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

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Abstract **Original Research Article**

This study investigates the phytochemical diversity of Prunus africana extracts using Fourier Transform Infrared (FTIR) spectroscopy. Ethanolic, butanolic, ethyl acetate, and aqueous extracts were analyzed, revealing distinct spectral patterns and functional groups. The FTIR spectra showed peaks for O-H, C-H, C-N, C-O, and =C-H groups, with specific extracts exhibiting unique functional groups such as N-H, C≡C, C-O, and S=O. The findings demonstrate the effectiveness of FTIR spectroscopy in characterizing and comparing phytochemical profiles, providing valuable insights into the chemical composition of P. africana. The study highlights the potential of FTIR spectroscopy for quality control and standardization of plant extracts, which is essential for ensuring the efficacy and safety of phytomedicines. The results lay the groundwork for further studies on the potential applications of P. africana in medicine, agriculture, and other fields.

Keywords: Prunus africana, FTIR, Extracts, Phytochemicals.

Introduction

Prunus africana, a medicinal plant native to Africa, has been traditionally used for centuries to treat various ailments, including prostate disorders and inflammation (Cunningham & Mbenkum, 1993, Begeno & Teka, 2019, Fabricant & Farnsworth 2001, Katiyar *et al*., 2012, Madivoli, *et al*., 2018). The plant's bark, in particular, is rich in phytochemicals, such as flavonoids, phenolic acids, and sterols, which are believed to contribute to its therapeutic properties (Lewak & Pieniazek, 1969). With the growing interest in natural products and phytomedicine, there is a need for comprehensive studies (Sasidharan *et al*., 2011, Ivanović *et al*., 2020, Uba *et al*., 2020, Elya, 2023) on the phytochemical composition of *P. africana* extracts.

Fourier Transform Infrared (FTIR) spectroscopy is a powerful analytical technique that provides valuable information on the molecular structure and composition of plant extracts (Schultz &

Baranska, 2007, Zhang *et al*., 2015, Ulpathakumbura *et al*., 2023). By analyzing the FTIR spectra of *P. africana* extracts, researchers can identify specific functional groups and molecular bonds, which can be used to compare the phytochemical profiles of different extracts. This comparative study investigates the phytochemical diversity of *P. africana* extracts using FTIR spectroscopy with different solvents for extraction. The choice of solvent plays a crucial role in extracting phytochemicals from plant materials (Zhang *et al*., 2018). Different solvents have varying polarities, which affect the extraction efficiency of specific compounds. Ethanol is a polar solvent that effectively extracts phenolic compounds and flavonoids. Acetone being an intermediate polarity solvent extracts a range of phytochemicals. Hexane is a non-polar solvent that extracts lipophilic compounds. Butanol is another organic solvent that can effectively extract a range of phytochemicals, including phenolic compounds and flavonoids. Aqueous solvents, such as water, are commonly used for extracting phytochemicals that are soluble in water. Aqueous extracts can contain polar compounds such as glycosides, polysaccharides, flavonoid glycosides and phenolic acids. Organic and aqueous solvents are valuable tools for extracting phytochemicals from plant materials. The choice of solvent depends on the specific application and the desired phytochemical profile. This work will compare the FTIR spectra of different extracts (using different solvents) to identify similarities and differences in their functional groups and evaluate the potential of FTIR spectroscopy as a tool for quality control and standardization of *P. africana* extracts. The findings will also highlight the utility of FTIR spectroscopy in the analysis and standardization of plant extracts, which is essential for ensuring the quality and efficacy of phytomedicines.

Materials and Methods

Preparation and extraction plant materials

P. africana (PA) leaves were and air-dried at room temperature (between 25-27 ^{o}C) for about 4 weeks and subsequently sun-dried (between 32-35 ^{o}C) for another week. The dried samples of PA were milled to fine powder with the aid of a kitchen blender. Afterwards, the milled samples were stored separately in air-tight containers. 2 kg of milled PA was extracted by maceration in 15 liters of ethanol (96 %) for 72 hours 3 times consecutively. The same weight (2 kg) of samples were subjected to same process using butanol, ethyl acetate, and water respectively. Thereafter, filtration was done separately 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 PA 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 and Discussion

FTIR evaluations of *P. africana*

FTIR analysis of the crude extract and solvent fractions of PA 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 (ELPA), butanol (BLPA), ethyl acetate (EAPA) and aqueous (ALPA) fractions are presented in Tables 1, 2, 3 and 4 respectively while their FTIR spectra are presented in fig. 1-4.

