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Comparative Study of Extracts from Phoenix dactylifera using Fourier Transform Infrared (FTIR) Spectroscopy: Unveiling Phytochemical Diversity

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Abstract **Original Research Article**

A comparative study of extracts from Phoenix dactylifera (date palm) fruits was conducted using Fourier Transform Infrared (FTIR) spectroscopy to unveil the phytochemical diversity. The fruits were extracted using ethanol, ethyl acetate, butanol, and water, and the resulting extracts were analyzed for their functional groups. FTIR analysis revealed the presence of various functional groups, including O-H, C-H, C≡C, C-O, and N-H, indicating the presence of phenolic compounds, alkaloids, and other bioactive molecules. The ethanolic extract (EFPD) showed strong O-H stretching vibrations (3265.1 cm^{-1}), while the ethyl acetate extract (EAPD) exhibited C=O stretching vibrations (1707.1 cm^{-1}). The butanol extract (BFPD) displayed C≡C stretching vibrations (2109.7 cm^{-1}), and the aqueous extract (AFPD) showed O-H stretching vibrations (3332.2 cm^{-1}). The results suggest that P. dactylifera extracts possess a rich phytochemical profile, warranting further exploration for potential applications.

Keywords: Phoenix dactylifera, FTIR, Extracts, Phytochemicals.

Introduction

Phoenix dactylifera, commonly known as the date palm, is a widely cultivated plant in arid and semi-arid regions, renowned for its nutritional and medicinal values (Al-Farsi & Lee, 2008). The date palm is a rich source of bioactive compounds, including phenolic acids, flavonoids, and alkaloids, which have been reported to possess antioxidant, antimicrobial, and anti-inflammatory properties (Baliga et al., 2011; Vayalil, 2012). The phytochemical composition of P. dactylifera has been extensively studied, revealing a diverse range of compounds with potential health benefits (Al-Farsi et al., 2005; Mansouri et al., 2005).

The extraction of bioactive compounds from plant materials is a crucial step in the discovery and development of new pharmaceuticals, nutraceuticals, and cosmeceuticals (Chemat et al., 2012). Various extraction methods, including solvent extraction, supercritical fluid extraction, and microwave-assisted extraction, have been

employed to recover bioactive compounds from P. dactylifera (Abbas et al., 2015; Al-Farsi & Lee, 2008). However, the choice of extraction solvent and method can significantly impact the yield and composition of the extracted compounds (Chemat et al., 2012).

Fourier Transform Infrared (FTIR) spectroscopy is a widely used analytical technique for the identification and characterization of functional groups in plant extracts (Eberhardt et al., 2007). FTIR spectroscopy provides a rapid and non-destructive means of analyzing the chemical composition of plant extracts, allowing for the identification of specific functional groups and the monitoring of changes in the chemical composition of extracts (Kumar et al., 2013).

This study aimed to compare the phytochemical diversity of P. dactylifera extracts obtained using different solvents, including ethanol, ethyl acetate, butanol, and water, using FTIR spectroscopy.

Materials and Methods

Preparation and extraction plant materials

The dry fruits of *P. dactylifera* (PD) was air-dried at room temperature (between 25-27 ^{o}C) for 4 weeks and sun-dried (between 32-35 ^{o}C) for 1week respectively. The dried fruits of PD (without the pits) were milled using a Hammer mill. The milled sample was stored in air-tight container prior to usage. 4 Kg of the milled *P. dactylifera* was weighed and subjected to extraction by maceration in 25 liters of ethanol (96 %) for 72 hours 3 times consecutively. The mixture was filtered using cheese cloth and then concentrated to dryness under reduced pressure using a rotary evaporator (Adebayo *et al*., 2010). Dried samples were refrigerated (4 ^{o}C) and kept for FTIR scanning.

Fourier-Transform Infrared Spectroscopy (FTIR) evaluations

The functional groups present in the extracts of PD were evaluated using FTIR as described by Ragavendran, Sophia, Arul, and Gopalakrishnan, (2011). Each sample (1 µl) was loaded in FTIR spectroscope with scan range 4000 – 650 cm^{-1}, resolution 8 cm^{-1} and background scans of 32.

Results

FTIR analysis of the crude extract and solvent fractions of PD led to the identification of some functional groups. Identification was done by comparison of the wave numbers obtained with a standard Infrared Spectroscopy Absorption Table (chem.libretexts.org). The bands identified with their corresponding functional groups for ethanolic (EFPD), ethyl acetate (EAPD), butanol (BFPD) and aqueous (AFPD) fractions are presented in Tables 1, 2, 3 and 4 respectively while their FTIR spectra are presented in fig. 1-4.

