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A Review on Extraction of Antioxidants from *Mangifera Indica L.* (Mango) Peel and Seed with Highest Extraction Yield

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Abstract Mangoes are rich with flavonoids and carotenoids with abundance of bioactive compounds that are suitable to be extracted and apply into various type of food as food additives. Mangoes are usually consumed in fresh or processed to extract it pulps and juices which causes bio-waste production. The peels and seeds are rarely used in food production, though it contained a considerable concentration of bioactive compounds which can be a functional component in preserving food. Presence of preservatives in food can inhibit the oxidation process within the food, preserving the taste, color and nutritive value. The extraction of natural antioxidants are being focused to obtain low-cost antioxidants to replace synthetic antioxidants. Moreover, recent researchers have been developing more efficient techniques of extraction for obtaining greater value of antioxidant extracts from various type of plants. There are several stages to extract bioactive compounds such as, the solvent is needed to penetrate into the solid matrix then solute must be dissolved in the solvent in order to diffuse out the solute from the solid matrix to collect the extracted solutes. The solubility of extraction performance can be affected by the properties of extraction solvent, the particle size of the raw materials, the solvent-to-solid ration, the extraction temperature and the extraction duration. This study will be conducted to review using Preffered Reporting Items for Systematic Review and Meta-Analyses (PRISMA) on suitable extraction method with highest extraction yield, characterization of antioxidant properties between peel and seed of fruits and evaluation of natural antioxidants applied on food. This study could contribute in future studies for highest extraction yield of bioactive compounds.

Keywords: Extraction, Natural Antioxidants, Bioactive Compounds, Antioxidants Properties, PRISMA

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1. Introduction

Mangoes (*Mangifera Indica L.*) are the most popular fruit which have its own various beneficial nutrients and specific taste. Mangoes are rich with flavonoids and carotenoids with abundance of bioactive compounds that are suitable to be extracted and apply into various type of food as food additives. The main bioactive compounds found in mangoes are mangiferin, catechins, quercetin, kaempferol, gallic acid, and benzoic acid, which are compounds associated with the prevention of degenerative diseases, including cancer, cardiovascular diseases, and diabetes [1].

Due to mango is a seasonal fruit, about 20.00 % of the production is processed to elaborate puree, nectar, leather, pickles and canned slices, among others, which have worldwide popularity [2]. Mangoes are usually consumed in fresh or processed to extract it pulps and juices which causes bio-waste production. The peels and seeds are rarely used in food production, though it contained a considerable concentration of bioactive compounds which can be a functional component in preserving food. Moreover, dried mango peels products can improve the sensory properties and oxidative stability of fat rich products [2].

Food additives are widely used in food industries mainly to preserve it from bacteria and prolong the shelf life. As preservatives, the component plays an important role in the supply of safe food. Preservatives can be divided into three groups such as anti-microbial, anti-darking and antioxidants [3]. Presence of preservatives in food can inhibit the oxidation process within the food, preserving the taste, color and nutritive value. There are several natural preservatives can act as antioxidants used in food such as, ascorbic acid, carotenoids, phenolic compounds and tocopherols [3]. The extraction of natural antioxidants are being focused to obtain low-cost antioxidants to replace synthetic antioxidants. Bioactive compounds can be found widely in every parts of plants such as, roots, bark, leaves, fruits, seeds flowers and kernels, though, the concentration of bioactive compounds obtained might be differ for each part.

The natural products can be obtained by extraction methods include solvent extraction, distillation method, pressing and sublimation according to the extraction procedures. There are several stages to extract bioactive compounds such as, the solvent is needed to penetrate into the solid matrix then solute must be dissolved in the solvent in order to diffuse out the solute from the solid matrix to collect the extracted solutes.