ETHANOLIC PA

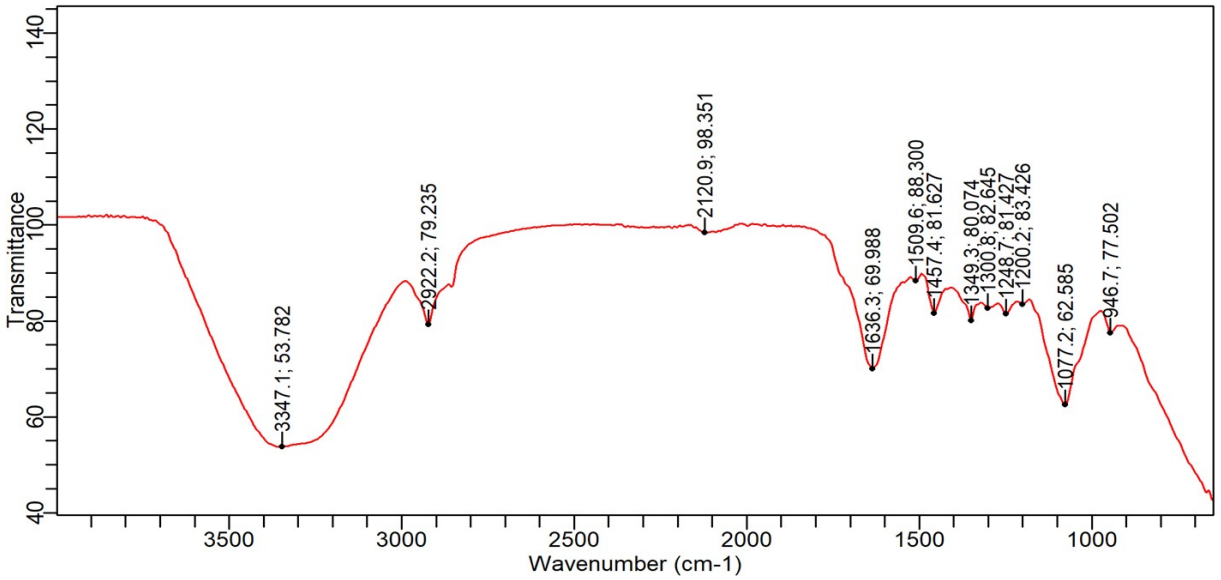

Figure 1: FTIR Spectrum of ELPA

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

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (alcohol) N-H (primary amine)	3347.1	Strong, broad/stretching
C-H (alkane) N-H (amide)	2922.2	Medium/stretching
C≡C (alkyne)-	2120.9	Weak/stretching
C-O (amino acids) C=C (alkene)	1636.3	Medium/stretching
N-O (nitro compound) C=H (aromatic)	1509.6	Weak/stretching
C=H (aromatic)	1457.4	Medium/bending
N-O (nitro compound) C-N (amine)	1349.3	Medium/stretching
N-O (nitro compound) C-F (alkyl halide)	1300.8	Medium/stretching
C-O (ether) C-F (alkyl halide) C-N (amine)	1248.7	Medium/bending
C-O (ether) C-F (alkyl halide) C-N (amine)	1200.2	Weak/bending
C-O (ether) C-F (alkyl halide) C-N (amine) =C-H (alkene)	1077.2	Strong/bending
=C-H (alkene)	946.7	Weak/bending

