner Institution 1	Austrian Drug Screening Institute (ADSI), University of Innsbruck, Austria
Project Co-Coordinator	o.Univ.-Prof.Mag.Dr.Dr.hc. Günther K. Bonn
Email Co-Coordinator	guenther.bonn@uibk.ac.at
Partner Institution 2	Institute of Analytical Chemistry and Radio-chemistry (ACRC) University of Innsbruck, Austria
Project Co-Coordinator	Univ.-Prof.Mag.Dr. Christian Wolfgang Huck
Email Co-Coordinator	christian.w.huck@uibk.ac.at
Please insert lines for further partners.	
No. of All Involved Institutions	03
Austrian Institutions	Institute of Analytical Chemistry and Radio-chemistry (ACRC) University of Innsbruck, Austria Austrian Drug Screening Institute (ADSI), University of

	Innsbruck, Austria		
Partner Country Institutions	Department of Chemistry, University of Swabi, Pakistan		
Project Start	November 01, 2020		
Duration in Months	36 months		
Total Costs Applied (€)	49600 €		
No. of Team Members (including Coordinator)	Male: 4	Female: 1	Total: 5
Coordinating Institution (including Project Coordinator)	Male: 1	Female: 0	Total: 1
Partner Institution 1 (including Co-Coordinator)	Male: 3	Female: 1	Total: 4
Please insert lines for further partners.			
Branch(es) of Science[1] (max. 3)	Branch Name Analytical Chemistry Natural Products Chemistry	Six-Digit Code 104002 104013	
Contribution to SDGs[2] (max. 3)	Name of SDG • Good Health and Well Being • Quality Education • Responsible Consumption and Production • Partnership for the Goals	SDG Number 3 4 12 17	

[1] http://www.statistik.at/kdb/downloads/pdf/OEFOS2012_EN_CTI_20190903_162012.pdf
[2] https://sustainabledevelopment.un.org/sdgs

Content

Funded by:

Federal Ministry
Republic of Austria
Education, Science
and Research

OeAD

1. Abstracts

Please provide two brief abstracts (English and German) of the project (ca. 500 words each)

Abstract (English)

Natural flora is the treasure of the diverse novel, biologically and medicinally important compounds which lay the foundation of drug discovery and the success in this field. There are several common forms of natural products, which are: Phytochemicals, nutraceuticals, cosmeceuticals, oleoresins, essential oil etc. According to the modern concept of health, the focus is not merely the eradication of disease but the care of health of human. This ratifies that the health care product should not only be active against the specific disease or any abnormal condition but also be safe in terms of other side effects. This reality validates the use of herbs and herbal based product for health care. In this context, phytocosmetics, aroma products, toiletries and personal care products have increasingly attracted interest by the market. Currently there is a strong innovation trend of the use of phytocosmetics in world market e.g. in some mature markets like Europe, Asia and the United States. According to the available literature, the global market for natural personal care products is estimated at more than $32 billion in 2014. Europe and North America are currently the biggest market for phytocosmetics while Asia and Latin America are the fastest growing regions. The global market potentials reveal the society interest in phytocosmetics which demands serious studies and special attention towards the phytocosmetics and phytocosmeceuticals.

This project is aimed at the mutual cooperation and coordination for the development research project focusing on phytochemical screening of the flora of local regions of Khyber Pakhtunkhwa, Pakistan and the Innsbruck, Austria and their cosmetological evaluation in order to reach at the safe, effective and non-toxic phytocosmetic products. The project is funded for the mobility and material expenses for researchers at the Department of Chemistry, University of Swabi, Khyber Pakhtunkhwa, Pakistan and Institute of Analytical Chemistry and Radio-chemistry (ACRC); Austrian Drug Screening Institute (ADSI), University of Innsbruck, Austria under the Cooperation Development Research program of OEAD-GmbH, Austria in order to achieve SDGs adopted by the UN member countries in 2015.

