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A Review on Recent Trends in Dates Seed Oil Production

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ABSTRACT: Cultivation plays a crucial role in Oman's agricultural sector, with date seeds emerging as a promising yet underutilized by-product. This literature review synthesizes recent research on date seed oil, focusing on its chemical composition, antioxidant properties, and potential for biofuel production. The review highlights various oil extraction techniques, including Soxhlet extraction, ultrasound-assisted extraction, and the use of novel green solvents such as protic ionic liquids. Key findings reveal that date seeds contain 4% to 13% oil and are rich in antioxidants, including tocopherols, tocotrienols, and oleic acid compounds. Additionally, various studies have demonstrated that date seed oil meets fuel standards, exhibits high thermal and oxidative stability, and offers favorable environmental benefits. Further research also suggests its applicability in the food, cosmetics, and pharmaceutical industries. Overall, the review underscores the economic and environmental advantages of utilizing date seed oil for sustainable bioenergy and industrial applications, while also identifying areas for future research, such as optimizing extraction methods and expanding commercial use.

Keywords: Dateseedoil, Biofuel, Fatty acid composition, Antioxidants, Biodiesel, Emission

1. Introduction

Due to growing interest in sustainable and value-added by-product utilization, agricultural importance has increased in recent years. Oman's output surpasses 3,000,000 metric tons, placing it in eighth place globally. In governance, around 7 million date palm trees are grown, with a yearly yield of 75%. However, humans consume half of the produced dates directly, with the remaining portion going to animal feed or ending up as agricultural trash including these items, which are frequently thrown away. Date seeds, or pits, have historically been regarded as low-value agricultural waste. Processing businesses face disposal issues because they are mostly used as animal feed or left unused. Recent studies, however, have recognized oils and fibers, creating new opportunities for their use. Substantial levels of unsaturated antioxidants, especially lauric and oleic ones, such phenolic compounds. In comparison to traditional fuels, date seed oil has advantageous physiochemical characteristics and emission profiles because of these attributes.

The growing interest in renewable and sustainable energy sources has prompted numerous studies into the techniques and industrial applications of date seed oil. In particular, its role as a second-generation biofuel has been highlighted through experimental engine tests, life-cycle assessments, and emission analyses. Beyond its fuel potential, the oil's antioxidant properties and thermal stability also indicate promising applications in food processing, cosmetics, and pharmaceuticals.

This literature review provides a comprehensive analysis of recent research focused on the

chemical characterization, oil extraction methods, biodiesel potential, and environmental implications of date seed utilization. The findings affirm the value of this agricultural by-product and support its integration into a circular bio economy model—particularly in date-producing countries like Oman.

2. Literature Review

Occupying half of Oman's cultivated land, the date palmstands as the principal agricultural crop, deeply ingrained in the nation's history. Beyond its long-standing role in meeting household needs and yielding by-products for animal husbandry and construction, there's a growing focus on processing dates into new products. Exciting experiments point towards the significant potential of date palms in creating novel products, such as biofuel [1].

Abdessalem Marabet et., al (2020) concluded that date seed oil, constituting 4% to 13% of the seed, holds promise as a functional oil source. The researchers found that the oil is composed of Saturated and unsaturated fattyacids, with lauric and oleic acids as the predominant ones. They also observed significant quantities of tocopherols, tocotrienols, phytosterols, and phenolic compounds. Their review further explored various extraction methods and the chemical composition of dates seedoil [2]

Abdessalem Marabet et al. (2020) reported that date seed oil, comprising 4% to 13% of the seed by weight, is a promising source of functional oil. Their research revealed that date seeds constitute 11% to 18% of the total fruit weight. The oil is rich in antioxidants and essential fatty acids, including oleic, myristic, palmitic, and linoleic acids. They also noted that the fatty acid composition varies among different date varieties [3]. Their study further evaluated multiple extraction methods and proposed applications for the oil in food, cosmetics, and industrial sectors.

Mortada A. conducted a Soxhlet extraction study to assess the economic feasibility of date seed oil as a biofuel source. His findings indicated that, compared to conventional oils, date seed oil holds considerable potential for biofuel applications due to its favorable properties and availability.

Farrukh Jamil et al. (2016) optimized the extraction process using experimental design and analysis of variance (ANOVA). Their study identified temperature as the most influential parameter affecting oil yield. Although their primary focus was on extraction efficiency, they highlighted the potential for further studies into biodiesel blending and engine performance [6].

Mohammad Kamil (2019) investigated biodiesel derived from desert palm species abundant in Oman. His research focused on optimizing production conditions, and biodiesel blends were tested across varying engine speeds (1600–3600 RPM) and load levels (50%, 75%, 100%). The biodiesel met international standards, with reductions in CO_2, CO, and HC emissions. However, NO_x emissions were elevated, suggesting a need for further emission control research.

Jawher (2019) found that date seeds contain between 3% and 16.7% oil, rich in fatty acids such as lauric, linoleic, palmitic, myristic, and predominantly oleic acid. The study highlighted the oil’s resistance to oxidation for up to 40 hours, indicating its suitability for frying and cooking applications [9].

Amna et al. (2019) examined the best seed size and extraction conditions for maximum oil recovery. Their study identified seeds within the 2–1 mm range as optimal and concluded that longer extraction durations enhanced yield, suggesting practical implications for commercial processing [10].

Saliha et al. (2023) investigated the production of ethanol, bio-oil, and biodiesel from date seeds. The study demonstrated that oil extraction acted as an effective pretreatment step to enhance total sugar protection, ultimately improving the efficiency of subsequent biofuel production. The research underscored the versatility of date seed-derived biofuels and promoted their sustainable role in waste management practices [11].