BUTANOLIC PA

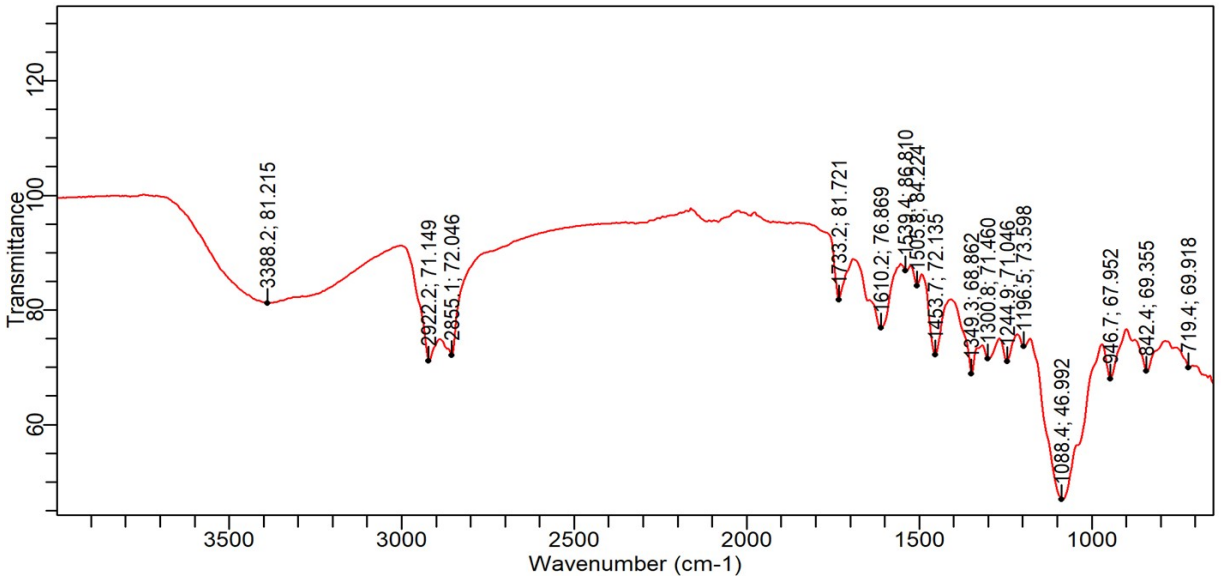

Figure 2: FTIR Spectrum of BLPA

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

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (alcohol) N-H (primary amine)	3388.1	Strong, broad/stretching
C-H (alkane) N-H (amide)	2922.2	Strong, sharp/stretching
C-H (alkane) N-H (amine salt)	2855.1	Strong, sharp/stretching
C=O (conjugated acid halide) C=O (aldehyde)	1733.2	Strong, sharp/stretching
C=C (conjugated alkene)	1610.2	Medium/stretching
N-O (nitro compound)	1539.4	Weak/stretching
N-O (nitro compound) C=H (aromatic)	1505.8	Weak/stretching
C=H (aromatic)	1453.7	Medium/bending
N-O (nitro compound) C-N (amine)	1349.3	Medium/bending
N-O (nitro compound) C-F (alkyl halide)	1300.8	Medium/stretching
C-N (amine) C-O (ether) C-F (alkyl halide)	1244.9	Medium/stretching
S=O (sulfate) S=O (sulfonyl chloride)	1196.5	Weak/bending
=C-H (alkene) C-N (amine) C-O (ether) C-F (alkyl halide)	1088.4	Weak/bending

=C-H (alkene)	**946.7**	**Weak/bending**
C=C (substituted alkene)	**842.4**	**Weak/bending**
C=C (substituted alkene)	**719.4**	**Weak/bending**