Zusammenfassung (Deutsch)

Die natürliche Flora ist der Schatz vielfältiger neuartiger, biologisch und medizinisch wichtiger Verbindungen, die den Grundstein für die Arzneimittelentwicklung und den Erfolg auf diesem Gebiet legen. Es gibt verschiedene gängige Formen von Naturprodukten: Phytochemikalien, Nutraceuticals, Cosmeceuticals, Oleoresine, ätherische Öle usw. Nach dem modernen Gesundheitskonzept liegt der Schwerpunkt nicht nur auf der Ausrottung von Krankheiten, sondern auch auf der Sorge um die Gesundheit des Menschen. Dies bestätigt, dass das Gesundheitsprodukt nicht nur gegen die spezifische Krankheit oder einen abnormalen Zustand wirksam sein sollte, sondern auch im Hinblick auf andere Nebenwirkungen sicher sein sollte. Diese Realität bestätigt die Verwendung von Kräutern und Produkten auf Kräuterbasis für die Gesundheitsfürsorge. In diesem Zusammenhang stoßen Phytokosmetik, Aromaprodukte, Toilettenartikel und Körperpflegeprodukte zunehmend auf Interesse am Markt. Derzeit gibt es einen starken Innovationstrend beim Einsatz von Phytokosmetika auf dem Weltmarkt, z. in einigen reifen Märkten wie Europa, Asien und den Vereinigten Staaten. Der verfügbaren Literatur zufolge wird der weltweite Markt für natürliche Körperpflegeprodukte im Jahr 2014 auf mehr als 32 Milliarden US-Dollar geschätzt. Europa und Nordamerika sind derzeit der größte Markt für Phytokosmetik, während Asien und Lateinamerika die am schnellsten wachsenden Regionen sind. Die globalen Marktpotenziale zeigen das gesellschaftliche Interesse an Phytokosmetika, das ernsthafte Studien und besondere Aufmerksamkeit für Phytokosmetika und Phytokosmezeutika erfordert.

Dieses Projekt zielte auf die gegenseitige Zusammenarbeit und Koordinierung für das Entwicklungsforschungsprojekt ab, das sich auf das phytochemische Screening der Flora der lokalen Regionen Khyber Pakhtunkhwa, Pakistan und Innsbruck, Österreich, und deren kosmetologische Bewertung konzentriert, um zu einer sicheren, wirksamen und nicht-medizinischen Methode zu gelangen. giftige phytokosmetische Produkte. Das Projekt wird für die Mobilitäts- und Sachkosten von Forschern am Department of Chemistry der University of Swabi, Khyber Pakhtunkhwa, Pakistan und am Institute of Analytical Chemistry and Radio-chemistry (ACRC) finanziert. Austrian Drug Screening Institute (ADSI), Universität Innsbruck, Österreich im Rahmen des Cooperation Development Research-Programms der OEAD-GmbH, Österreich, um die von den UN-Mitgliedsländern im Jahr 2015 verabschiedeten SDGs zu erreichen.

2. Introduction, objectives and overview of the project

Nature has been in use by the human being since long and medicinal plants and their products have been playing its role as the primary producer for the consumers in form of food, medicine, beauty, aroma, other therapeutical material etc. Natural flora is the treasure of the diverse novel, biologically and medicinally important compounds which lay the foundation of drug discovery and the success in this filed. There are several common forms of natural products, which are: Phytochemicals, nutraceuticals, cosmeceuticals, oleoresins, essential oil etc. It has been the reality that herbal based products are always welcomed in the ancient times as well as in this modern age where the allopathic medicine and synthetic chemicals have made incomparable and unparallel progress.

A big question on the herbal based product throughout the world is the lack of quality control, efficacy and toxicity studies which attributes the satisfaction, confidence of the consumers and reliability of the products. Plants contain hundreds and thousands of compounds in macro and micro level, responsible for the desirable biological effect. Usually it is a challenging task to attribute a specific pharmacological action to a single ingredient in a herbal drug and thus the multiple components investigation is more reasonable choice for the quality control. Chemical complexity and biodiversity of these herbs and herbal products is another obstacle, complicating the quality control procedure. However, it is necessary to determine the chemical profile, efficacy and toxicity of herbs and plant based products for better scientific, legal and clinical acceptability as well as for getting position in global market.

Legal requirements emphasize the need of a quality control protocol which can be achieved by standardizing the raw material and the final product. Standardization is the process of knowing ingredients present in the specific material in term of its quality and quantity. This process can be split into the following steps:

- Purification of the analytes
- Qualitative investigations of these pure analytes
- Structure elucidation and authentication
- Quantification of the analytes present in the plant extracts using these isolated and purified authenticated standards

Pharmacological or biological studies of the herbs and the herbal products includes: its efficacy, toxicity and dose determination. These can be performed through the *in vitro* and *in vivo* studies.

