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Qualitative Phytochemical Analysis of Yemeni *Vachellia flava* (Fabaceae) and Its Honey

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Abstract

Vachellia flava, synonym Acacia *ehrenbergiana*, known as "Salam" in Arabic, is a wild flowering tall tree belong to Fabaceae family. In Yemen, it thrives in specific ecological niches and traditionally utilized for charcoal and Qataran production, firewood and apiculture, yielding high-quality honey. This study aimed to conduct the first qualitative analysis of the phytochemical constituents of different solvent extracts of the leaves, bark, and pods of Yemeni *V.flava*, alongside the aqueous solution of its produced honey. The plant parts were subjected to serial exhaustive extraction using petroleum ether, acetone, and methanol using Soxhlet extraction. The obtained extracts were subjected to the test of several phytochemical classes following the standard procedures. Phytochemical screening revealed distinct profiles across extracts. The petroleum ether leaves extract contained exclusively phytosterols, triterpenes, and terpenoids, whereas methanol and acetone extracts shared alkaloids, glycosides, flavonoids, phenolics, carbohydrates, proteins, and fatty acids with methanol uniquely containing saponins and acetone exhibiting amino acids and phytosterols. Bark petroleum ether extract showed glycosides, phytosterols, triterpenes, and terpenoids, while methanol and acetone extracts both contained alkaloids, anthraquinones, glycosides, flavonoids, phenolics, proteins, amino acids, and fatty acids; methanol included saponins, and acetone had additional carbohydrates and phytosterols. Pods petroleum ether extract contained alkaloids and phytosterols, while methanol and acetone extracts featured glycosides, carbohydrates, flavonoids, phenolics, proteins, amino acids, and phytosterols while methanol extract alone contained anthraquinones. Analysis of aqueous honey solution detected only alkaloids, carbohydrates, phenols, flavonoids, and proteins. Notably, petroleum ether extracts of bark and pods contained glycosides and alkaloids, respectively, suggesting the presence of nonpolar forms of these metabolites in Yemeni *V. flava*. The findings demonstrate that both *V. flava* and its honey harbor a diverse array of bioactive phytochemicals with potential applications in medicinal and industrial sectors.

Article Info

Keywords:
Vachellia flava , Acacia ehrenbergiana, Phytochemical screening, Salam Honey, Yemen flora , Salam tree , Fabaceae, Biuret test

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1. INTRODUCTION

Living organisms, including plants, produce thousands of different organic compounds known as phytochemicals. Phytochemicals of low molecular weight (e.g., alkaloids, flavonoids, glycosides, terpenes, phenolic and polyphenolic compounds, and phytosterols) are called secondary metabolites and are believed to have no apparent function in the basic processes of growth and development of the plant, but they play a significant ecological role in attraction, stimulation, and defense against competitors, pathogens, or predators [1]. Secondary metabolites are a source of complex mixtures of compounds that are of great importance to human health as they have a wide range of biological activities, such as wound healing, analgesic, antidiarrheal, antidiabetic, anti-inflammatory, antimicrobial, and antiparasitic effects [2]. Since ancient times, humans have utilized the healing power of plants in indigenous medicine. Owing to their wide range of biological activities, phytochemicals