Herkat H. analyzed the chemical composition and antioxidant properties of date seed oil from eight different Algerian date varieties. The analysis revealed high antioxidant activity, attributed to significant concentrations of oleic, lauric, and myristic acids. Using Soxhlet extraction with 400 mL of n-hexane over 30 grams of ground date seeds, the study maintained a gradually increasing temperature during a 3-hour reflux. The extracted oil was stored in dark, refrigerated conditions for further phytochemical and antioxidant analysis, emphasizing the oil's potential in health-related applications [12].

Kamla S. Al-Mawali et al. (2021) developed a novel magnetic catalyst for the esterification of date seed oil, enabling efficient recovery and reuse. The catalyst showed excellent activity under optimized conditions and could be separated easily using a magnet. Notably, it maintained performance over five reuse cycles with minimal degradation, suggesting a cost-effective and sustainable solution for biodiesel production [13].

Rambabu (2023) employed ultrasound-assisted extraction to maximize biodiesel yield from date seed oil. Under optimal conditions—temperature at 52°C and a reaction time of 10 minutes—a biodiesel yield of 97.3% was achieved. ANOVA results confirmed that all process variables and their interactions significantly affected the yield, demonstrating the technique’s efficiency and scalability [14].

Abdessalem Mrabet et al. (2020) further emphasized the nutritional and industrial value of date seed oil, identifying a rich profile of unsaturated fatty acids, tocopherols, phytosterols, and phenolic compounds. Their comprehensive review highlighted various extraction methods and supported the oil's applicability in the food, cosmetic, and pharmaceutical sectors [15].

Mohammed Talhami et al. (year not specified) concluded that date pits, typically regarded as agro-industrial waste, contain between 7.6% and 10.9% oil, highlighting their potential as a sustainable feedstock for biofuel production. The study introduced a green and cost-effective extraction technique using protic ionic liquids, which achieved up to 84% oil recovery. The extracted oil, rich in oleic, lauric, myristic, and palmitic acids, demonstrated consistent composition across eight date varieties. Moreover, the method exhibited stable performance across multiple extraction cycles, offering a promising alternative to conventional toxic organic solvents [16].

Souhail et al. conducted a comparative analysis of the Deglet Nour and Allig date palm cultivars to assess their composition and oil characteristics. On a dry-weight basis, oil content was reported as 10.19% for Deglet Nour and 12.67% for Allig. Carbohydrates were identified as the predominant component. Oleic acid emerged as the dominant unsaturated fatty acid, while palmitic acid was the primary saturated fatty acid. Additional analyses of the oil's thermal, sensorial, and physical characteristics highlighted its simplicity and oxidative stability, reinforcing its potential for diverse applications [17].

Al-Hussain et al. (2025) investigated the polyphenol content, antioxidant activity, and oil yield of date seeds. Oil yields ranged from 10.21% to 12.69%, with oleic acid making up nearly 50% of the total fatty acid content. The oils also exhibited high antioxidant levels (41.1% to 63.2%), polyphenol content (274 to 302.5%), and vitamin E concentrations (16.68 to 19.2%). These characteristics suggest strong antimicrobial and therapeutic properties, supporting the oil’s application in food, cosmetics, and pharmaceutical industries [18].

Fahad Al Juhaimi et al. (2011) assessed oil extracted from seven different Saudi date seed varieties. The oil content ranged from 4.68% to 7.96%, while protein levels were between 3.47% and 3.71%. Oleic acid was identified as the dominant fatty acid. The seeds demonstrated high antioxidant activity (78.03 to 79.94 mg/mL) and total phenolic content (around 4.65 mg GAE/g). Furthermore, the seeds contained significant levels of essential minerals such as calcium, magnesium, potassium, and phosphorus,

indicating their potential for nutritional and industrial applications [19].

Nehdi et al. (2018) analyzed the physicochemical properties of oils from six Saudi date palm cultivars. The average oil content was 7%, with oleic acid being the predominant fatty acid (48.67%). The oils also had a high total tocopherol content (70.75 mg/100g), primarily composed of α-tocotrienol. The study found that the oils exhibited strong thermal and oxidative stability, making them suitable for culinary and food-processing applications [20].

3. Conclusions

The literature review comprehensively confirms the growing significance of date seeds as a valuable and underutilized by-product with promising industrial applications. As date cultivation dominates Oman's agricultural landscape, leveraging the potential of its by-products—particularly seeds—for value-added applications is both economically and environmentally strategic.

Multiple studies reviewed reveal that date seeds contain oil ranging between 4% and 13%, rich in fatty acids such as myristic, palmitic, and linoleic acids. The presence of tocopherols, tocotrienols, and phenolic compounds further enhances the value of date seed oil. Its thermal and oxidative stability, along with antimicrobial and anti-inflammatory properties, opens avenues for use not only in food processing and cosmetics but also in the pharmaceutical industry.

Research has also demonstrated the potential of date seed oil as a sustainable biofuel. Various extraction techniques—such as Soxhlet extraction, ultrasound-assisted extraction, and the use of green solvents like ionic liquids—have been explored to optimize oil yield and quality. Biodiesel produced from date seed oil meets international fuel standards and has shown promising results in engine performance and emission reduction.

Experimental studies, including those conducted locally in Oman, support the utilization of waste date seeds for bioenergy and other value-added products, aligning with national sustainability goals. This growing body of research advocates for transforming date seed waste into commercially viable resources. However, gaps remain in scaling up these findings, optimizing cost-effective extraction techniques, and fully integrating them into industrial processes.

In conclusion, scientific evidence confirms that date seed oil is a multifunctional resource aligned with Oman's circular economy and renewable energy ambitions. Future research should prioritize refining extraction methods, evaluating long-term engine performance with biodiesel blends, and expanding the scope of applications across various sectors.

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