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Assessment of Phenolic, Mineral Composition and Antibacterial Activity of Khastawi Dates Seeds Powder in Iraq

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Abstract

Aqueous and alcoholic extractions were performed on Khastawi date seed powder to isolate flavonoids and estimate the total phenolic content. The extracted phenolic compounds were subsequently evaluated for their antibiotic activity and reducing strength. Phenolic compounds were detected using the FTIR and UV-Vis techniques. Alcoholic extraction proved superior, as flavonoids-being phenolic compounds exhibit greater solubility in alcohol than in water. The yield of the alcoholic extract was found to be 57%. The FTIR spectrum displayed a strong absorption band at 3200-3600 cm^{-1} (O-H stretching), which was accompanied by other peaks at 2850–3100 cm^{-1} (C–H stretching) and >3000 cm^{-1} (aromatic C–H). C=C stretching (1400-1600 cm^{-1}) and phenolic C-O stretching (1150-1250 cm^{-1}) further supported flavonoid presence. UV-Vis spectra showed clearly defined peaks that are characteristic of high concentration and conjugation of phenolic compounds. According to High-Performance Liquid Chromatography (HPLC) analysis, flavonoids extraction through alcohol was found to be more yielding, since the area under the curve was larger. EDX analysis pointed to strong signals from iron (Fe) and oxygen, which could be interpreted as indications of high flavonoid content and great reducing ability. The analyzed material displayed peaks at 136.2 and 847.3cps. The antibiotic activity of Khastawi date seeds extracts (for ethanol and ethyl acetate) at a concentration of 50 mg/ml showed inhibitory effect against both of G+ (*Staphylococcus aureus and Staphylococcus epidermidis*) and G- (*Acinetobacter, Proteus*) bacteria. G+ strains showed slightly higher sensitivity, with inhibition zones ranging from 10-13 mm. Generally, the ethanol extract exhibited slightly higher antibacterial activity compared to the ethyl acetate extract.

Keywords: Khastawi date seed, phenolic compounds, biological activity, alcoholic extractions, flavonoids

Introduction

The fruit of the date plant (*Phoenix dactylifera*) is rich in nutrients and contains 70% to 80% carbohydrates, primarily fructose and glucose (Al-Farsi and Lee 2007). Date fruit is rich in proteins, pectin, lipids, salts, minerals, and phenolic substances (Hussain *et al*., 2020). The fruit is marketed globally as a premium chocolate, mostly consumed raw or utilized in baking and producing confections (El Hadrami and Al-Khayri, 2012; Chandrasekaran and Bhkali, 2013). There is been a significant increase in date production and consumption worldwide. Nevertheless, the role of dates in confectionery has yet to be fully explored in terms of quality enhancement.

It is widely accepted that date pits (the seeds found inside the date fruit) are the largest waste of the date industry, which are considered both a significant economic resource and a potential environmental problem if they are allowed to accumulate excessively in the environment. In the past, the flesh of the date was considered to be the only commercially viable portion of the date palm and thus, the seeds were disposed of. Further to this, seeds have been found to possess multi-aromatic properties, which means they contain alcohols, citrates, aldehydes, ketones, both saturated and unsaturated hydrocarbons, and are rich in α-tocopherol, ascorbic acid, glutathione, and polyphenol compounds such as sinapic acid, and caffeic acid with traces of protocatechuic acid (Ranasingh *et al*., 2022). A recent investigation on dietary fiber extracted from date seeds, is shown to be high in polyphenols, and the study examined the phenolic, flavonoid, and antioxidant contents of date seed extracts (Djaoudene *et al*., 2019), indicated that the range of phenolic compounds found in date seeds was 21.0-62.0 mg of gallic acid per 100g. Although date seed is a rich source of essential nutrients, like oil, protein, dietary fiber, and carbohydrates, it is also considered a source of phenolic compounds and antioxidants. No local study has examined this issue in detail, so we determined that this study is required to extract bioactive compounds from date seed powder and to estimate the antioxidant activity of phenolic and flavonoid compounds earlier identified (Bouaziz *et al*., 2020).

Flavonoids and phenolic chemicals found natural food products are frequently identified and quantified via HPLC analysis. Since the majority of natural food items contain a wide variety of phenolic compounds, many of which have similar chemical properties like polarity, making it very challenging to completely separate all eluents, their analysis is especially complex (Proestos *et al*., 2006). The Folin-Ciocalteu procedure and a colorimetric method have been used to determine the total phenolic and flavonoid contents, respectively. The content of the extracts was assessed through a UV-based high-performance liquid chromatography (HPLC) technique. *Arbutus unedo L.* total phenolic contents ranged from 12.75±0.06 to 34.17±1.36 mg gallic acid equivalent/g of the extract's dry weight. The catechin equivalent/g of total flavonoids ranged from 2.18±0.10 to 6.54±1.14 (Bouzid *et al*., 2014).