have been isolated from plants for diverse applications including medicinal (e.g., drug discovery), agricultural (e.g., biopesticides), and industrial (e.g., nutraceuticals and cosmetics) applications [3, 4]. Yemen is well known for its biodiversity, as it hosts a variety of ecosystems and habitats, ranging from coastal mangroves, shrubs, and dunes along the coastal plains to the eastern deserts and an array of montane habitats. This results in a rich variety of natural habitats, species, and genetic diversity, including many endemic species [5]. As these resources are of major economic importance, further studies are needed to investigate the phytochemical profile and biological activities of Yemen flora [6]. According to Al-Khulaidi (2013), there are twenty-nine species of *Acacia* in Yemen [7]. One of the most important *Acacia* species in Yemen is *V. flava* (Figure 1). *V. flava* is often found on the Tihama coastal plain, which runs along the Red Sea coast of Yemen. This region has a hot, arid climate with sparse vegetation, making it suitable for drought-resistant species such as *V. flava*. It also thrives in the desert regions of eastern Yemen, particularly in Ramlat al-Sab'atayn and Ramlat al-Wahiba. Additionally, this species is widespread across other parts of Yemen, including the Western Mountains, Sa'dah, Marib, Rada'a, Harib, Abyan, Shabwa, and Hadhramaut. In the eastern Tihamah plain, approximately 20 km from the Red Sea between Wadi Mawr and Wadi Zabied, there are many blocks of woodland dominated by *V. flava*. It is one of the most important trees in the region, as it is a source of livelihood for poor rural and urban communities. It plays a crucial role in preventing soil erosion and provides shade and shelter to wildlife. It is also used for wood and gum, as a fodder for livestock and bees, and has value in traditional medicine. It produces premier-quality honey locally known as salam honey. It also produces charcoal and tar, which are medicinal fluids known locally as the Qataran. This fluid is used as an animal medicine for the treatment of insect and fungal parasites (lice, ticks, and scabies), especially camels. It is also used in the treatment of human skin diseases caused by parasites, particularly on the scalp [8]. In Africa and Australia, gum obtained from the plant is used as an emollient [9] and to treat various alignments and diseases [10, 11].

Despite its medicinal value, this plant did not receive sufficient attention from the scientific community until 2002. The first investigation of the antioxidant activity of *V. flava* was performed on honey (salam honey) collected from Tihamah-Yemen. The findings of the study showed that among nine different types of local Yemeni and imported honey, salam honey has the highest phenolic content and antioxidant activity [12]. Honey is rich in various phytochemicals including phenols, flavonoids, terpenes, organic acids, and amino acids. The composition and concentration of these compounds vary depending on the floral source of nectar collected by the bees [13]. During the last two decades, an increasing number of

Source: African plants, a photo guide

Source: © Jean-Paul Peltier (www.teline.fr)

Figure 1. ***Vachellia flava***

studies have reported the chemical profile, nutritional value, and biological activities of *V. flava* collected from North Africa and the Arabian Peninsula, which proved the medicinal and nutritional value of the plant identifying key phytochemical constituents including phenolic compounds, alkaloids, flavonoids, terpenes, tannins, and [14–23]. To the best of our knowledge, no data are available for the chemical profile of *V. flava* grown in Yemen. Studying the phytochemical profile of plants grown in a local environment is critical because secondary metabolites vary significantly across regions owing to adaptive responses to climatic conditions, soil type, and moisture availability[24, 25]. These variations are driven by genetic adaptations that encode diverse synthases for secondary metabolite production [26]. Knowing the phytochemical profile of local plants is important as it can direct further investigations, possible applications, and potential uses. The main aim of the current study was to

provide the first report on the phytochemical profile of the leaves, bark, and pods of *V. flava* grown in the Tihamah region, Yemen, and honey produced.

2. MATERIALS AND METHODS

2.1. Chemicals (Solvents, Solutions, and Chemical Reagents)

All solvents (acetone, chloroform, ethanol, methanol and petroleum ether) were purchased from BDH ,UK or Denteck, The Netherlands. All other chemicals and reagents were of analytical grade and prepared following established protocols [27].

2.2. Honey Sample (Collection and Source)

The honey sample was purchased from the local market at Tihamah region, Hodeidah Governorate.

