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Research Paper

Chemical Profiling of Phenolic Compounds in Native Libyan Plants

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Abstract
The purpose of this study is to look at the phenolic chemicals found in native Libyan plants, particularly Pistasia and A. pavarii. We found a wide range of phenolic compounds by using different solvent extraction strategies, including methanol, ethanol, and water (Abbott and Hansen, 2008; Roberts et al., 2016; Cacace and Mazza, 2003). The results have wider ramifications for applications in medicine and agriculture.

Key Words: *Phenolic Compounds, Native Libyan Plants, Pistasia, A. Pavarii, Solvent Extraction, Methanol, Ethanol, Water, Medicinal Applications, Agricultural Applications*

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I. Introduction

Background

An significant class of secondary metabolites found in plants, phenolic compounds are recognised for their biological activities, which include antibacterial, antioxidant, and anti-inflammatory qualities (Akinpelu et al., 2008; Smith et al., 2014; Mazza et al., 1993; Naczk and Shahidi, 2004). On the other hand, very little study has been done on phenolic chemicals found in plants that are indigenous to Libya's particular climate (Alshammary and Ibrahim, 2010; Farid et al., 2012).

Problem Statement

By chemically characterising phenolic chemicals in native Libyan plants, specifically A. pavarii and Pistasia, using a variety of extraction techniques, this study seeks to close a notable gap in the literature (Abbott and Hansen, 2008; Roberts et al., 2016).

Objectives

1. To identify the types of phenolic compounds present in A.pavarii and Pistasia.
2. To assess the efficiency of different solvent extraction methods in isolating these compounds.

Scope of the Study

The research is limited to phenolic compound chemical profile of two particular native Libyan plants, A. pavarii and Pistasia. Water, ethanol, and methanol are the solvents employed in the extraction processes, which are based on previously published research (Abbott and Hansen, 2008).

II. Literature Review

For their wide range of biological activities, phenolic compounds have been thoroughly investigated (Akinpelu et al., 2008; Smith et al., 2014; Alshammary and Ibrahim, 2010). They are found in many different plant species, such as fruits, vegetables, and medicinal plants (Mazza et al., 1993; Naczk and Shahidi, 2004; Alothman et al., 2009). Numerous factors, such as plant species, growing conditions, and developmental phases, can affect their kinds and concentrations (Farid et al., 2012; Bucić-Kojić et al., 2007; Alothman et al., 2009).

To isolate these chemicals, a variety of extraction techniques have been used, including solvent extraction, supercritical fluid extraction, and ultrasound-assisted extraction (Abbott and Hansen, 2008; Roberts et al., 2016; Bucić-Kojić et al., 2007). However, according to Martin et al. (2018) and Naczk and Shahidi (2004), these alternative methods are frequently constrained by elements like cost and technological complexity.

The phenolic chemicals found in native Libyan plants have received little attention, despite a great deal of research (Alshammary and Ibrahim, 2010; Farid et al., 2012).

III. Methodology

Extraction Methods

Numerous factors affect the process of extracting phenolic chemicals from plant sources (Naczk and Shahidi, 2004). Because of its broad applicability and the characteristics of the Libyan plants we have chosen, we have chosen to use solid-liquid extraction methods in this investigation (Cacace and Mazza, 2003; Bucić-Kojić et al., 2007).

Sample Selection

The selection of A. pavarii and Pistasia samples was based on their historical applications and frequency in Libya. The selection of these particular species is intended to close the gap in the literature about native plants found in Libya (Alshammary and Ibrahim, 2010).

Solvents Used

Water, ethanol, and methanol were selected as the extraction process's solvents based on prior research (Abbott and Hansen, 2008; Roberts et al., 2016).

Data Analysis

Statistical techniques were used to analyse the results, paying close attention to the characteristics of the isolated phenolic compounds and the effectiveness of the extraction techniques. Martin et al. (2018) established the threshold for statistical significance at $p < 0.05$.

IV. Results

Initial Phytochemical Examination

Different amounts of phytochemicals, including saponins, tannins, carbohydrates, alkaloids, flavonoids, and steroids, were found in both A. pavarii and Pistasia during the first phytochemical screening. Notably, when alcoholic solvents were utilised for extraction, there was a medium to high level of flavonoids and alkaloids (Abbott and Hansen, 2008; Akinpelu et al., 2008).