These phenolic and flavonoid compounds are widely known for their antimicrobial properties, and may contribute to inhibiting the growth of various pathogenic bacteria. Therefore, the antibacterial activity of the

studied extracts was evaluated against several clinically relevant bacterial species.

Clusters of the facultative anaerobic, Gram-positive *Staphylococcus aureus* bacteria resemble grapes. It is a leading cause of sepsis, pneumonia, endocarditis, and infections of the skin and soft tissues. Exotoxins, surface adhesions, and immune evasion mechanisms are some of the factors that contribute to *S. aureus* virulence. The coagulase-negative, Gram-positive *Staphylococcus epidermidis* is frequently found on human skin. Although it is mostly nonpathogenic, it still acts as an opportunistic pathogen and creates infections that are connected with medical devices, such as bloodstream infections due to catheter use, infections in artificial joints, etc. *Acinetobacter* is an aerobic, Gram-negative coccobacillus that is found in water and soil. It is a newly recognized nosocomial pathogen that produces blood, wound, and ventilated pneumonia infections. Gram-negative facultative anaerobic bacilli are referred to as Proteus species especially *Proteus mirabilis* and *Proteus vulgaris*. They are predominant in the gastrointestinal tract and are famous for their ability to cause wound infections, renal calculi, and urinary tract infections. *E. coli* is a Gram-negative bacillus, facultative anaerobic, and a commensal of the human gut microbiota. Conversely, pathogenic strains of *E. Coli* like enterohemorrhagic *E. Coli* (EHEC) and uropathogenic *E. Coli* (UPEC) can lead to the development of sepsis, gastroenteritis, and urinary tract infections (Ramos *et al*., 2020).

This Study aims to address the problem of wasted date pits, despite their richness in bioactive compounds with significant health benefits. The study's importance stems from the scarcity of local research focusing on the extraction and evaluation of phenolic compounds and flavonoids from date pits. The research seeks to extract these compounds and estimate their total phenolic content. It also aims to assess their antibiotic activity and highlight their potential as a valuable natural resource.

Materials and Methods

Study Locations and Experimental design

This study was conducted in the laboratories of the Chemistry and Biology Departments at the College of Science and the College of Education for Pure Sciences, Kirkuk University, Iraq. The treatment studied included three extract solvents: (aqueous, ethanol and ethyl acetate). The antibacterial activity of the ethanol and ethyl acetate extracts at a concentration of 50 mg/ml was tested against Gram-positive and Gram-negative bacteria using the diffusion method on agar. The diameter of the inhibition zones (mm), was used as a covariate. All experiments were performed in triplicate, and the results were statistically analyzed using one- way analysis of variance (ANOVA) at a significance level of $P \leq 0.05$.

Collection of Materials and Preparation of the seed sample

The seeds of the Khastawi date variety were obtained from the local Iraqi market. After manually separating the seeds from the fruit, they were thoroughly washed to remove impurities and then left to dry at room temperature. Next, the seeds were ground using an electric grinder to obtain a fine, homogeneous powder. Finally, the date seed powder was stored in sterile, airtight containers until its use in subsequent analyses Preparation of date seeds extracts

Aqueous extract

Following Ratheesh and Helen (2007) and Sawsan (2020) methods, 10 g of date seed powder was dissolved in 60 ml of deionized water and heated to 70°C for five minutes.

This was left to stand till the next day, then filtered with filter paper to get rid of insoluble materials, then filtrate was then placed in a centrifuge for 10 minutes, then in an oven at 37°C and left for the next day to concentrate the solution and obtain a precipitate.

Ethanol extract

Following Noumi *et al.* (2022) method, 10 g of date seed powder was dissolved in 100 ml of ethanol (99.9%) and left for 24 h. The mixture was then filtered with filter paper to remove insoluble materials, after which the filtrate was placed in an oven at 37°C and left until the next day to concentrate the solution and obtain a precipitate.

Determination of Total Phenols by FT-IR

The total phenolic content of aqueous and alcoholic flavonoid extracts was analyzed using Fourier Transform Infrared (FT-IR) spectroscopy. Samples of each extract were dried and finely ground, then mixed with spectroscopic grade potassium bromide (KBr) to form pellets. FT-IR spectra were recorded in the range of 4000 – 400 cm^{-1} using a spectrometer (Shimadzu , Japan) . Characteristic absorption bands corresponding to phenolic O -H stretching vibrations (around 3200–3600 cm^{-1}) and aromatic C=C stretching (around 1500 - 1600 cm^{-1}) were identified. The intensity of these bands was compared with calibration curves prepared using standard phenolic compounds (e.g., gallic acid) to estimate the total phenolic content. Both aqueous and alcoholic extracts were analyzed under identical conditions to allow comparison of phenolic yields between solvents (da Silva *et al*., 2018)

Preparation of sample for high-performance liquid chromatography

High-Performance Liquid Chromatography (HPLC)