2.3. Plant Material

2.3.1. Collection and Taxonomy:

Plant samples were collected from the Almasni district, Tihamah region, Hodeidah Governorate, located on the western coast of Yemen. The plant was identified and verified by morphological and botanical traits by Prof. Hassan Ibrahim (plant taxonomist), authenticated at the herbarium of the Department of Biological Sciences, Sana'a University, and was given a **voucher specimen no (731)**

2.3.2. Preparation for Extraction

The collected plant parts were washed thoroughly with running tap water and distilled water. Leaves, bark, and pods were cut into small pieces and air-dried under shade for two weeks. An electric blender was used to grind the dried plant parts into a fine powder, which was then kept in labeled airtight glass jars and stored at room temperature (24 $\pm$ 4 °C) until further treatment. Crude plant extracts were prepared using Soxhlet extraction by a serial exhaustive extraction technique, which involves successive extraction with solvents of increasing polarity. Finely ground samples were first extracted with petroleum ether ((200 mL per 20 g of leaves or bark and 150 mL per 15 g of pods) for approximately 8 h. The solid dried residue was subjected to further extraction with acetone for approximately 8 h. This procedure was repeated using methanol for 6 h. The extraction was conducted in a water bath (Karl Kolb Scientific Technical Supplies, Germany). The plant solvent extracts were evaporated to dryness using a rotary vacuum evaporator and kept in a dry and cool environment until further analysis. Honey samples were prepared by dissolving 1 g honey in 50 ml of distilled water.

2.4. Phytochemical Analysis

A small amount of each extract was dissolved in the appropriate solvent, and the solutions obtained alongside the honey aqueous solution were subjected to the test of several phytochemical classes according to standard procedures [2, 27–29], as summarized in table 1. In all experiments, a test tube containing the extract solution was used as a control to compare the color change of the plant extract after the addition of the test reagent. Visual changes were observed immediately after mixing the extracts with the appropriate reagents or after waiting for a few minutes (up to 5 min) for some tests. For some phytochemical classes, two tests were performed for confirmation purposes.

3. RESULTSAND DISCUSSION

The serial exhaustive extraction technique was selected to ensure that a wide range of phytoconstituents with different polarities were extracted from the plant to obtain a complete picture of the phytochemical profile of the leaves, bark, and pods of *V. flava* grown in Yemen. Qualitative phytochemical screening of various extracts revealed the presence of anthraquinones, glycosides, phenols, tannins, flavonoids, terpenoids, saponins, proteins, carbohydrates, and lipids, as summarized in Table 2. In contrast, the honey produced was found to contain alkaloids, carbohydrates, flavonoids, phenols, and proteins. The results were graded on a scale ranging from absence (- - -) to weak presence (+), moderate (++), and strong (+++).

The results were graded on a scale ranging from absence (—) to weak presence (+), moderate (++), and strong (+++).

3.1. Alkaloids determination

In the present study, the Hager's and Wagner's tests were used to identify the presence of alkaloids. Wagner's test yielded an orange buff precipitate with all extracts, except petroleum ether extracts and honey aqueous solution. On the other hand, none of the extracts precipitated with Hager's reagent, except for honey, which produced a good amount of yellow crystalline precipitate, and the petroleum ether extract for pods that gave less precipitate. The positive reaction of the petroleum ether pod extract with picric acid suggests the presence of non-polar alkaloids in Yemeni *V. flava*, necessitating further characterization using GC-MS. Testing the presence of alkaloids could be very challenging, as some alkaloids are known to not respond to some reagents such as caffeine, which does es not give yellow precipitates with Hager's reagent, but responds positively to other reagents [2]. The opposite result was observed for the honey aqueous solution, as it gave a yellow crystalline precipitate with Hager's reagent and no precipitate