According to the modern concept of health, the focus is not merely the eradication of disease

but the care of health of human. This ratifies that the health care product should not only be active against the specific disease or any abnormal condition but also be safe in terms of other side effects. This reality validates the use of herbs and herbal based product for health care. In this context, phytocosmetics, aroma products, toiletries and personal care products have increasingly attracted interest by the market. Currently there is a strong innovation trend of the use of phytocosmetics in world market e.g. in some mature markets like Europe, Asia and the United States. According to the available literature, the global market for natural personal care products is estimated at more than $32 billion in 2014. Europe and North America are currently the biggest market for phytocosmetics while Asia and Latin America are the fastest growing regions. The global market potentials reveal the society interest in phytocosmetics which demands serious studies and special attention towards the phytocosmetics and phytocosmeceuticals.

This project aimed at the mutual cooperation and coordination for the development research project focusing on phytochemical screening of the flora of local regions of Khyber Pakhtunkhwa, Pakistan and the Innsbruck, Austria and their cosmetological evaluation in order to reach at the safe, effective and non-toxic phytocosmetic products. The project is funded for the mobility and material expenses for researchers at the Institute 1 and Institute 2 under the Cooperation Development Research program of OEAD-GmbH, Austria in order to achieve SDGs adopted by the UN member countries in 2015.

3. Narrative summary of the project: activities and results, elaboration of the research findings, methodology used, innovative aspects of the project

Summarize the completed activities and illustrate the achieved results. Elaborate on the research findings, the methodology used and on innovative aspects of the project. The use of individual sub-chapters is encouraged.

Due to the COVID-19 pandemic restrictions and limitation, activities of the project have been affected very much since its start. However, two visits of the Project Coordinator from Pakistan to the University of Innsbruck, Austria were made in February 14 to 27, 2022 and August 15-28, 2022 to discuss and plan the activities as proposed in the project with the partner project coordinators in Austria Prof. Dr. Guenther Bonn, Prof. Dr. Christian Huck and other project members from the University of Innsbruck. A number of meetings were held during these visits in order to finalize the plan and its execution.

Methodology

Collection of plant materials

Literature study of the published material related to phytocosmetics has been made and most of the plants to be studied under this project have been selected based on the literature review. The collected plants were authenticated by a Taxonomist. These plants parts were then washed, chopped and then left to dry under shade. The dried materials were ground to powder.

Extraction

Optimizations of extraction in different solvents were performed. These solvents were water, 100% acetone, 100% ethanol, 80% ethanol, 50% ethanol and 70% ethanol. 70% ethanol was selected as extracting solvent for further work based on its extraction yield and easy availability.

About one gram of each powdered plant material was extracted in 20, 20 ml of each solvent by refluxing for 2 hours with continuous magnetic stirring. Extracts were allowed to cool at room temperature and then centrifuged for 10 minutes at 4x1000 rpm using eppendorf centrifuge. They were preserved in refrigerator for further work.

Determination of polyphenolic compounds

Preparation of Standards

Stock solution of gallic acid was prepared with a concentration of 100 ppm by dissolving 10 mg of gallic acid in 100 mL of distilled water. Further dilutions were made for the standard calibration curve diluting stock solution to 50, 25 and 10 ppm with distilled water.

Folin-Ciocalteau Method

Polyphenolic compounds were determined by Folin-Ciocalteau method using gallic acid as the reference standard. 5 mL of diluted FC reagent (1:10 FC reagent to water) were added to one milliliter of each of standards, extract and blank (water) in test tubes. These were mixed thoroughly through vortex mixing. 4 mL of Na_2CO_3 solution (7.5%) were added to each mixture after 8 minutes and mixed thoroughly through vortex mixing. These test tubes were covered and stored for 2 hours at room temperature and away from strong light. Absorbance of these test solutions were read against the prepared blank at 740 nm using UV-visible spectrophotometer.

Quantification of Total Flavonoids Contents

Amount of total flavonoids were estimated using the procedure adopted by Chang et al, 2002. Quercetin was used as standard and six working standard solutions were prepared in the

concentration range: 0.01 mg/mL to 0.1 mg/mL in methanol, for constructing the calibration curve. 0.5 mL of plant extract /standard solution/Blank (methanol) was mixed with 1.5 mL of methanol in a test tube. 0.1 mL of 10% aluminum chloride, 0.1 mL of 1 M potassium acetate and 2.8 mL of distilled water were added to the test tube and mixed thoroughly after each addition. The solutions were stored for 30 minutes at room temperature. The absorbance of the reaction mixtures were measured at 415 nm using the UV-Visible spectrophotometer correcting the absorbance with the prepared blank solution.