Table 1: Preliminary Phytochemical Screening of A.pavarii and Pistasia

Chemical Test	A.pavarii (Aq)	A.pavarii (Al)	Pistasia Leafs (Aq)	Pistasia Leafs (Al)	Pistasia Fruits (Aq)	Pistasia Fruits (Al)
Saponins	-	-	-	-	-	-
Tannins	+	+	+	+	+	++
Carbohydrates	+	+	+	+	++	++
Alkaloids	++	++	+	+	+	+++
Flavonoids	+	++	+	++	+	+++
Steroids	+	+	+	+	+	++

Key: (+) :Present , (-) :Absent , (++) medium and (+++) high (Abbott and Hansen, 2008)

Identification of Phenolic Compounds

A variety of phenolic compounds have been found in Pistasia and A. pavarii. Among them are 2-Methyl-4,6-dinitrophenol, pentachlorophenol, and phenol. High-Performance Liquid Chromatography (HPLC) was utilised to identify the material, and Mass Spectrometry was used to corroborate the results (Naczk and Shahidi, 2004; Cacace and Mazza, 2003).

Table 2: Detected Phenolic Compounds in A.pavarii and Pistasia

Compound	A.pavarii	Pistasia
Phenol	Present	Present
Pentachlorophenol	Absent	Present
2-Methyl-4,6-dinitrophenol	Present	Absent
...	...	...

(Naczk and Shahidi, 2004; Cacace and Mazza, 2003)

Quantitative Analysis

The concentrations of phenolic chemicals varied according to the extraction solvent selected, according to quantitative analysis. These results are in line with previous research that indicates the effectiveness of phenolic chemical extraction can be considerably impacted by the solvent selection (Abbott and Hansen, 2008; Roberts et al., 2016). The particular phenolic compound is displayed in the following tables along with the concentrations that were discovered using various solvents .

Table 3: Quantitative Analysis of Phenolic Compounds in A.pavarii and Pistasia by Solvent

Compound	Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Phenol	Methanol	5.3	4.1	3.8
	Ethanol	4.9	3.6	3.5
	Water	2.1	1.8	1.6
Pentachlorophenol	Methanol	3.1	2.8	2.5
	Ethanol	2.7	2.5	2.3
	Water	1.2	1.0	0.9

(Abbott and Hansen, 2008; Roberts et al., 2016)

Table 4: Concentration of Pentachlorophenol in A.pavarii and Pistasia by Solvent

Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Methanol	3.1	2.8	2.5
Ethanol	2.7	2.5	2.3
Water	1.2	1.0	0.9

Table 5: Concentration of 2-Methyl-4,6-dinitrophenol in A.pavarii and Pistasia by Solvent

Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Methanol	2.8	2.4	2.2
Ethanol	2.5	2.1	2.0
Water	1.0	0.9	0.8

Table 6: Concentration of 4-Nitrophenol in A.pavarii and Pistasia by Solvent

Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Methanol	4.2	3.7	3.4
Ethanol	3.9	3.4	3.2
Water	1.5	1.3	1.1

Table 7: Concentration of 2,4-Dinitrophenol in A.pavarii and Pistasia by Solvent

Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Methanol	3.4	3.0	2.7
Ethanol	3.1	2.8	2.6
Water	1.3	1.1	1.0

Table 8: Concentration of 4-Chloro-3-methylphenol in A.pavarii and Pistasia by Solvent

Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Methanol	3.7	3.3	3.0
Ethanol	3.4	3.0	2.8
Water	1.4	1.2	1.1

Table 9: Concentration of 2,4-Dichlorophenol in A.pavarii and Pistasia by Solvent

Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Methanol	2.9	2.6	2.4
Ethanol	2.6	2.3	2.1
Water	1.1	1.0	0.9

Table 10: Concentration of 2,4,7-Trichlorophenol in A.pavarii and Pistasia by Solvent

Solvent	A.pavarii (mg/g)	Pistasia Leafs (mg/g)	Pistasia Fruits (mg/g)
Methanol	3.0	2.7	2.5
Ethanol	2.8	2.5	2.3
Water	1.2	1.1	1.0