Table 1. Qualitative phytochemical screening tests

Phytoconstituent	Test name and procedure	Positive Observation
Carboxylic acids	**Acidity test:** 1 ml extract + 1 ml $NaHCO_3$	Effervescence
Alkaloids	**Hager's test:** 1 ml extract + two drops of Hager reagent	Yellow color crystalline precipitate
	Wagner's test: 1 ml extract + two drops of Wagner reagent	Reddish brown precipitate
Anthraquinones	**Bornträger's test:** 1 ml extract + 1 ml benzene, shake well then add 1 ml of dil. ammonia solution	Rose pink coloration
Carbohydrates	**Fehling's test:** 1 ml extract + few drops of Fehling's reagents 1+2	Brick-red precipitate or green coloration
Glycosides	**Keller–Kiliani test:** 1 ml extract + 1 ml glacial acetic acid + few drops of $FeCl_3$ + 1 ml Conc. H_2SO_4 through the test tube sides	Reddish brown ring at the intersection
	Legal test: 1 ml extract + few drops of 10% NaOH and 1 ml of 0.3% sodium nitroprusside	Instant dark red color
Fatty acids, Lipids	**Saponification test:** 1 ml extract + 1 ml of 10% NaOH and heat on water bath for 15 min	Formation of soap or greasy, solid substance
Flavonoids	**Alkaline reagent test:** 1 ml extract + few drops of 40% NaOH. The color formed disappear with addition of HCl.	**Flavanes, flavanols:** yellow color. **Chalcones, Aurones:** orange color.
Flavonoids, Phenols, Tannins	**$FeCl_3$ test:** 1 ml extract + few drops of $FeCl_3$	Dark green/blue, orange-red, violet color
Proteins, Amino acids	**Biuret test:** 1 ml extract + 1 ml 10% NaOH + 2 drops of $CuSO_4$	**Proteins:** purple or violet color
	Ninhydrin test: 1 ml extract + few drops of ninhydrin reagent and boil for 5 mints	**Amino acids:** pink, blue or violet color except proline gives a yellow
Phytosterols, Triterpenes, Terpenoids	**Salkowski test:** 1 ml extract + 1 ml chloroform + drops of Conc. H_2SO_4	**Terpenoids, triterpenes:** red, pink, or purple in organic layer. **Sterols:** Green/blue in acid layer.
	Liberman–Burchard test: 1 ml extract + 2 ml of acetic anhydride + 2 ml Conc. H_2SO_4	**Steroids, Terpenoids:** green to blue color
Saponins	**Froth test:** 1 ml extract + 5 ml of H_2O then shake thoroughly	The produced foam last for 5 min

Table 2. The Phytochemical analysis of *Vachellia flava* grown in Yemen

Tested Phytochemical Classes	Test name	Samples subject to analysis of phytochemical classes									
		Pet. Ether Plant Extracts			Acetone Plant Extract			Methanol Plant Extracts			Honey *aq.* Solution
		Leaves	Bark	Pods	Leaves	Bark	Pods	Leaves	Bark	Pods	
Alkaloids	Hager	- - -	- - -	+	- - -	- - -	- - -	- - -	- - -	- - -	+++
	Wagner	- - -	- - -	- - -	++	++	- - -	+++	+++	- - -	++
Anthraquinones	Bornträger	- - -	- - -	- - -	- - -	+	- - -	- - -	+++	+++	- - -
Carbohydrates	Fehling	- - -	- - -	- - -	+	+	++	++	- - -	++	+++
Carboxylic acids	Acidity	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Flavonoids	Alkaline reagent	- - -	- - -	- - -	+++	+++	+++	+++	+++	+++	+++
Glycosides	Keller-Kiliani	- - -	+++	- - -	+	++	+++	++	++	+++	- - -
	Legal	- - -	+++	- - -	++	+++	+++	+++	+++	+++	- - -
Flavonoids Phenols Tannins	$FeCl_3$	- - -	- - -	- - -	+++	+++	+++	+++	+++	+++	+++
Fatty acids, Lipids	Saponification	- - -	- - -	- - -	+	+	- - -	++	++	- - -	- - -
Protein	Biuret	- - -	- - -	- - -	+	++	+++	+	+	+++	+++
Amino acids	Ninhydrin	- - -	- - -	- - -	+++	+	+++	- - -	++	+++	++
Phytosterols Triterpenes Terpenoids	Salkowski	+++	++	+	- - -	+	+++	- - -	- - -	+++	- - -
	Liberman-Burchard	++	+	+	+++	+	+++	- - -	- - -	+++	- - -
Saponins	Froth	- - -	-	- - -	- - -	-	- - -	++	+++	- - -	- - -