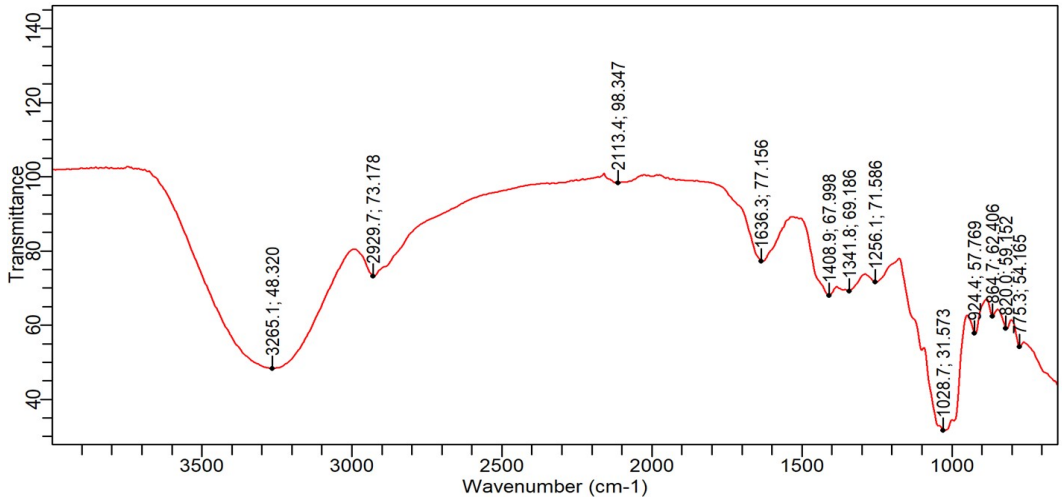

Figure 1: FTIR Spectrum of EFPD

Table 1: Identified bands and functional groups obtained from the FTIR spectrum of EFPD

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (carboxylic acid) O-H (alcohol) N-H (amine)	3265.1	Strong, broad/stretching
C-H (alkane) O-H (alcohol) N-H (amine salt)	2929.7	Strong, sharp/stretching
C≡C (alkyne) N=C=S (isothiocyanate)	2113.4	Strong, sharp/stretching
C-O (amino acids) C=C (alkene)	1636.3	Strong, sharp/stretching
S=O (sulfonyl chloride) O-H (alcohol)	1408.9	Medium/stretching
N-O (nitro compound) C-N (amine)	1341.8	Weak/bending
C-O (ether) C-N (amine)	1256.1	Weak/stretching
C-O (vinyl ether) C-N (amine)	1028.7	Medium/stretching
=C-H (alkene)	924.4	Medium/stretching
C-O (primary alcohol)	864.7	Weak/bending
C=C (alkene)	820.0	Weak/bending
C=C (alkene)	775.3	Weak/bending