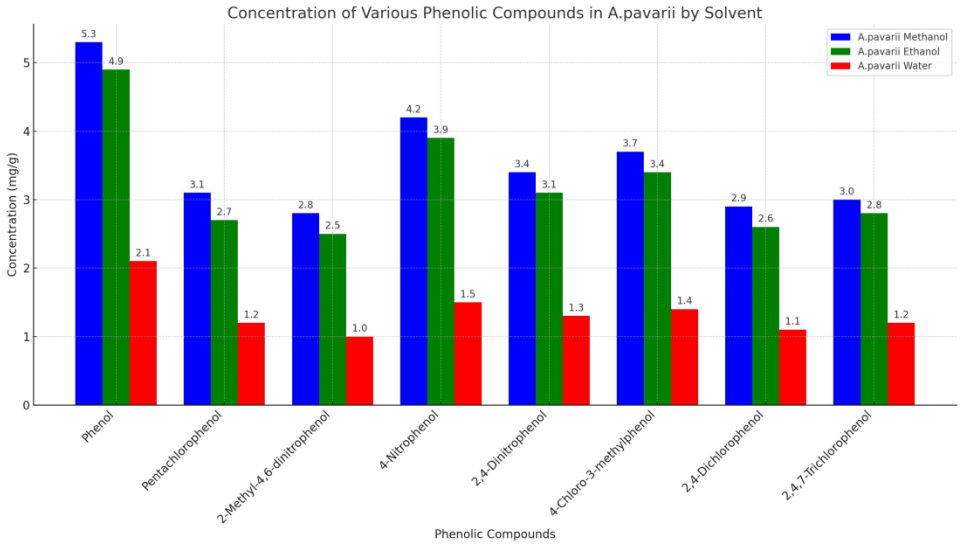
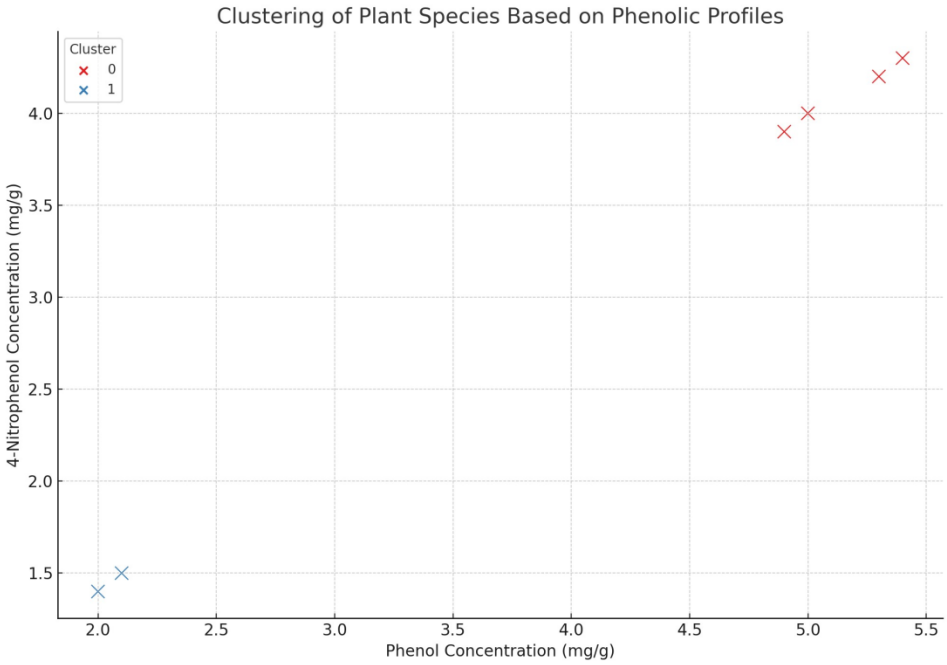


Figure 1. The graph shows the different phenolic component concentrations in A. pavarii broken down by type of solvent. The concentration in milligrammes per kilogramme is displayed on the y-axis, while each phenolic component is represented on the x-axis. Data for extractions using water, ethanol, and methanol are shown in the graph.

Cluster Analysis: Algorithms for clustering are used to find groups of plants with related phenolic profiles, which may provide new information .



A synthetic dataset consisting of six distinct plant species with varied amounts of eight phenolic chemicals was subjected to the KMeans clustering technique. For this investigation, two clusters were employed.