with Wagner's reagent, confirming the presence of alkaloids. This positive response for Hager's test could be attributed to the presence of pyrrolizidine alkaloids that has reported to be the main alkaloids in honey in several studies [30–32]. Plant-derived alkaloids serve dual ecological and medicinal roles, while protecting plants against herbivores, pathogens, and microbial infections, as well as diverse pharmacological properties. Their broad spectrum of bioactivities has enabled extensive clinical application, demonstrating analgesic, antiasth-

matic, anticancer, anti-inflammatory, antihypertensive, antipyretic, and antihyperglycemic effects [32] .

3.2. Carboxylic acids determination

In the present study, the acidity test did not indicate the presence of carboxylic acids in any of the examined extracts or the honey aqueous solution.

3.3. Carbohydrates determination

Fehling test was used to detect carbohydrate, in this test all methanolic and acetonic extracts and honey aqueous solution produced green coloration after adding of Fehling reagents, which then turned to brick-red precipitate after boiling the solution in water bath for 15 mints confirming the presence of carbohydrates.

3.4. Anthraquinones determination

Bornträger's test is a specific test for anthraquinones that react with ammonia solution to form a colored complex, typically pink, red, or violet, which indicates their presence [33]. In this study, only the methanolic extracts of bark and the methanolic and acetonic extracts of pods were pink, while the rest of the extracts and honey samples did not exhibit any change. Anthraquinones are a widespread class of naturally occurring compounds that belong to the quinone family. They represent the most abundant subgroup of natural quinones and are also the largest category of natural pigments, with approximately 700 identified variants. Traditionally valued as natural dyes, anthraquinones exhibit diverse bioactive properties, including antitumor, anti-inflammatory, diuretic, antiarthritic, antifungal, antibacterial, antimalarial, and antioxidant activities. Moreover, they are known for their laxative effects [34].

3.5. Glycosides determination

Two tests were used for glycoside screening: the Keller-Kiliani test and the legal test. In all extracts, except for most petroleum ether extracts and aqueous solution honey, a clear brown ring or instant bloody red was observed, confirming the presence of glycosides in the leaves, bark, and pods. Acetonic extracts exhibited the most intense color change, demonstrating the superior efficiency of acetone in extracting glycosides, which is consistent with the high polarity of most glycosides. Notably, the petroleum ether bark extract yielded positive results in glycoside tests, suggesting the presence of non-polar glycosides (e.g., cardenolides, such as digitoxin and digoxin), which requires further investigation. Glycosides are an important class of therapeutic compounds that have diverse pharmacological applications. Among the most clinically significant uses is the treatment of cardiovascular conditions, which are specifically known as cardiac glycosides.

3.6. Flavonoids determination

The alkaline reagent test (40% NaOH) was used to detect the presence of flavonoids, which typically produce a yellow color for flavones and flavanols, a deeper yellow or orange color for chalcones and aurones, and red to blue or green for anthocyanins [35]. In this study, all methanolic and acetonic extracts of leaves, bark, and pods produced an orange color, indicating the presence of chalcones and aurones. The honey aqueous solution, on the other hand, produced deep yellow color that indicates the presence of flavones and flavanols. Flavonoids, a class of potent natural antioxidants, exhibit significant therapeutic potential for multiple medical applications. These bioactive compounds have cardioprotective, antidiabetic, antiviral, anti-inflammatory, antimutagenic, and anticarcinogenic properties, making them valuable candidates for pharmacological development and preventive medicine [36].