Antioxidant activity

The scavenging activity of all the extracts on DPPH (1,1-diphenyl-2-picrylhydrazyl) was determined based on the reduction of purple DPPH to yellow coloured diphenylpicryl-hydrazine (Imam *et al.*, 2012; Zhao *et al.*, 2013). The extracts were dissolved in DMSO in a concentration of 100 ppm. Different concentrations of each extract were prepared in DMSO. Sample solution in different concentrations was added to test tubes and allowed to react with one mL of 0.3 mM DPPH solution in ethanol to produce the test solutions. DMSO was used as a blank solution. Negative control was prepared by mixing 1 mL of DPPH solution with DMSO (2.5 mL). The solutions were kept in the dark at room temperature for 30 min to let them react. The measurement of absorbance and colour changes was done at the wavelength of 517 nm. Ascorbic acid (vitamin C) was used as the standard sample.

Anti-Tyrosinase Activity

Tyrosinase is a copper-containing monooxygenase that is widely distributed in nature. The enzyme hydroxylates monophenols to o-diphenols and oxidizes o-diphenols to o-quinones. Quinones are highly reactive compounds that upon further oxidation, could convert to eumelanin polymers through a radical-coupling pathway. Besides, quinone can polymerize spontaneously, resulting in melanin formation, and can react with amino acids or proteins, thus enhancing the brown color production by the parent compound.

100 µL of test sample solution containing 20 µL of plant extract was mixed with 20 µL of Tyrosinase enzyme (1000 U/mL) and 20 µL of 0.1 M phosphate buffer (pH 6.8). This is called sample solution with enzyme. Sample solution without enzyme was also prepared using the procedure mentioned above but without enzyme. Blank solutions (without plant extract) were also prepared with and without enzyme. Positive control solutions (0.5 mg/mL in water) were prepared with and without enzyme.

20 µL of 0.85 mM L-DOPA (L-3,4-dihydroxyphenylalanine) solution as the substrate was added to each sample and blank solutions and mixed well. These were incubated at 25 °C for

10 minutes. The amount of dopachrome produced in the reaction mixtures were measured at 475 nm using the microplate reader.

Results of the TPC, TFC, anti-oxidant and anti-tyrosinase activities assays

	Name of Plant material	Total Polyphenolic Compounds (mg of Gallic acid equivalents/g of dried plant)	Total Flavonoids Contents (mg of Quercetin equivalents/g of dried plant)	Antioxidant Activity	Anti Tyrosinase Activity
1	Matricaria chamomilla flower	80.12	32.10	✓	✓
2	Taraxacum officinale	27.30	10.92	✓	✓
3	Achilla millifolia	65.80	26.32	✓	✓
4	Althea officinalis	23.60	7.08	✓	✓
5	Equisetum arvense	30.40	10.64	✓	✓
6	Juglans regias	150.20	60.0	✓	✓
7	Quercus robur bark	135.10	40.5	✓	✓
8	*Piper nigrum*	8.4	5.3	✓	✓
9	*Bunium persicum*	**13.4**	8.5	✓	✓
10	*Crocus sativus*	**9.6**	3.5	✓	✓
11	*Arachis hypogaea* (aerial part)	120.45	57.0	✓	✓
12	*Verbena officinalis* (aerial part)	0.2186	0.2181	✓	✓
13	*Verbena officinalis* (root part)	0.2239	0.0644	✓	✓
14	*Prunus dulcis* nuts	0.008	0.001	✓	✓

3.1. Research stays for the project

Due to the COVID-19 pandemic restrictions and limitation, activities of the project have been affected very much since its start. However, two visits of the Project Coordinator from

Pakistan to the University of Innsbruck, Austria were made in February 14 to 27, 2022 and August 15-28, 2022 to discuss and plan the activities as proposed in the project with the partner project coordinators in Austria

3.2. List of all research stays

Project Coordinator research stays in Austria

1st: February 14-27, 2022;

2nd: August 15-28, 2022)

3.3. Reports of all research stays of project members

Two visits of the Project Coordinator from Pakistan to the University of Innsbruck, Austria were made in February 14-27, 2022 and August 15-28, 2022 to discuss and plan the activities as proposed in the project with the partner project coordinators in Austria Prof. Dr. Guenther Bonn, Prof. Dr. Christian Huck and other project members from the University of Innsbruck. A number of meetings were held during these visits in order to finalize the plan and its execution.