ETHYL ACETATE PA

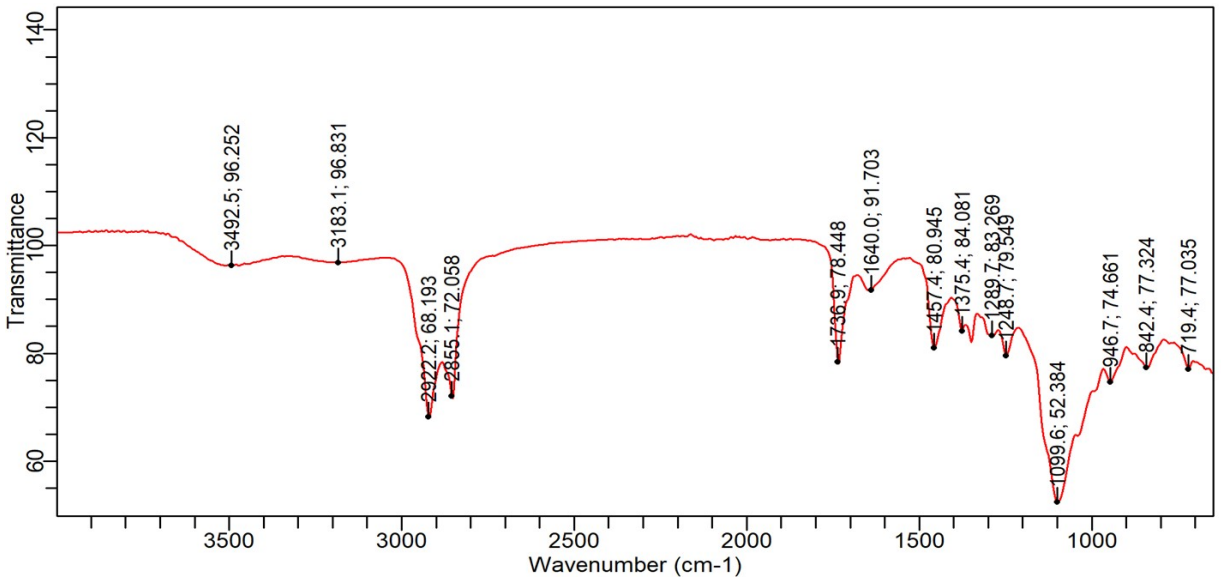

Figure 3: FTIR Spectrum of EAPA

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

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (alcohol) **N-H (primary amine)**	**3492.5**	**Medium, broad/stretching**
O-H (carboxylic acid) **N-H (amine salt)**	**3183.1**	**Medium, broad/stretching**
C-H (alkane) **N-H (amide)**	**2922.2**	**Strong, sharp/stretching**
C-H (alkane) **N-H (amine salt)**	**2855.1**	**Strong, sharp/stretching**
C=O (conjugated acid halide) **C=O (aldehyde)**	**1736.9**	**Strong, sharp/stretching**
C=N (imine/oxime) **C=C (conjugated alkene)**	**1640.0**	**Medium/bending**
C=H (aromatic)	**1457.4**	**Medium/bending**
O-H (carboxylic acid) **O-H (phenol)**	**1375.4**	**Medium/bending**
N-O (nitro compound)	**1289.7**	**Medium/stretching**
C-N (amine)	**1248.7**	**Medium/stretching**
C-O (ether) **C-N (amine)**	**1099.6**	**Weak/bending**

=C-H (alkene)	**946.7**	**Weak/bending**
C=C (alkene)	**812.4**	**Weak/bending**
C=C (substituted alkene)	**719.4**	**Weak/bending**