There are several factors can affect the solubility of extraction performance such as, the properties of extraction solvent, the particle size of the raw materials, the solvent-to-solid ration, the extraction temperature and the extraction duration [4]. Moreover, recent researchers have been developing more efficient techniques of extraction for obtaining greater value of antioxidant extracts from various type of plants such as, Microwave-assisted extraction (MAE). Microwave (MW) heating is proven to be efficient in releasing the bioactive compounds quickly from plant cell compartments [5].

Two parts of mango fruits, peels and seeds, will be used in this study because of its abundance availability due to bio-waste production. This study will be conducted to explore the potential of antioxidant will be obtained from the extraction as preservative towards food. The performance of bioactive compound will be observed and compared between peels and seeds in form of the shelf-life of food.

1.1 Literature Review

Natural antioxidants can help in lowering incidence of degenerative of diseases such as cancer, arthritis, heart disease and inflammation [6]. These antioxidants can be obtained from various of tropical fruits such as apple, papaya, banana and mango. Antioxidants are substances which help in prevention and delaying oxidative damage of lipids, proteins and nucleic acids by reactive oxygen species that involved reactive free radicals. The most abundant antioxidants in fruits are polyphenols and various types of vitamins such as vitamin A, B, C and E. These polyphenols are mostly known as flavonoids which usually present mainly in ester and glycoside forms. Antioxidant activity in polyphenolic compounds from mango are the strongest which can help to inhibit bioactivity in cancer cell line models [7].

1.2 Natural and Synthetic Antioxidants

In food industry, synthetic antioxidants are widely used to improve the characteristics and properties of processed food due to its abundant availability. However, many studies of synthetic food additives have causes numerous complications related with gastrointestinal, respiratory, dermatological and neurological adverse reactions [8]. For example, the usage of Potassium sorbate as one of the main preservatives used in food industry had caused several drawbacks on human health when being consume simultaneously.

In particular, the synthetic preservative had caused allergic effects such as urticarial and asthma and also cases of intolerance. For instance, the antioxidants which can be found in plants and fruits can be classified as the absolute natural antioxidants which can act as additives and preservatives. These antioxidants also can inhibit the growth of microbes and help in improving the properties of food, thus, can be used as the alternatives to synthetic antioxidants in food industry. Vitamins, polyphenols and carotenoids are the most natural antioxidant molecule which can be substitute as natural preservatives [9].

1.3 Use of Antioxidants in Food Industry

Natural and processed food are fragile due to exposure towards contaminated environment which contributes the growth of microbes and become rotten. The food industry solved this problem by using preservatives to enable distribution and to prolong the useful life of their production. Antioxidants can act as preservatives for food which play a vital role to inhibit oxidation of the food which leads to food spoilage.

In the food industry field, preservatives are used to avoid rotting while antioxidants are used to prevent the chemical reactions leading to unpleasant taste or odor [10]. Antioxidants play an important role for inhibiting or quenching free radicals and terminate the chain reaction before vital molecules are damaged. Antioxidants entered in the widely emerging food industry as an important means to limit the degradation of stored foods as a result of oxidation process by free radicals [11].

1.4 *Mangifera Indica L.*

Mangifera Indica L., known as mango belongs to genus Mangifera, consists of about 30 species of tropical fruiting trees in the flowering plant family Anacardiaceae which have various medicinal properties. Mango possess antidiabetic, antioxidant, anti-viral, cardiotonic, hypotensive and anti-inflammatory properties [12]. Bioactive compounds that can be found in mango pulps, seeds, peels, leaves and stem bark have the most potent antioxidants such as xanthones. Mangiferin that can be found in mango is a xanthone that can protect mitochondrial membrane against lipid peroxidation and promotes anti-bacterial effects [13]. There are abundance of Hydrogen atoms in the chemical structure of mangiferin which can help in neutralizing free radicals.

2. Materials and Methods

In this study, the screeing of related articles are conducted by following Preffered Reporting Items for Systematic Review and Meta-Analyses (PRISMA) method strategy in order to obtain accurate evidence on suitable extraction method with highest extraction yield, characterization of antioxidant properties between peel and seed of fruits and evaluation of natural antioxidants applied on food.