4. Contribution to the SDGs and implementation of gender and diversity issues

The project is in line with the 17 SDGs (the 2030 agenda) adopted by the UN member states in 2015 aiming to adopt strategies for ending poverty and other deprivations through improving health and education, reduce inequality and spur economic growth while taking into consideration the climate change and to preserve our nature – forests and oceans. The project is aimed at the healthy partnership between the organizations from the developed country Austria and developing country Pakistan for achieving the SDGs adopted by the UN member states in 2015.

5. Sustainability and application of results

The project is sustainable and is aimed at the healthy partnership between the organizations from the developed country Austria and developing country Pakistan for achieving the SDGs adopted by the UN member states in 2015 which ultimately will be helpful in adopting strategies for ending poverty and other deprivations through improving health and education, reduce inequality and spur economic growth while taking into consideration the climate change and to preserve our nature – forests and oceans.

5.1. Status of partners and partner organisations, scope for follow up projects and activities

The Project Coordinator Prof. Dr. Muhammad Nasimullah Qureshi, Department of Chemistry, Uinersity of Swabi, Pakistan, is the alumnus of the University of Innsbruck and has completed doctoral studies from the Institute of Analytical Chemistry and Radiochemistry (ACRC), University of Innsbruck, Austria under the supervision of Prof. Dr. Guenther Bonn who is currently the CEO of the Austrian Drug Screening Institute (ADSI) and former head of the ACRC. Both the Institutes of the 350 years old university, the University of Innsbruck, Austria, are well established institutes having well equipped laboratories, well trained scientific staff and researchers. Department of Chemistry has been established in 2016 is the growing public sector chartered university, University of Swabi, Pakistan (established in 2012) intending to establish all the required facilities, technology, skilled man power and conducive environment for conducting development research projects. This project strengthened the already developed coordination and opened new doors for mutual cooperation and coordination for scientific research, sharing of experiences and dissemination of knowledge.

6. Partnership and cooperation within the project

This project has been completed by the mutual cooperation and coordination between the partner institutes:

Institute 1: Department of Chemistry, University of Swabi, Pakistan

Institute 2: Institute of Analytical Chemistry and Radio-chemistry (ACRC);

Austrian Drug Screening Institute (ADSI), University of Innsbruck, Austria

6.1. Reflection on the project environment

Due to the COVID-19 pandemic restrictions and limitation, activities of the project have been affected very much since its start. However, two visits of the Project Coordinator from Pakistan to the University of Innsbruck, Austria were made in February 14 to 27, 2022 and August 15-28, 2022 to discuss and plan the activities as proposed in the project with the partner project coordinators in Austria. COVID-19 pandemic restrictions and limitation in the year 2021 till mid of 2022 of the project while in the remaining time duration, laboratory work was carried out by the enrolled master students under the supervision of the project coordinator as we could not get PhD students for the project in the Department of Chemistry,

University of Swabi, although advertisement has been made by the University, as they could not fulfill the eligibility criteria for admission.

6.2. Response to challenges and difficulties, unexpected outcomes

- Visa process at the Austrian Embassy in Islamabad took long time. For the last two visits, embassy took longer time than usual to give the appointment date to submit the application and also took longer time to issue the visa.
- Accommodation in Innsbruck in the hostels attached with the University and OEAD during the semesters is almost not available and to manage stay in the hotels is difficult with the amount allocated.
- Recruitment of the PhD students for the execution of the project during the COVID19 time was not possible. The University of Swabi advertised the admissions in PhD in Chemistry program for semester Fall 2022, but could not get students for the project as they could not fulfill the eligibility criteria for admission. This is to mention that the project only funds the short stay in Austria and does not cover the whole study duration and research work in Pakistan. Therefore, PhD students solely for the project could not be admitted and have to look for the University for its advertisement for the program as per its academic calendar, fulfillment of the eligibility criteria and interest of the admitted students in this project.
- The project experimental work was carried out with master research students and the laboratorywork was performed in the University of Swabi, Pakistan due to the difficulties in recruiting PhD candidates.
- Inflation in Pakistan is at its peak and the fluctuation in dollar rate is very much. The people in Pakistan especially the students are passing through financial crises.

