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Physicochemical Characteristics and Antioxidative Potential of Mahua (Madhuca Longifolia) Seed Oil: A Comprehensive Analysis

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ABSTRACT

A thorough evaluation of the qualities and health benefits of Mahua (Madhuca longifolia) seed oil is presented in the research that examines its physicochemical parameters and antioxidative potential. This study reveals the oil's nutrient rich profile by analyzing important metrics like density, peroxide levels, fatty acid content, and viscosity. Furthermore, tests that measure its ability to scavenge free radicals are used to investigate its powerful antioxidant properties. These findings suggest that Mahua seed oil may be a valuable natural resource for many different businesses, including those dealing with food, pharmaceuticals, and cosmetics, due to its oxidative stability and health-promoting properties.

Keywords: Seed, Oxidative, Physicochemical, Oil, Food.

INTRODUCTION

Native to the Indian subcontinent, the Mahua tree (Madhuca longifolia) is famous for the ecological and economic value it provides. Traditional rural communities have long relied on the oil extracted from Mahua seeds for a variety of purposes, including cooking, lighting, and even traditional medicine. Researchers have taken a keener interest in Mahua seed oil's bioactive components and physicochemical properties, especially its antioxidative capabilities, in the last few years. The oil, derived from the tree's seeds, has antioxidant and essential fatty acid properties that make it a potential contender for use in the culinary, pharmaceutical, and cosmetics sectors, among others. When it comes to edible oils, their physicochemical characteristics are what really matter when it comes to quality, shelf life, and industrial applicability. "Considerations such as the oil's fatty acid content, saponification value, iodine value, and peroxide value are essential for determining its nutritional and functional qualities. Due to its stable composition and balanced ratio of saturated to unsaturated fatty acids, the natural oil derived from mahaa seed is a great choice. The relatively high concentrations of oleic acid and palmitic acid in oils contribute to their resistance to oxidative degradation, resulting in a longer shelf life. In regions where Mahua trees are abundant, this oil could be used as a replacement since it is thick and has a viscosity comparable to other popular cooking oils." The antioxidative potential of Mahua seed oil is among the most appealing qualities that have attracted researchers, in addition to its fundamental physicochemical properties. Free radicals may cause oxidative stress, cell damage, and chronic illnesses including cancer, heart disease, and neurological problems; antioxidants neutralize these radicals. According to research, Mahua seed oil is rich in tocopherols, flavonoids, and phenolic compounds, all of which are natural antioxidants. Several in vitro studies have shown the potent free radical scavenging capability of the bioactive chemicals found in mahaja seed oil. This suggests that it could be useful as a dietary oil or in nutraceutical or cosmetic products that fight oxidative stress and promote health.

Additionally, there is a rising worldwide interest in sustainable and environmentally friendly alternatives to synthetic goods, which is aligned with the application of Mahua seed oil. This tree is perfect for sustainable oil production since it thrives in dry and semi-arid climates and needs little agricultural inputs. Mahua seed oil has a lot of promise because of the growing interest in health-promoting natural oils and the importance of environmentally responsible farming methods. Preservatives, functional food components, and bio-based cosmetics are just a few of the many potentials uses for the oil. In addition to demonstrating the oil's worth as a functional and nutritional supplement, this in-depth investigation of Mahua seed's physicochemical properties and antioxidant capacity paves the way for future studies of its possible industrial uses. This research adds to our knowledge of sustainable resources by highlighting the oil's health advantages and natural qualities, which may have an impact on local economies as well as global companies.

LITERATURE REVIEW

Mishra, Alok & Poonia, Amrita. (2019) The primary obstacle to the potential industrial use of Mahua flowers is their post-harvest deterioration, which occurs as a result of poor collecting and handling methods as well as unsanitary storage conditions. By enhancing its collection, handling, and pre-processing methods, its industrial-scale application may be expanded beyond liquor production to include a range of value-added and functional food items.