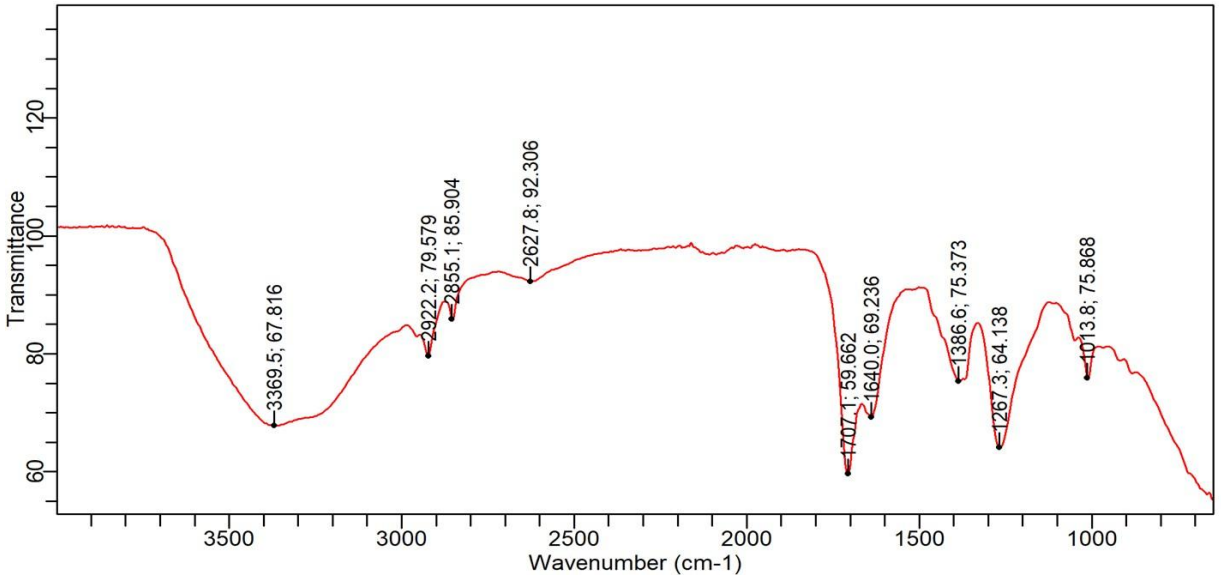

Figure 2: FTIR Spectrum of EAPD

Table 2: Identified bands and functional groups obtained from the FTIR spectrum of EAPD

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (alcohol) N-H (primary amine)	3369.5	Strong, broad/stretching
C-H (alkane) O-H (alcohol) N-H (amine salt)	2922.2	Medium, sharp/stretching
C-H (alkane) N-H (amine salt)	2855.1	Strong, sharp/stretching
O-H (carboxylic acid) S-H (thiol compound)	2627.8	Medium/stretching
C=O (conjugated acid halide) C=O (aldehyde)	1707.1	Weak/stretching
C-O (amino acids) C=C (alkene)	1640.0	Medium/bending
N-O (nitro compound) C-N (amine)	1386.6	Medium/stretching
C-O (ether) C-N (amine)	1267.3	Medium/stretching
C-O (vinyl ether) C-N (amine)	1013.8	Medium/stretching

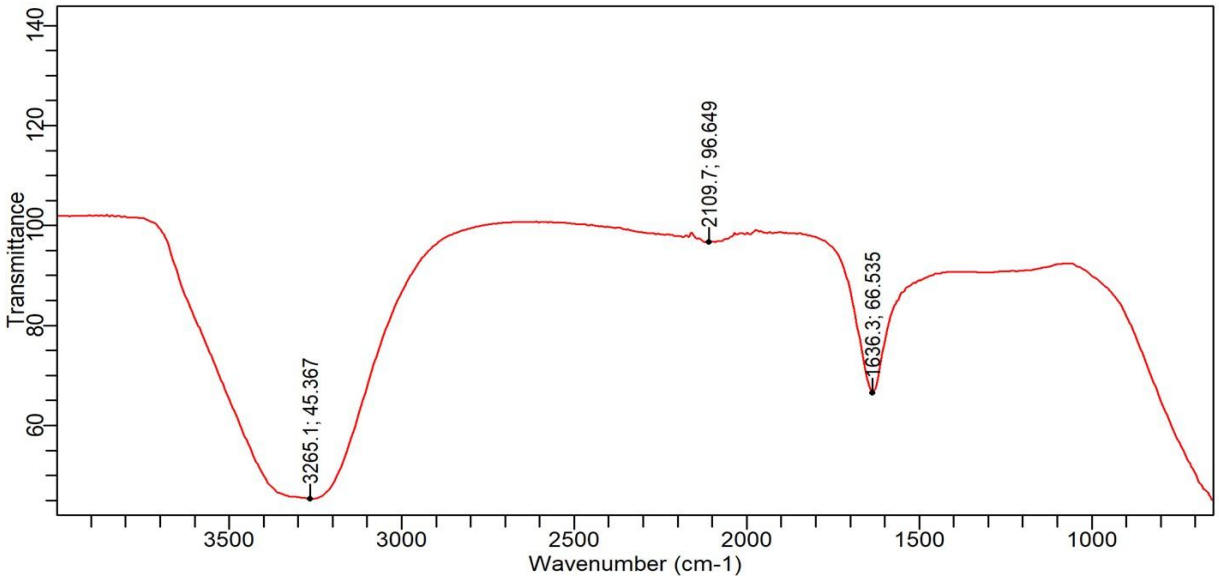

Figure 3: FTIR Spectrum of BFPD

Table 3: Identified bands and functional groups obtained from the FTIR spectrum of BFPD

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (carboxylic acid) O-H (alcohol) N-H (amine)	3265.1	Strong, broad/stretching
C≡C (alkyne) N=C=S (isothiocyanate)	2109.7	Medium/stretching
C-O (amino acids) C=C (alkene)	1636.3	Medium/stretching