AQUEOUS PA

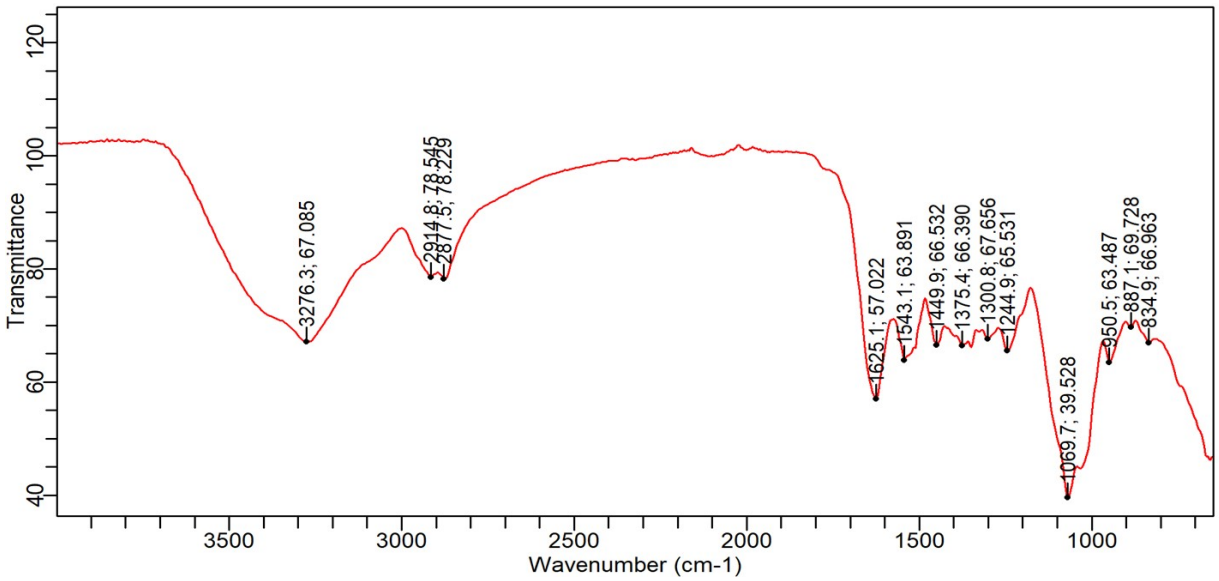

Figure 4: FTIR Spectrum of ALPA

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

Functional groups	Wave number (cm^{-1})	Strength/vibration type
O-H (carboxylic acid) **O-H (alcohol)**	**3276.3**	**Strong, broad/stretching**
C-H (alkane) **O-H (alcohol)**	**2914.8**	**Strong, sharp/stretching**
C-H (alkane) **O-H (alcohol)**	**2877.5**	**Strong, sharp/stretching**
C-O (amino acids) **C=C (alkene)**	**1625.1**	**Strong, sharp/stretching**
N-O (nitro compound)	**1543.1**	**Medium/stretching**
C-H (alkane)	**1449.9**	**Weak/bending**
C-H (alkane)	**1375.4**	**Weak/stretching**
N-O (nitro compound) **C-F (alkyl halide)**	**1300.8**	**Medium/stretching**
C-N (amine) **C-O (ether)** **C-F (alkyl halide)**	**1244.9**	**Medium/stretching**
C-O (primary alcohol)	**1069.7**	**Weak/bending**

=C-H (alkene)	**950.5**	**Weak/bending**
=C-H (alkene)	**887.1**	**Weak/bending**
C=C (substituted alkene)	**834.9**	**Weak/bending**

The FTIR spectra obtained were in agreement with literature. Comparison of the spectra showed peaks for O-H (alcohol) between 3276 and 3493 cm^{-1}. Peaks for C-H (alkane), C-N (amine), C-O (ether), and =C-H (alkene) were observed for all extracts while N-H bonds were revealed in the spectra of ELPA, BLPA, and EAPA but not in ALPA. A weak stretching of C≡C (alkyne) and medium stretching of C-O (amino acids) were only noticed in ELPA but were not present in the other extracts. C=C (alkene), N-O (nitro compound), and C=H (aromatic) were observed in ELPA and EAPA with N-O also revealed in ALPA and C=H also revealed in BLPA. C-F (alkyl halide) w observed in ELPA, BLPA and ALPA. N-H (amine salt), C=O (conjugated acid halide), C=O (aldehyde), and C=C (conjugated alkene) was revealed in BLPA and EAPA. S=O (sulfonyl chloride) and S=O (sulfate) was observed only in BLPA, C=N (imine/oxime) and O-H (phenol) was observed only in EAPA, and C-O (primary alcohol) was only revealed in the spectra of ALPA. C=C (substituted alkene) and O-H (carboxylic acid) was observed in both EAPA and ALPA with C=C (substituted alkene) also revealed in the BLPA.

Conclusion

This study demonstrates the phytochemical diversity of *Prunus africana* extracts using FTIR spectroscopy. The comparative analysis of the FTIR spectra revealed a range of functional groups, including hydroxyl, alkyl, amine, ether, and alkene groups, which were present in all extracts. Notably, distinct spectral patterns were observed for each extract, highlighting their unique phytochemical profiles. The presence of various functional groups, such as N-H, C≡C, C-O, and S=O, in specific extracts suggests the diversity of bioactive compounds present in *Prunus africana*. These findings provide valuable insights into the chemical composition of *Prunus africana* and lay the groundwork for further studies on its potential applications in medicine, agriculture, and other fields. The FTIR spectroscopy technique proved to be a useful tool for characterizing and comparing the phytochemical profiles of different extracts, and its application can be extended to other plant species. The findings demonstrate the effectiveness of FTIR spectroscopy in characterizing and comparing phytochemical profiles, providing valuable insights into the chemical composition of this medicinal plant.

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