Munasinghe, Mihiri & Wansapala, Jagath. (2016) Oil may be extracted from Madhuca longifolia seed kernels in three different ways: solvent extraction, pressing, or a mix of the two. A yield of 52.22±0.63% was achieved by Soxhlet extraction with n-Hexane, which was the most beneficial outcome. An output of 25.95±0.82% was achieved with the use of the pressing technique. The percentage that was produced by the combined approach was 43.73±0.86%. We compared the oil's physical and chemical characteristics to those of coconut oil and looked at the results. A saponification value of 182.79±1.49 mg KOH/g was attained. The measured amount of iodine was 56.28±0.69 grams per 100 grams.

Gupta, Aditi et al., (2012) The most common species in the multifunctional genus Madhuca—which is part of the Sapotaceae family—are “Madhuca latifolia”, “M. longifolia”, and “M. butyracea”. Due to the extensive usage of almost every component of the tree, it is commercially significant. This study provides a comprehensive overview of mahua ecology, distribution, species, and many components and their applications, with a special emphasis on the flower, oil, and seed cake. Intoxicating liquor, nutraceuticals, and the treatment of skin ailments are all made possible by the use of flowers. Biodiesel made from mahua seed oil has been making a big splash as of late. About 60% of the seeds remain as de-oiled seed cake after the oil is extracted. Cake and its many uses are covered extensively in the article.

Yadav, Sangita et al., (2011) A total of 37 genotypes of Madhuca longifolia were examined for the sorts of oils and fatty acids they contained. The plants were cultivated in 13 districts throughout Tamil Nadu, India. “In fatty acid profile, oil content, iodine value, saponification value, cetane number, and O/L ratio, genotypes were strongly correlated.”

MATERIALS AND METHODS

Materials

The seeds of the Mahua plant, scientifically known as Madhuca longifloia, were bought in a market in central Sri Lanka. The seed coat was delicately removed by hand, and any seeds that were broken or moldy were thrown out. The seeds were left to air-dry at room temperature after being dusted. Using a hammer miller, they were then reduced to a mesh size of 1.4 mm or smaller. Lastly, they were stored at a temperature of -18 ◦C until they were required. Analytical or HPLC grade solvents and compounds were used throughout.

Conventional mechanical extraction (ME)

I measured up around 10 grams of seeds, placed them in the AOSIDA home oil press machine (made in China), and let it heat up for 5 minutes. To extract crude oil, press seeds at a temperature over 90 ◦C for 5 minutes and filter through a 50-μm mesh.

Mahua fruit oil characterization

Under these circumstances, oil was extracted from mahua seeds in the UAE with a yield of 56.77% and a recovery of 99.54% in terms of physicochemical qualities, oil composition, and phytonutrients. Cooked for 35 minutes at 35 ◦C in a combination of 20 g/mL seed, 40% water, and a 1:1 ratio of isopropyl alcohol to acetone. Next, the oil in question was contrasted with seed oils derived from SXE and ME.

Scanning Electron microscopy

A scanning electron microscope ("HITACHI SU8010, Japan") operating at 5 kV voltage at room temperature was used to examine the surface morphologies of mahua seed powder treated with UAE, ME, and SXE. Coating the samples with gold was done before they were loaded into the machine.

Statistical analysis

"All of the tests were run using at least two independent analyses. To illustrate the results, "the mean ± standard deviation" was used. In order to determine whether there was a significant difference at $p < 0.05$, the one-way ANOVA and the Tukey test were used."

RESULTS AND DISCUSSION

Physicochemical characteristics of oil extracted from mahua trees

In Table 1 you can see the physical and chemical properties of mahua oil. The oil obtained from the three processes has significantly different refractive index, iodine, and saponification values ($P < 0.05$), even if there is a little variation.

Table 1 The physical and chemical characteristics of mahua seed oil after extraction.