7. Reflection on project success with special regard to project aims and expected results

Overall the project was successful with regards to its aim and the expected results in establishing and strengthening the healthy partnership between the organizations from the developed country Austria and developing country Pakistan for science and technology. This project will further strengthen the mutual cooperation and linkage between the partner institutes for the sharing of experience, expertise, technology and dissemination of knowledge in the relevant field.

8. Publications

existing publications, confirmed publications (incl. planned publication date), planned publications

Following publications are planned to be published:

- A review on the Phytocosmetics
- Cosmetological evaluation of selected plants
- Natural hydrogels synthesis and their applications in cosmetics

9. Pictures










10. Further Comments

Mutual coordination and cooperation is required in research which will be continued for establishing linkages and other development research projects between the partner institutes. Activities of the project will be continued for providing safe and effective herbal based cosmetics and medicine.

11. Glossary

Institute 1: Department of Chemistry, University of Swabi, Pakistan

Institute 2: Institute of Analytical Chemistry and Radio-chemistry (ACRC);

Austrian Drug Screening Institute (ADSI), University of Innsbruck, Austria

TPC: Total Polyphenolic Compounds

TFC: Total Falvonoids Contents

FC reagent: Folin-Ciocalteau reagent

SDGs: Sustainable Developmental Goals

Na_2CO_3: Sodium carbonate

DPPH: 1,1-diphenyl-2-picrylhydrazyl

DMSO: Dimethyl sulphoxide

12. Literature

Abbasi, A. M., Khan, M. A., Ahmad, M., Zafar, M., Jahan, S., & Sultana, S. (2010). Ethnopharmacological application of medicinal plants to cure skin diseases and in folk cosmetics among the tribal communities of North-West Frontier Province, Pakistan. *Journal of Ethnopharmacology*, *128*(2), 322-335.

Aburjai, T., & Natsheh, F. M. (2003). Plants used in cosmetics. *Phytotherapy Research*, *17*(9), 987-1000.

Ahmad, I., Ibrar, M., & Ali, N. (2011). Ethnobotanical study of tehsil kabal, Swat district, KP, Pakistan. *Journal of Botany*, *2011*.

Akhtar, N., Rashid, A., Murad, W., & Bergmeier, E. (2013). Diversity and use of ethno-medicinal plants in the region of Swat, North Pakistan. *Journal of Ethnobiology and Ethnomedicine*, *9*, 1-14.

Alamgeer, Sharif, A., Asif, H., Younis, W., Riaz, H., Bukhari, I. A., & Assiri, A. M. (2018). Indigenous medicinal plants of Pakistan used to treat skin diseases: a review. *Chinese Medicine*, *13*, 1-26.

Bijauliya, R. K., Alok, S., Kumar, M., Chanchal, D. K., & Yadav, S. (2017). A comprehensive review on herbal cosmetics. *International Journal of Pharmaceutical Sciences and Research*, *8*(12), 4930-4949.

Chang, C. C., Yang, M. H., Wen, H. M., & Chern, J. C. (2002). Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *Journal of food and drug analysis*, *10*(3).

Costa, I. M. (2015). Phytocosmetics–where nature meets well-being. *Journal of Phytocosmetics and Natural Ingredients*, *2*(1).

D'Amelio Sr, F. S. (1998). *Botanicals: a phytocosmetic desk reference*. CRC Press.

Dini, I., & Laneri, S. (2021). The new challenge of green cosmetics: Natural food ingredients for cosmetic formulations. *Molecules*, *26*(13), 3921.

Drouet, S., Garros, L., Hano, C., Tungmunnithum, D., Renouard, S., Hagège, D., & Lainé, É. (2018). A critical view of different botanical, molecular, and chemical techniques used in authentication of plant materials for cosmetic applications. *Cosmetics*, *5*(2), 30.

El Maaiden, E., Bouzroud, S., Nasser, B., Moustaid, K., El Mouttaqi, A., Ibourki, M., & El Kharrassi, Y. (2022). A comparative study between conventional and advanced extraction techniques: Pharmaceutical and cosmetic properties of plant extracts. *Molecules*, *27*(7), 2074.

Fan, M., Zhang, G., Hu, X., Xu, X., & Gong, D. (2017). Quercetin as a tyrosinase inhibitor: Inhibitory activity, conformational change and mechanism. *Food Research International*, *100*, 226-233.