2.1 Materials

1. Electronic Database:

- ScienceDirect
- Mendeley
- ResearchGate

2. Preffered Reporting Items for Systematic Review and Meta-Analyses (PRISMA).

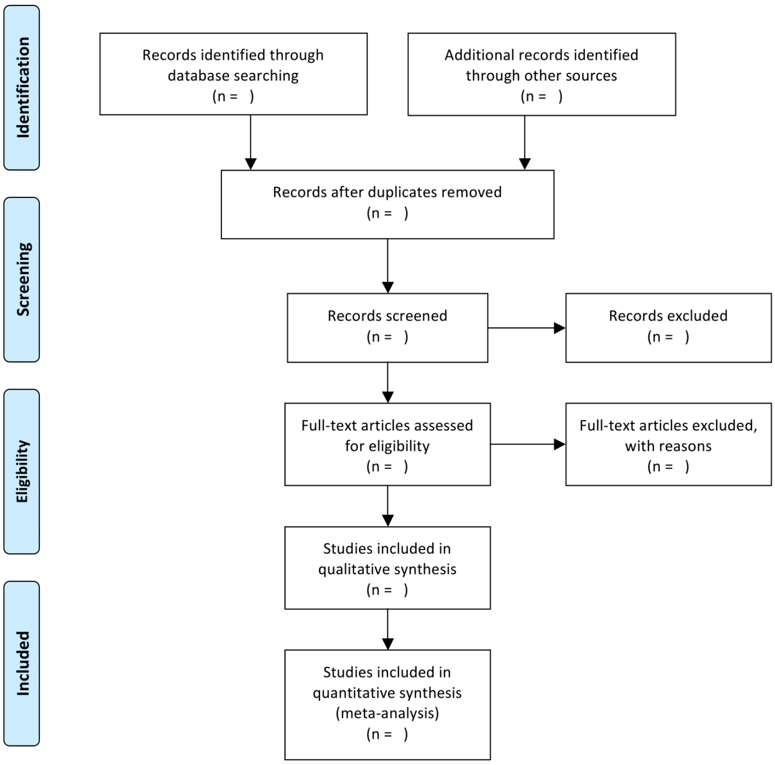

Figure 1: A PRISMA Flow Diagram of the search strategy [14]

2.2 Methods

The review on related articles were covered from the year 2020 up to 2021. Electronic databases were selected as search medium which are ResearchGate, ScienceDirect and Mendeley in order to identify published studies examining the extraction of antioxidants from peel and seed of *Mangifera Indica L.* and both of its properties as well as evaluation of extracted antioxidants towards food. Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) guidelines is used in this methodology.

3. Results and Discussion

In this chapter discussed further on the findings obtained from the related studies. In this chapter, there are three sections which includes with data and discussion on the suitable extraction method to extract antioxidants from *Mangifera Indica L.* with the highest yield, characterization and comparison of antioxidants properties from peel and seed of *Mangifera Indica L.* and evaluation of antioxidants properties.

3.1 Summary of the primary research

Table 1: Summary of the primary search results from Electronic Databases

Source	Search Area	Coverage	Objectives	Keywords for Each Objectives	Hits
ResearchGate, ScienceDirect, Mendeley	Title, Abstract, Keywords, Full-text article	2020 - 2021	To identify the suitable extraction method to extract antioxidants from *Mangifera Indica L.* with the highest yield.	"Extraction of natural antioxidants from fruits" "Different extraction method for antioxidants" "Extraction of mangiferin" "Effects of extraction method towards antioxidants" "Extraction of phenolic content"	110
			To characterize and compare the antioxidants properties of peel and seed of *Mangifera Indica L.*	"Characterization of antioxidants properties from peel and seed" "Evaluation of antioxidants properties of peel and seed from fruits" "Antioxidant properties of fruits"	102
			To evaluate antioxidant effects on food.	"Evaluation of natural antioxidants towards food" "Ability of natural antioxidants as preservative towards food" "Effects of natural antioxidants on shelf-life of food"	112
				Total	324

3.2 Data Extraction and Analysis

After conducting data selection strategy, there are 21 articles will be further discuss in Chapter 4. In this section, the author, journal, year of publication and the title of the articles will be recorded in table form. Table 2, Table 3 and Table 4 are the list of the selected articles followed accordingly to the objectives.