Method	Iodine value (I_2/100 g)	Saponification value (mg of KOH/g)	Acid value (mg KOH/g)	Free fatty acid (%)	Refractive index (25 ◦C)	Peroxide value (meq/kg)	p-anisidine value (meq/kg)	Color		
								L*	a*	b*
UAE	41.75 ± 1.31[a]	172.30 ± 0.32c	30.49 ± 0.10b	16.65 ± 0.07b	67.17 ± 0.94a	6.77 ± 0.42b	0.35 ± 0.20b	54.49a	— 2.47a	49.2a
SXE	43.73 ± 0.10[ab]	190.22 ± 2.56b	42.61 ± 3.27a	21.30 ± 1.63a	69.60 ± 0.46 ab	13.80 ± 1.01a	1.05 ± 0.30ab	4.9c	— 0.12b	1.89b
ME	43.08 ± 1.45[ac]	207.94 ± 3.33a	46.22 ± 0.12a	24.62 ± 0.03a	70.22 ± 0.05 ac	5.63 ± 0.37b	1.90 ± 0.33a	5.32b	— 0.20b	2.56b

While SXE and ME had higher hydrolytic stability, UAE oil had significantly lower free fatty acid and acid values ($p < 0.05$), indicating that it was more stable. Soxhlet extraction involves exposing oil to air for 8 hours, which may lead to a rise in FFA, but UAE extraction, which only takes 35 minutes, reduces hydrolysis since moisture is the major source of oil hydrolysis. In contrast to SXE and ME, which employ 80 ◦C, the UAE uses a lower temperature of 30 ◦C, which might slow down the oxidation process. In order to decrease autoxidation, the oil system's antioxidant activity—which includes the inherent capabilities of polyphenols and carotenes—is crucial. The UAE method successfully extracts and retains a higher concentration of carotenoids from mahua oil, which are responsible for the oil's signature yellow and red hues. The fact that UAE achieved much higher values for L*, a*(red), and b*(yellow) than SXE and ME lends credence to this.

SEM

Images of mahua seed powder treated with SXE, ME, and UAE may be seen in the scanning electron micrographs that follow. As seen in Figure 1, the cavitation effect causes the cell to rupture, resulting in the formation of a porous structure. With such a limited oil production, it is clear that the ME squeezing mechanism is insufficient to crack the cell and release further oil, as seen by the smooth surface in Fig. 2. The seed powder treated with SXE has a coarser surface than ME, indicating a larger yield from SXE; nevertheless, random pore development is not as noticeable as in UAE. One possible explanation for the improved antioxidant component extraction might be the damaging character of sonic cavitation, as seen in Figure 3.

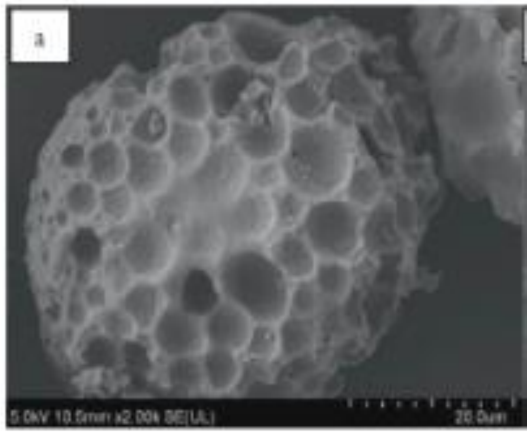

Figure 1. Scanning electron micrographs taken at a magnification of 2.00 k of UAE-sourced mahua seed powder.

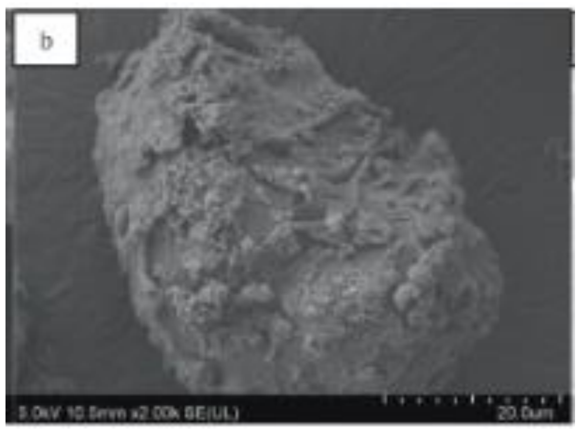

Figure 2. SEM pictures taken at a magnification of 2.00 k of mahua seed powder treated with SXE.