Fonseca, S., Amaral, M. N., Reis, C. P., & Custódio, L. (2023). Marine Natural Products as Innovative Cosmetic Ingredients. *Marine Drugs*, *21*(3), 170.

Genva, M., Lheureux, L., Saive, M., Maes, C., & Fauconnier, M. L. (2022). Study of the Cosmetic Potential Uses of Plants from Mayotte as Skin Care Agents through the Screening of Their Biological Activities. *Nutraceuticals*, *2*(4), 420-440.

Hamayun, M. (2007). Traditional uses of some medicinal plants of Swat Valley, Pakistan. *Indian Journal of Traditional Knowledge 6*, 636-641.

Hyde, K. D., Bahkali, A. H., & Moslem, M. A. (2010). Fungi - an unusual source for cosmetics. *Fungal Diversity*, *43*, 1-9.

Imam, H., Kasimu, R. & Aisa, H. A (2012). Analysis on the chemical components and antioxidant activity of volatile oil from *Fructus ocimi basilica*. *Medicinal Plants, 3*(2), 11-14.

Jakimiuk, K., Sari, S., Milewski, R., Supuran, C. T., Şöhretoğlu, D., & Tomczyk, M. (2022). Flavonoids as tyrosinase inhibitors in in silico and in vitro models: Basic framework of SAR using a statistical modelling approach. *Journal of Enzyme Inhibition and Medicinal Chemistry*, *37*(1), 427-436.

Jiang, C. B., Chang, M. J., Wen, C. L., Lin, Y. P., Hsu, F. L., & Lee, M. H. (2006). Natural products of cosmetics: analysis of extracts of plants endemic to Taiwan for the presence of tyrosinase-inhibitory, melanin-reducing, and free radical scavenging activities. *Journal of Food and Drug Analysis*, *14*(4), 2.

Kamkaen, N., Mulsri, N., & Treesak, C. (2007). Screening of some tropical vegetables for antityrosinase activity. *Thai Pharmaceutical Health Science Journal 2*.

Khalid, M., Bilal, M., Hassani, D., Zaman, S., & Huang, D. (2017). Characterization of ethno-

medicinal plant resources of karamar valley Swabi, Pakistan. *Journal of Radiation Research and Applied Sciences*, *10*(2), 152-163.

Le, X. T., Nguyen, B. T., Dang, Y. P., Tran-Nguyen, K. U., Le-Dang, T. D., Pham, C. D., & Pham-Vu, M. C. (2023). Screening of herbal plants for inhibitory activity and extracting skin-whitening active ingredients from papaya fruit. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1226, No. 1, p. 012020). IOP Publishing.

Malik, K., Ahmad, M., Zafar, M., Ullah, R., Mahmood, H. M., Parveen, B., & Lubna. (2019). An ethnobotanical study of medicinal plants used to treat skin diseases in northern Pakistan. *BMC Complementary and Alternative Medicine*, *19*, 1-38.

Nema, N. K., Maity, N., Sarkar, B., & Mukherjee, P. K. (2011). Cucumis sativus fruit-potential antioxidant, anti-hyaluronidase, and anti-elastase agent. *Archives of Dermatological Research*, *303*, 247-252.

Park, K. Y., & Kim, J. (2020). Synthesis and biological evaluation of the anti-melanogenesis effect of coumaric and caffeic acid-conjugated peptides in human melanocytes. *Frontiers in Pharmacology*, *11*, 922.

Pereira, L. (2018). Seaweeds as source of bioactive substances and skin care therapy - cosmeceuticals, algotheraphy, and thalassotherapy. *Cosmetics*, *5*(4), 68.

Sumit, K., Vivek, S., Sujata, S., & Ashish, B. (2012). Herbal cosmetics: used for skin and hair. *Inventi Journal*, *2012*, 1-7.

Vichit, W., & Saewan, N. (2022). Anti-oxidant and anti-aging activities of Callus culture from three rice varieties. *Cosmetics*, *9*(4), 79.

Wu, Y., Choi, M. H., Li, J., Yang, H., & Shin, H. J. (2016). Mushroom cosmetics: the present and future. *Cosmetics*, *3*(3), 22.

Zhao, Y., Dou, J., Wu, T. & Aisa, H. A. (2013). Investigating the antioxidant and acetylcholinesterase inhibition activities of *Gossypium herbaceam*. *Molecules, 18*(1), 951-962.