Table 2: List of retrieved articles for Objective 1

No.	Authors, Journal, Year of Publication	Title
1	Zainurin, N.A.A., Hashim, Y.Z.H-Y., Mohamed Azmin, N.F. and Al-Khatib, M.F.R., 2020	Understanding the effects of different parameters of Soxhlet extraction on bioactive compounds from Aquilaria malaccensis leaf through GCMS-based profiling
2	Mathilde Hirondart, Natacha Rombaut, Anne Sylvie Fabiano-Tixier, Antoine Bily and Farid Chemat, 2020	Comparison between Pressurized Liquid Extraction and Conventional Soxhlet Extraction for Rosemary Antioxidants, Yield, Composition, and Environmental Footprint
3	Rut Fernández-Marín, Susana C. M. Fernandes, María A. Andrés and Jalel Labidi, 2021	Microwave-Assisted Extraction of Curcuma longa L. Oil: Optimization, Chemical Structure and Composition, Antioxidant Activity and Comparison with Conventional Soxhlet Extraction
4	Antonio Martinez-Abad, Marina Ramos, Mahmoud Hamzaoui, Stephane Kohnen, Alfonso Jiménez and María Carmen Garrigós, 2020	Optimisation of Sequential Microwave-Assisted Extraction of Essential Oil and Pigment from Lemon Peels Waste
5	Somruedee Thaiphanit , Warintorn Wedprasert, Aristha Srabua, 2020	Conventional and microwave-assisted extraction for bioactive compounds from dried coffee cherry peel by-products and antioxidant activity of the aqueous extracts
6	Md Saifullah, Rebecca McCullum, Adam McCluskey, Quan Vuonga, 2020	Comparison of conventional extraction technique with ultrasound assisted extraction on recovery of phenolic compounds from lemon scented tea tree (Leptospermum petersonii) leaves
7	Marcela Morales, Karol Zapata, Carlos A. Sagaste, Alberto A. Angulo4, Benjamín Rojano, 2020	Optimization of the ultrasound-assisted extraction of polyphenol, mangiferin, and its antioxidant expressionin mango peel (Mangifera indica) using response surface methodology

Table 3: List of retrieved articles for Objective 2

No.	Authors, Journal, Year of Publication	Title
1	Belay Dereje & Solomon Abera, 2020	Effect of pretreatments and drying methods on the quality of dried mango (Mangifera Indica L.) slices
2	Courage Sedem Dzaha, Yuqing Duana, Haihui Zhanga, Chaoting Wena, Jixian Zhanga, Guangying Chenc, Haile Ma, 2020	The effects of ultrasound assisted extraction on yield, antioxidant, anticancer and antimicrobial activity of polyphenol extracts: A review
3	Haripriya Ravikumar, Chua Bee Lin, Chen Yen Leng, Ameena Ali, Choo Choong Oon, 2020	Pre-treatment temperature and multi-response surface optimisation of ultrasound-assisted extraction of antioxidants from red dates
4	Tandokazi Pamela Magangana, Nokwanda Pearl Makunga, Olaniyi Amos Fawole and Umezuruike Linus Opara, 2020	Processing Factors Affecting the Phytochemical and Nutritional Properties of Pomegranate (Punica granatum L.) Peel Waste: A Review
5	Chonthicha Kongkwamcharoen, Arunporn Itharat, Weerachai Pipatrattanaseree, and Buncha Ooraikul, 2021	Effects of Various Preextraction Treatments of Crinum asiaticum Leaf on Its Anti-Inflammatory Activity and Chemical Properties
6	Fen Yu, Na Wan, Qin Zheng, Yuanhui Li, Ming Yang, Zhenfeng Wu, 2020	Effects of ultrasound and microwave pretreatments on hydrodistillation extraction of essential oils from Kumquat peel
7	Małgorzata Nowacka, Magdalena Dadan and Urszula Tylewicz, 2021	Current Applications of Ultrasound in Fruit and Vegetables Osmotic Dehydration Processes