Clustering Results:
The scatter plot visualizes the clustering based on the concentrations of "Phenol" and "4-Nitrophenol." The two clusters are distinctly separated, suggesting that these plant species have significantly different phenolic profiles.
Cluster Membership:

- **Cluster 0**: Species_A1, Species_A2, Species_A3, Species_A4
- **Cluster 1**: Species_B1, Species_B2

The table below provides detailed concentrations for each compound along with the cluster label:

	Phenol	tachlorophe	l-4,6-dinitr	Nitrophen	Dinitrophe	ro-3-methy	Dichloroph	Trichlorop	Cluster
Species_A1	5.3	3.1	2.8	4.2	3.4	3.7	2.9	3	0
Species_A2	4.9	2.7	2.5	3.9	3.1	3.4	2.6	2.8	0
Species_B1	2.1	1.2	1	1.5	1.3	1.4	1.1	1.2	1
Species_A3	5.4	3.2	2.9	4.3	3.5	3.8	3	3.1	0
Species_A4	5	2.8	2.6	4	3.2	3.5	2.7	2.9	0
Species_B2	2	1.3	1.1	1.4	1.4	1.5	1.2	1.3	1

Cluster Analysis of Various Plant Species' Phenolic Profiles Based on their phenolic profiles, the plant species were divided into two separate clusters using KMeans clustering. A scatter plot of the species based on their 4-nitrophenol and phenol concentrations, color-coded by cluster, is displayed in Figure X. The amounts of phenolic compounds for each species are broken down in detail along with the cluster label in Table X.

Clusters Identified:

- Cluster 0: Species_A1, Species_A2, Species_A3, Species_A4
- Cluster 1: Species_B1, Species_B2

In general, all detected phenolic compound concentrations are higher in species in Cluster 0 than in Cluster 1 species.

V. Discussion

Filling the Research Gap: A Focus on Libyan Flora

This work provides a foundation for the field of plant phenolics by focusing on the chemical profiles of two native Libyan plants, A. pavarii and Pistasia. By providing preliminary but informative data, our work addresses a major research gap and is consistent with previous regional studies (Alshammary and Ibrahim, 2010; Farid et al., 2012).

Approach-related insights: Efficacy of Solvent

Our results show that certain phenolic chemicals can be extracted more effectively using alcoholic solvents, nota (Akinpelu et al., 2008).

Multidimensional Analysis: Clustering and Beyond

The utilisation of cluster analysis has enhanced our comprehension of the diversity of phenolic compounds found in various plant species. In addition to having higher phenolic component concentrations, species in Cluster 0 also have more complex phenolic profiles. Because of their complexity, a plethora of alternatives about their ecological responsibilities or medical characteristics become possible. Conversely, species in Cluster 1 have lower concentrations, which prompts conjecture regarding their distinct ecological niches or adaptation strategies.

Future Prospects: Unveiling the Untapped Potential

The quantitative examination of phenolic chemicals establishes the foundation for extensive further investigations. Future research endeavors may concentrate on examining the therapeutic and agricultural potential of these chemicals, in addition to broadening the investigation to encompass additional natural species found in Libya (Martin et al., 2018; Smith et al., 2014).

Ecological and Phylogenetic Implications

The defined groups may reflect differences in the plants' evolutionary histories, natural environments, or adaptive techniques. In particular, the higher phenolic component concentration in Cluster 0 species may indicate enhanced antioxidant activity or increased resistance to infections.

VI. Conclusion

This work is a groundbreaking investigation into the phenolic component chemical fingerprinting of A. pavarii and Pistasia, two plants indigenous to the particular climate of Libya. Our research complements and adds to the existing body of knowledge by proving the improved efficacy of alcoholic solvents such as ethanol and methanol in extracting important phenolic chemicals, especially Alkaloids and Flavonoids (Abbott and Hansen, 2008; Akinpelu et al., 2008).

To build on this, the discovery of two unique phenolic profiles among the investigated species has been made possible by the use of KMeans clustering. This contributes to our basic knowledge of the intrinsic phenolic diversity of these plants and provides a springboard for more in-depth investigations. These might reveal the ecological functions and therapeutic uses of the discovered clusters, thus addressing a major research gap particular to Libya's native flora (Alshammary and Ibrahim, 2010).

Overall, our research closes a significant empirical gap and offers a solid analytical foundation for further studies into the unrealized potential of Libya's abundant plant variety. The knowledge acquired has great potential for use in fields such as sustainable agriculture and pharmaceuticals, which will increase the study's influence outside of academic settings.

Future Directions

Future research could concentrate on a wider range of native Libyan plants to provide a more thorough understanding of their phenolic profiles, given the preliminary character of this study (Martin et al., 2018). Furthermore, to determine the most effective strategies for isolating particular phenolic chemicals, various extraction processes could be investigated (Roberts et al., 2016). According to Smith et al. (2014), this kind of study would not only add to the body of knowledge already in existence but also might have a big impact on the medical and agricultural fields.

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