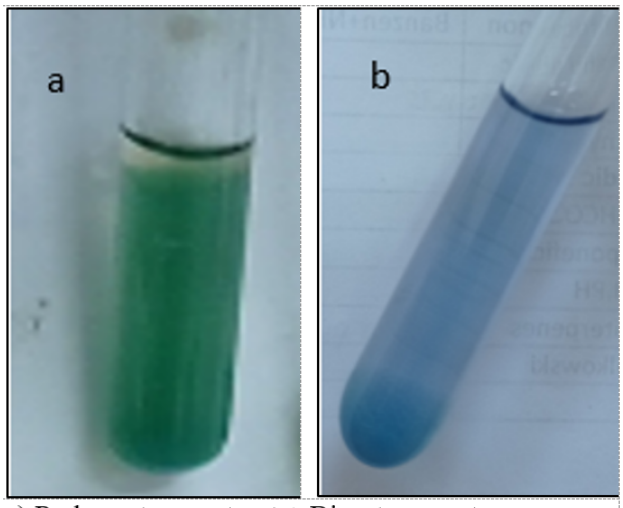
3.7. Phenols and tannins determination

Phenolic derivatives are the largest group of secondary metabolites. All of these phenolic compounds can react with ferric chloride to form colored complexes. As a result, a wide range of colors, including orange, brown, green, blue, and violet, were reported for polyphenols when treated with ferric chloride. The presence of several polyphenol compounds complicates test results. In this study, the methanolic and acetonic extracts of leaves and pods produced a dark blue precipitate, whereas the bark produced a dark green precipitate. In contrast, the honey aqueous solution produced a dark orange color, suggesting the presence of flavonoids. This is supported by a recent review on the chemical composition of honey that found, among the active phytochemicals presents in honey, flavonoids are the most abundant polyphenols in different types of honey [13].

3.8. Proteins and amino acids determination

The Biuret test detects peptide bonds producing purple or violet color; therefore, it is specific for proteins and peptides and does not react with free amino acids or other non-protein nitrogenous compounds. The Biuret test, although less sensitive than assays such as the Bradford method, is reliable for detecting moderate to high protein concentrations. In the present study, all extracts and honey aqueous solutions, except petroleum ether extracts, produced dense emerald green precipitates that interfered with the purple or violet color. The formation of green color may be due to the presence of reducing com-

pounds in the plant extracts, such as polyphenols, which cause the formation of intermediate copper compounds during the reduction of Cu^{2+} to Cu^{+}. This interference of colors was resolved by precipitating these interfering compounds several times and performing the biuret test on the filtrate. In this case, a light purple color was observed, confirming the presence of proteins in the tested samples (Figure 2). This additional step is essential to prevent false-negative results in the biuret test. Amino



a) Pods acetone extract + Biuret reagents
b) Filtrate of the same extract + Biuret reagents

Figure 2. Biuret test for protein

acid tests with ninhydrin give yellow, pink, blue, or violet colors [2]. The ninhydrin test revealed that the leaves, bark, pods, and honey contain different types of amino acids with varied colors. For leaves, only the acetonic extract produced a bright green color, whereas methanol and petroleum ether did not show any color change. The green color could be due to the presence of tyrosine and tryptopha [35]. In the case of the bark extract, petroleum ether had no color change, while acetone had a pale yellow and methanol a pale pink color, indicating a low amino acid content. On the other hand, pod extracts gave an intense violet color with methanol extract, yellow with acetone, and no color change for petroleum ether. This indicates that the pods are rich in amino acids, such as proline and other amino acids. A brown color was observed for the honey aqueous solution, indicating that salam honey is rich in amino acids.

3.9. Fatty acids and lipid determination

The saponification test showed that only the leaves and bark contained fatty acids and lipids. Greasy substances were observed in both the methanolic and acetonic extracts, and the amount of the substances was greater in the methanolic extracts.