Table 4: List of retrieved articles for Objective 3

No.	Authors, Journal, Year of Publication	Title
1	Marcela Morales, Karol Zapata, Carlos A. Sagaste, Alberto A. Angulo4, Benjamín Rojano, 2020	Optimization of the ultrasound-assisted extraction of polyphenol, mangiferin, and its antioxidant expressionin mango peel (Mangifera indica) using response surface methodology
2	Nguyen Thi Truc Loan, Dang Thanh Long, Pham Nguyen Dong Yen, Truong Thi Minh Hanh, Tri Nhut Pham and Dung Thuy Nguyen Pham, 2021	Purification Process of Mangiferin from Mangifera indica L. Leaves and Evaluation of Its Bioactivities
3	Verónica Marcillo-Parra, Mayra Anaguano, Maritza Molina, Diego SantiagoTupuna-Yerovic, Jenny Ruales, 2021	Characterization and quantification of bioactive compounds and antioxidant activity in three different varieties of mango (Mangifera indica L.) peel from the Ecuadorian region using HPLC-UV/VIS and UPLC-PDA
4	Veeranjaneya Reddy Lebaka, Young-Jung Wee, Weibing Ye and Mallikarjuna Korivi, 2021	Nutritional Composition and Bioactive Compounds in Three Different Parts of Mango Fruit
5	Andrex A.S. Veiga, Vitor A.N.Bragança, Luiz H.C.Holanda, Raimundo P.Braga Jr., Alanna C.L.F.Sousa, Kelton L.B.Santos, Joyce K.L.Vale, Rosivaldo S.Borges, 2021	An asymmetric performance between mangiferin and isomangiferin as antioxidants
6	Vicente Tirado-Kulieva, Sheyla Atoche-Dioses, Ernesto Hernández-Martinez, 2021	Phenolic compounds of mango (Mangifera indica) by-products: Antioxidant and antimicrobial potential, use in disease prevention and food industry, methods of extraction and microencapsulation
7	Svetlana N. Morozkina, Thi Hong Nhung Vu, Yuliya E. Generalova, Petr P. Snetkov and Mayya V. Uspenskaya, 2021	Mangiferin as New Potential Anti-Cancer Agent and Mangiferin-Integrated Polymer Systems— A Novel Research Direction

3.3 Determination of suitable extraction method

3.3.1 Soxhlet Extraction (SE)

According to International Organization for Standardization (ISO standards), soxhlet extraction (SE) is the most widely used method for solid-liquid extraction in natural product chemistry and is a reference procedure for fat and oil extraction [15]. In general, an analytical technique for antioxidants from plants or spices consists of two steps: extraction (e.g., Soxhlet) and maceration (e.g., maceration).In general, an analytical procedure for antioxidants from plants or spices comprises two steps, extraction such as, Soxhlet, maceration followed by analysis by spectrophotometry, high performance liquid chromatography coupled or not to mass spectrometry (HPLC-MS), gas chromatography coupled or not to mass spectrometry (GC–MS). The extract and excess solvent were evaporated under reduced pressure at 40ºC using a rotary evaporator to get concentrated crude ethanolic extracts. Following solvent evaporation, the weight of the extracts was measured and preserved in a petri dish wrapped with aluminium foil for later analysis.