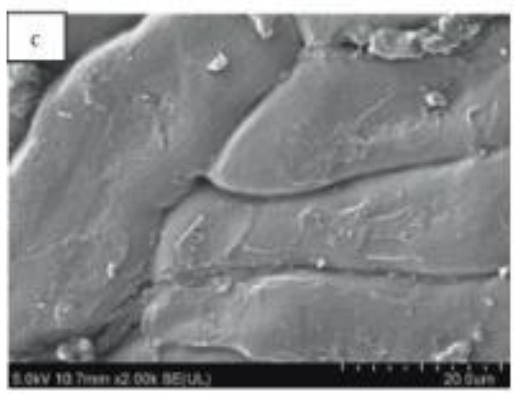

Figure 3. SEM pictures taken at a magnification of 2.00 k of mahua seed powder that has been treated with ME.

Antioxidant activity

TPC, free radical assays and FRAP

Even though the operating conditions in the UAE were softer than in SXE, the SEM pictures showed that the process of sonic cavitation could still provide yields that were almost as high as in SXE. Acoustic cavitation and gentle processing conditions worked together to increase antioxidant extractability without causing any damage. We also decided to test the extracted mahua oil's antioxidant capability because of the striking color difference we saw. So, to find out how much antioxidant power the extracted mahua seed oil has, we ran the TPC, ABTS, DPPH, and FRAP tests, and the findings are in Table 2.

Table 2 The outcomes of FRAP, TPC, DPPH (IC50), and ABTS (IC50) tests conducted on mahua oil derived using various methods.

Method	TPC (mg GAE/ kg of oil)	DPPH(IC50) (mg/mL)	ABTS(IC50) (mg/mL)	FRAP (mg Trolox/kg of oil)
UAE	303.82 ± 3.14a	106.64 ± 5.20c	37.82 ± 1.49c	1052.82 ± 19.15a
SXE	83.49 ± 1.58c	812.41 ± 2.22a	752.33 ± 0.26a	582.43 ± 57.54c
ME	120.10 ± 4.64b	625.36 ± 1.59b	394.85 ± 7.67b	713.26 ± 33.20b

With 301.81 mg GAE/kg of TPC obtained, which is more than three times that of SXE and more than twice that of ME, it is clear that the UAE is extracting an excess of polyphenols. Also, when tested against free radicals, antioxidant capacity followed suit. Since a lower sample concentration is required to scavenge the free radicals, an improved antioxidant activity is shown by a reduced IC50 value in DPPH and ABTS tests. The discovery that the DPPH IC50 values varied occurred in the following order: dose per milliliter The values for the UAE are 106.60, ME is 622.38, and SXE is 810. The ABTS IC50 values for the UAE, ME, and SXE were 39.80 mg/mL, 757.3 mg/mL, and 757.3 mg/mL, respectively. In contrast, FRAP determines antioxidant strength by the capacity to decrease the ferric Fe (III) ion to Fe(ll). An antioxidant with a higher reducing power is more effective. According to FRAP results, UAE oil has double the reducing power of SXE and a much greater power than ME. Based on the underlying mechanisms of each extraction process, it is not surprising that antioxidant tests consistently show that UAE-extracted mahua seed oil has the greatest and most profound antioxidant capacity, followed by mechanical and Soxhlet.

CONCLUSION

Mahua (Madhuca longifolia) seed oil has promising antioxidative potential and useful physicochemical characteristics, according to detailed research. This oil's abundance of beneficial fatty acids, natural antioxidants, and high oxidative stability make it very promising in many fields, including the cosmetics, food, and pharmaceutical sectors. In keeping with its sustainable production, it supports global efforts to promote eco-friendly alternatives. In this research, the health advantages and multipurpose nature of Mahua seed oil are highlighted. It encourages further research and development to find the best ways to use it in different industries.

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