3.10. Steroids, terpenes, terpenoids determination

Two tests were performed for these classes of phytochemicals: the Salkowski test and the Liebermann–Burchard test. In the Salkowski test, the formation of a red, pink, or purple color in the organic layer indicates the presence of terpenoids and triterpenes. Steroids were identified by the formation of green or blue acid layers. However, testing real plant samples usually does es not give this distinct coloration due to the presence of many phytocomponents in the extract that may interact with the reagent. In this study, several colors were observed, ranging from green to pink and red, indicating the presence of steroids, terpenes, and terpenoids. The varied coloration obtained for this test was also observed in other studies [37]. Terpenoids have demonstrated significant therapeutic potential through their multiple pharmacological activities. These include antimicrobial, antifungal, and antiviral properties as well as antihyperglycemic, anti-inflammatory, and antioxidant effects. Additionally, they exhibit antiparasitic activity, immunomodulatory capacity, and function as effective skin permeation enhancers in transdermal drug delivery systems [38].

3.11. Saponins determination

The froth test showed that only methanolic extracts of leaves and bark contained saponins, and the amount of foam produced by bark extracts was greater and more stable than that produced by leaf extracts. Saponins are known for their multiple biological activities, including fungicidal, antimicrobial, antiviral, anti-inflammatory, anticancer, antioxidant, and immunomodulatory effects have all been observed [39]. They also exhibit significant therapeutic potential for pharmaceutical applications, including hypolipidemic, anticancer, and hypoglycemic effects. Research has suggested that a saponin-rich diet may help prevent dental caries and inhibit platelet aggregation. Additionally, saponins demonstrate clinical promise for managing hypercalciuria and counteracting acute lead poisoning. Their medicinal applications have been extended to include use as expectorants and antitussives. Beyond healthcare, saponins serve as valuable ingredients in cosmetics because of their natural emulsifying, foaming, and cleansing properties [40].

3.12. Phytochemical constituents in *V. flava* grown in Arab peninsula and North Africa

Phytochemical screening of the aqueous extract *V. flava* collected from a local farm in Alquieiya, KSA, was found to contain alkaloids, flavonoids, tannins, saponins, and glycosides [20], which is in good agreement with our findings. However, more phytochemicals were detected

in our study because of the use of several solvents of increasing polarity that revealed the presence of a broader spectrum of phytochemical classes present in Yemeni *V. flava*. Phytochemical screening of several extracts of *V. flava* collected from the desert of Qatar revealed glycosides, tannins, flavonoids, terpenoids, saponins, phenol, and anthraquinones; however, alkaloids were not detected in any extract [18]. In North Africa, the only data available on the phytochemical composition of *V. flava* is the quantitative GC-MS analysis of the aerial parts of *V. flava* from Aswan, Egypt, which reveals the presence of flavonoids such as rutin, isoquercitrin, myricetin, quercetin, and catechin, and their glycoside derivatives, in addition to some phenolic compounds such as gallic acid and methyl gallate [22], whereas *V. flava* from Sudan was dominated by polysaccharides, phenols (pyrogallol), hydrocarbons, terpine (phytol), and a wide range of fatty acids [10]. It is clear that the phytochemical profile of *V. flava* differs from region to region owing to various environmental factors.

4. CONCLUSION

Phytochemical screening of *V. flava* from Yemen revealed diverse profiles of bioactive compounds in its leaves, bark, and pods, indicating its potential as a valuable natural resource for pharmaceutical and industrial applications. Notably, Salam honey was found to contain nutritionally and medicinally relevant phytochemicals, including flavonoids, polyphenols, amino acids, and proteins, consistent with the chemical profile of Yemeni *V. flava*. To confirm this correlation, further analysis of the floral components of the plants is recommended. This preliminary phytochemical analysis demonstrated the utility of such screening methods for the rapid identification of major compound classes during initial plant evaluation. Such approaches offer cost- and time-efficient alternatives when advanced analytical instrumentation is not available. However, to fully characterize the phytochemical potential of this species, we recommend follow-up studies employing quantitative analytical techniques (e.g., HPLC and GC-MS) to determine the exact composition and concentrations of bioactive constituents in *V. flava* plant parts from different locations in Yemen and its derived honey products.

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