3.3.2 Microwave-Assisted Extraction (MAE)

Microwave-assisted extraction is a unique technology for extracting soluble compounds from a variety of materials into a fluid [16]. Microwave-assisted extraction consists of three phases that must be completed in order. First, at increased temperature and pressure, solutes are separated from active sites in a sample matrix. Then, a solvent diffuses into the matrix of the sample. Finally, the solutes are released into the solvent from the sample matrix. Microwave-assisted extraction has various advantages, including faster heating for bioactive material extraction, shorter temperature gradients, and lower evaporation rates. Furthermore, it can extract bioactive chemicals faster and with better recovery than traditional extraction methods. As a result, microwave-assisted extraction is a viable alternative to traditional extraction methods. In the event of bioactive compound extraction, it is favoured. Adsorption resins were used to purify the extracts obtained by MAE. The adsorption power of the coloured metabolites was assessed during the screening and selection of the optimum resin. The adsorption strength was determined by using a UV-Vis spectrophotometer set to 440 nm to measure the extract's absorbance before and after treatment with the resins.

3.3.3 Ultrasound-Assisted Extraction (UAE)

Various revolutionary extraction techniques have been used in extraction due to low solvent consumption, shorter working durations, and increased efficiency, allowing for fast and efficient extraction at subcritical solvent parameters [17]. The solvent characteristics, volume, pH, temperature, pressure, and the number of extraction steps all affect the extractability of phenolic chemicals from plant matrices. Due to the effects of the ultrasound wave, which causes acoustic cavitation in the solvent, Ultrasound Assisted Extraction (UAE) is considered an efficient extraction method. The ultrasonic also has a mechanical impact, allowing more solvent to penetrate the tissue and increasing the contact surface area between the solid and liquid phases. Finally, the solute diffuses quickly from the solid to the liquid phase. In the UAE, sonication power has an impact on extraction efficiency. The selective extraction of phenolic chemicals is influenced by temperature, solvent, and pH. The selection of appropriate solvents is critical in the field of extraction chemistry for extracting the maximum amount of desired chemical components. Extraction was carried out using solvents with varied polarity that are suitable for use in food and pharmaceuticals. The extraction solvents have a big impact on the phenolic component extraction yield and antioxidant properties. When compared to single solvents, the binary solvent, which is a blend of water and organic solvent, had a greater extraction efficiency when utilising UAE.

3.4 Effects of pre-treatment and drying methods on phenolic compounds

The pH of samples dried by various procedures ranged from 3.68 to 3.17, which is in good accord with reported values of 3.09 to 4.11 [18]. The pH of dried mango slices was found to be lower than the fresh value of 3.86. This could be linked to the concentration of organic acids as a result of the drying process removing water. As indicated in Table 3.5, the freeze-dried mango slices had the lowest pH value of 3.17, while the solar-dried sample had the highest pH value of 3.68, which could be attributed to the lengthy drying process causing more organic acids to be degraded. The lower pH could indicate microbial infection resistance on the shelf. In terms of pretreatment, the order of pH contents was lemon juice, control, salt solution, hot water blanching.

Table 5: Physicochemical properties of dried mango as affected by pre-treatments and drying methods

	pH	TA (g/100g)	TSS (°Brix)	Hardness (N)
Drying Methods				
Solar	3.68	2.20	75.31	8.26
Tray	3.33	2.41	69.36	7.27
Freeze	3.17	2.54	85.14	10.20
Fluidized	3.49	2.26	86.29	15.63
Pre-Treatments				
Lemon juice	3.33	2.40	79.05	10.35
Hot water blanching	3.49	2.27	78.93	9.50
Salt solution	3.46	2.35	79.17	11.52
Control	3.39	2.39	78.95	9.99
LSD	0.03	0.14	1.59	0.68
CV	0.88	7.32	2.43	7.91

For the materials dried by different drying processes, the ascorbic acid values in Table 4.5 found in this study ranged from 33.18 to 41.24 mg/100g. The operation condition was found to cause a drop in ascorbic acid levels. It's possible that ascorbic acid degrades due to its heat labile nature. Vitamin C losses are also affected by drying processes and raw material type, as well as other factors including pretreatments. Freeze and fluidized bed dried samples had the highest vitamin C levels of 41.06 and 41.24 mg/100 g, respectively, with no significant differences between them. This great retention could be attributable to the rapid drying, which prevented ascorbic acid loss, and the use of vacuum in the process, which was done at a low temperature.