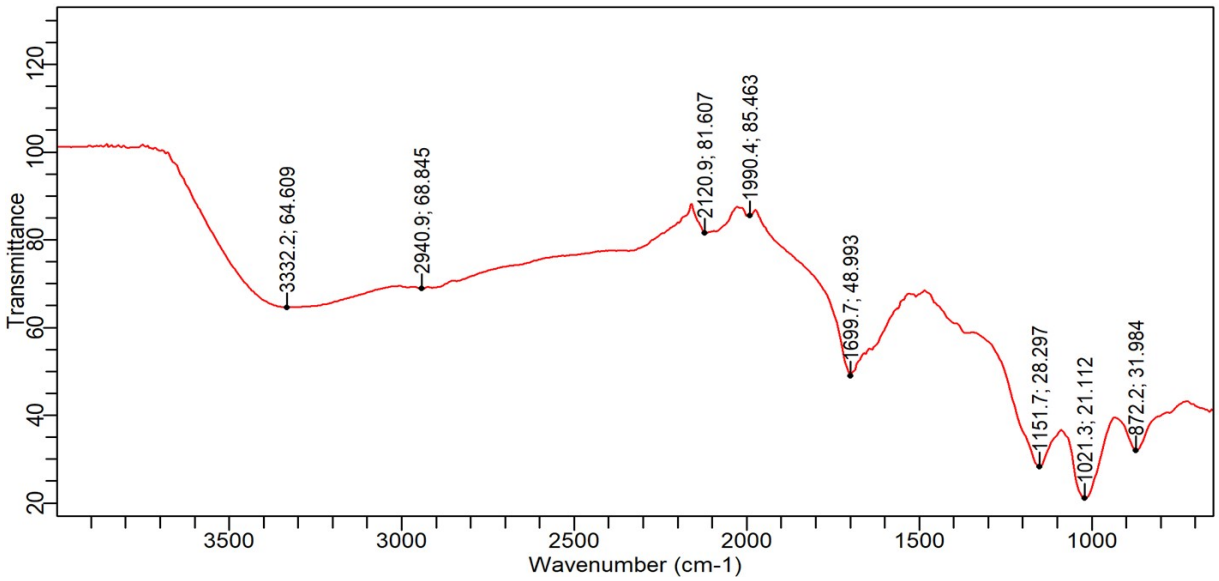

Figure 4: FTIR Spectrum of AFPD

Table 4: Identified bands and functional groups obtained from the FTIR spectrum of AFPD

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (alcohol) N-H (primary amine) C-H (alkyne)	3332.2	Strong, broad/stretching
C-H (alkane) O-H (alcohol) N-H (amine salt)	2940.9	Medium/stretching
C≡C (alkyne)-	2120.9	Weak/stretching
C-H (aromatic compound)	1990.4	Weak/bending
C-O (conjugated aldehyde)	1699.7	Weak/stretching
C-O (aromatic ether)	1151.7	Medium/bending
C-O (vinyl ether) C-N (amine)	1021.3	Medium/stretching
C=C (alkene)	872.2	Medium/bending

Discussion

The FTIR analysis of P. dactylifera extracts revealed a diverse range of functional groups, indicating the presence of various bioactive compounds. The identified functional groups, such as O-H, C-H, and C-O, are commonly associated with phenolic compounds, flavonoids, and alkaloids. These compounds are known for their antioxidant, antimicrobial, and medicinal properties. The presence of these functional groups suggests that P. dactylifera extracts may have potential applications in the pharmaceutical, food, and cosmetic industries. The variation in functional groups across different extracts highlights the importance of selecting the optimal solvent for extraction to target specific bioactive compounds. For instance, the ethanolic extract (EFPD) showed strong O-H stretching vibrations, indicating a high content of phenolic compounds, while the ethyl acetate extract (EAPD) exhibited C=O stretching vibrations, suggesting a higher content of carbonyl-containing compounds.

Conclusion

This study demonstrates the phytochemical diversity of P. dactylifera extracts, highlighting their potential as a source of bioactive compounds. The identified functional groups provide a basis for further research into the specific compounds responsible for the observed bioactivities. Further studies are necessary to isolate, characterize, and evaluate the biological activities of these compounds, paving the way for their potential applications in various industries. The findings of this study suggest that P. dactylifera extracts may be a valuable resource for the development of natural products with medicinal and industrial applications.

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