Table 6: The antioxidants of dried mango as affected by pre-treatments and drying methods

Drying Methods		
	Vitamin C (mg/100g)	Total Phenol Content (mg/100g)
Solar	33.18	251.12
Tray	35.97	178.05
Freeze	41.06	131.13
Fluidized	41.24	220.00
Pre-Treatments		
Lemon juice	39.18	195.62
Hot water blanching	38.07	203.90
Salt solution	37.42	190.58
Control	36.78	190.20
LSD	0.69	0.82
CV	2.20	0.51

3.5 Evaluation on antioxidants properties

3.5.1 Effect of Extraction Time and Temperature

The effect of varied extraction periods on the mangiferin content was investigated, while the other variables were kept constant: a liquid-to-solid ratio of 10/1, an ethanol concentration of 60, and an extraction temperature of 60 °C [19]. The results are shown in Figure 2 After 4 minutes of extraction, the mangiferin content had reached its maximum level (0.87 Abs). The mangiferin content gradually decreased as the extraction time increased from 5 to 15 minutes. This discovery could be explained by the fact that, because mangiferin has reached equilibrium dissolution at 4 minutes, increasing the extraction period to more than 4 minutes would result in solvent evaporation as well as exposure to the compound's environmental deterioration. As a result, 4 minutes was chosen as an appropriate extraction period for subsequent tests.

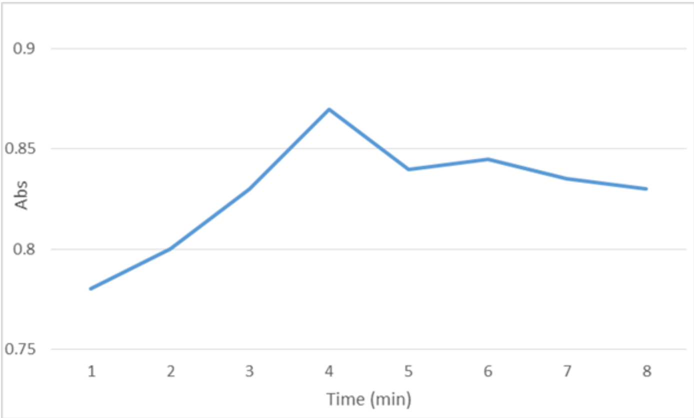

Figure 2: Effect of extraction time (min) on mangiferin content

The influence of different extraction temperatures on the mangiferin content was investigated, with the following other circumstances in place: a liquid-to-solid ratio of 10/1 and an extraction period of 10 minutes. Overall, the mangiferin content increased significantly from 0.778 to 0.842 Abs when the extraction temperature was increased from 15 to 60 °C, as shown in Figure 3. However, as the temperature rose to 75 °C, the level began to drop to 0.79533 Abs. Previous research has found that a temperature of 60 °C is ideal for promoting mangiferin solubility and desorption. Solvent evaporation and mangiferin breakdown were observed in the current investigation when the extraction temperature was raised above 60 °C. As a result, the extraction temperature of 60 °C was chosen for subsequent tests.

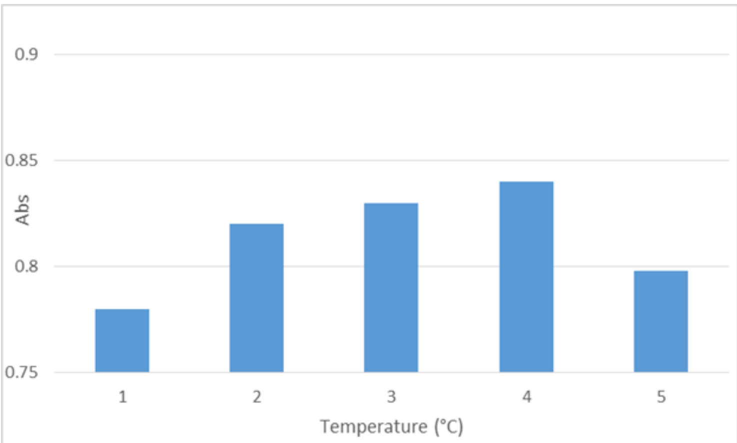

Figure 3: Effect of extraction temperature (°C) on mangiferin content

3.5.2 HPLC Analysis

The crude extract of local mango leaves was made utilising the ultrasonic extraction method with ethanol as the extraction solvent in this investigation. The extraction efficiency obtained was 14.17 % (w/w), which was somewhat higher than the 13.93 % (w/w) found in previous studies. To be more specific, recent experiments used methanol as the solvent and extended the extraction process for four days, but the current approach, which uses ethanol as the solvent and ultrasonic extraction, yielded a similar efficiency (14.17 percent) and only took four minutes. As a result, the current procedure can be regarded a step forward in terms of extraction efficiency and time, providing crucial information for future optimization studies and industrial-scaled experiments. Table 7 shows the findings of an HPLC study of mangiferin in a crude extract of mango leaves collected from UAE. In summary, upon examining the crude extract, seven peaks are visible, each with a different R.T. and peak area.

Table 7: HPLC analysis of mangiferin content (mg/g)

Sample	Concentration (g/mL)	Retention Time (min)	Peak Area (LU*s)	Mangiferin Content (mg/g)
Standard mangiferin	0.001	14.164	1506.542	1000
Crude leaves extract	0.01	14.296	143.269	9.51
Dichloromethane fraction	0.01	14.286	637.637	42.325
Ethyl acetate fraction	0.03	14.286	4846.101	107.223
Purified mangiferin	0.8	14.103	1135.188	941.882

3.5.3 Antioxidant Activity of Purified Mangiferin

The purification was aided by the antioxidant activity of crude ethanol extract, ethyl acetate fractions, standard mangiferin, and purified mangiferin produced from UAE, as shown in Table 8. It is commonly known that assessing the biological activities of plant-based extracts, such as antioxidant and antimicrobial activity, can give crucial information about the extraction and purification procedures' efficacy. As a result of the findings of this investigation, it can be stated that the use of ultrasonic extraction, liquid–liquid fractionation, and column chromatography to generate mangiferin with a high antioxidant potential was successful. This combinatory process is therefore highly suggested for mangiferin extraction, due to the benefits of reduced energy and extraction time usage.

Table 8: Antioxidant activity of mangiferin in related samples

Sample	IC_{50} (µg/mL)	r^2
Standard mangiferin	16.383	0.9925
Crude leaves extract	27.522	0.9918
Vitamin C	2.551	0.9915
Ethyl acetate fraction	15.548	0.997
Purified mangiferin	13.841	0.9915

4. Conclusion

In conclusion, the findings of this study offer insight into the use of by-products from mango as a promising source of mangiferin extraction to reduce agricultural waste. For a desire of 0.93, the ideal extraction conditions in criollo mango peel were defined as 10 minutes at 54 °C. In previous studies stated that total phenols and mangiferin concentration, as well as ABTS and ORAC antioxidant activity, were found to be very close to the results predicted by the model when evaluating the ideal conditions in peel. It can be deduced from the foregoing that the ultrasonic extraction process in the mango peel was optimised. The peel has a high metabolite content and antioxidant activity, indicating that it might be used as a functional addition in juices, nectars, and other mango-based products. According to the current findings, freeze and fluidized bed drying procedures generated better dried mango slices with higher quality criteria. Pretreatments were discovered to be an effective way for preserving the colour and vitamin C content of dried mango fruits. Finally, one of the ways for controlling unwanted quality changes is to choose the proper pre-treatment during mango slice drying. Furthermore, pretreatments and drying procedures exhibited the potential to extend the shelf life of dried mango slice.

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