A sample for high-performance liquid chromatography (HPLC) involved the addition of one hundred microliters of date seed extract to one milliliter of methanol after a three-minute vortexing period. Subsequently, one hundred microliters of the sample were injected into the HPLC apparatus. For the preparation of the HPLC standard, a standard solution was created by dissolving one milligram in one hundred milliliters of methanol for each plant chemical. The materials required included 1 g of the element to be extracted, 10 ml of petroleum ether (PE), 10 ml of ethyl acetate, 10 ml of water, three separate clean containers (glass or any non-reactive material), stirring equipment, filter devices such as filter syringes, and HPLC tubes. Liquid chromatography (HPLC) analysis was performed using a Japan HPLC Shimadzu system. For soaking, 1 g of the ingredient was placed into each of the three separate containers; 10 ml of petroleum ether (PE) was added to the first container, 10 ml of ethyl acetate to the second container, and 10 ml of water to the third container. The samples were soaked for three days, with the containers kept closed to prevent evaporation and contamination, and the mixtures were stirred occasionally to ensure even extraction. After the soaking period, each solution was filtered to remove undissolved particles using a 0.45 µl syringe filter to ensure clarity. Diagnosis and purification were carried out using high-performance liquid chromatography (HPLC) (Japan HPLC Shimadzu) equipped with a Phenomenex C18 column (100 Å, 250 × 60 mm). The mobile phase consisted of a mixture of water and methanol at a volume ratio of 60:40 (v/v), which was filtered and degassed using an ultrasonic device (sonicator). The flow rate was set at 1 ml/min, detection was performed at a

wavelength of 280 nm, and an injection volume of 20 microliters was used. The retention time (Rt) of the standard compounds was compared with the retention time of the compounds separated from the aqueous, petroleum ether, and ethyl acetate extracts.

Energy dispersive X-ray analysis (EDX) for determination of elemental Composition of Khastawi Date Seeds

Is a method employed to determine the elemental composition and conduct chemical analysis of materials with an atomic number (Z) greater than 3(20) The analytical procedure involves directing a high-energy electron beam at the specimen This electron bombardment leads to the emission of X-rays from the atoms located on the surface of the specimen.

Sample preparation for EDX test

Following Al-Dahhan *et al.* (2024) method, 1 g of date seed powder was placed in a 100 ml beaker, then 15 ml of 65% nitric acid and 10 ml of 37% hydrochloric acid were added. The mixture was placed on a magnetic stirrer until complete dissolution, after which it was filtered using Whatman No. 41 filter paper. After cooling, the filtrate was diluted with deionized water to a final volume of 100 ml, and the prepared solution was used for the test.

Biological activity

The preparation method for the ethanol and ethyl acetate extract from date seeds involves a systematic approach (Thouri *et al*., 2017). with certain modifications. Initially, 10 grams of powdered seeds from the Iraqi Khastawi date variety were weighed and soaked in 50 milliliters of each solvent for a duration of 24 hours. The following day, the solution was filtered through multiple layers of sterile gauze. The filtrate was then concentrated using a water bath maintained at 37 degrees Celsius, and the resulting extract was stored in the refrigerator until it was required for biological activity testing (Mansor *et al*., 2022).

Antimicrobial Activity

The antibacterial activity of Khastawi date seed extracts was evaluated using the agar well diffusion method. Gram-positive bacterial strains, including *Staphylococcus aureus* and *Staphylococcus epidermidis*, and Gram-negative strains, including *Acinetobacter spp*. and *Proteus spp*., were used. Bacterial suspensions were prepared and their density adjusted to a 0.5 McFarland standard, then spread onto nutrient agar plates using the surface-swiping method. Sterile wells were then created in the culture medium, and specific amounts of the ethanolic extracts and ethyl acetate at a concentration of 50 mg/ml were added to the wells. The plates were incubated at 37°C for 24 hours, and the diameter of the inhibition zones surrounding the wells was measured using a ruler. The diameter of the inhibition zone was considered an indicator of antibacterial activity.

In this study, Gentamycin was used as the standard antibiotic disc for comparison with the antibacterial activity of Khastawi date seed extracts in agar well diffusion assay.

Statistical Analysis

Results were expressed as mean ± standard deviation. The data were statistically analyzed using ANOVA to compare different treatments, and a significance level of ($P \leq 0.05$) was used to determine significant differences between the results.

Results and Discussion

Determination of total phenols (Aqueous and alcoholic extractions for flavonoids)

The FTIR spectrum of in Figure 1 showed the broad peak at 3200–3600 cm^{-1} due to the O-H groups, band at (2850-3000) cm^{-1} are due to an aliphatic C–H bond, while peaks approximately below 3100 cm^{-1} are due to aromatic C-H Stretch (Al-Khazraji and Al-Janabi, 2016), the peaks at (1400–1600 cm^{-1}) due to the C=C Stretch of an aromatic ring. Phenolic C-O stretching showed a peak located between 1150 and 1250 cm^{-1}.

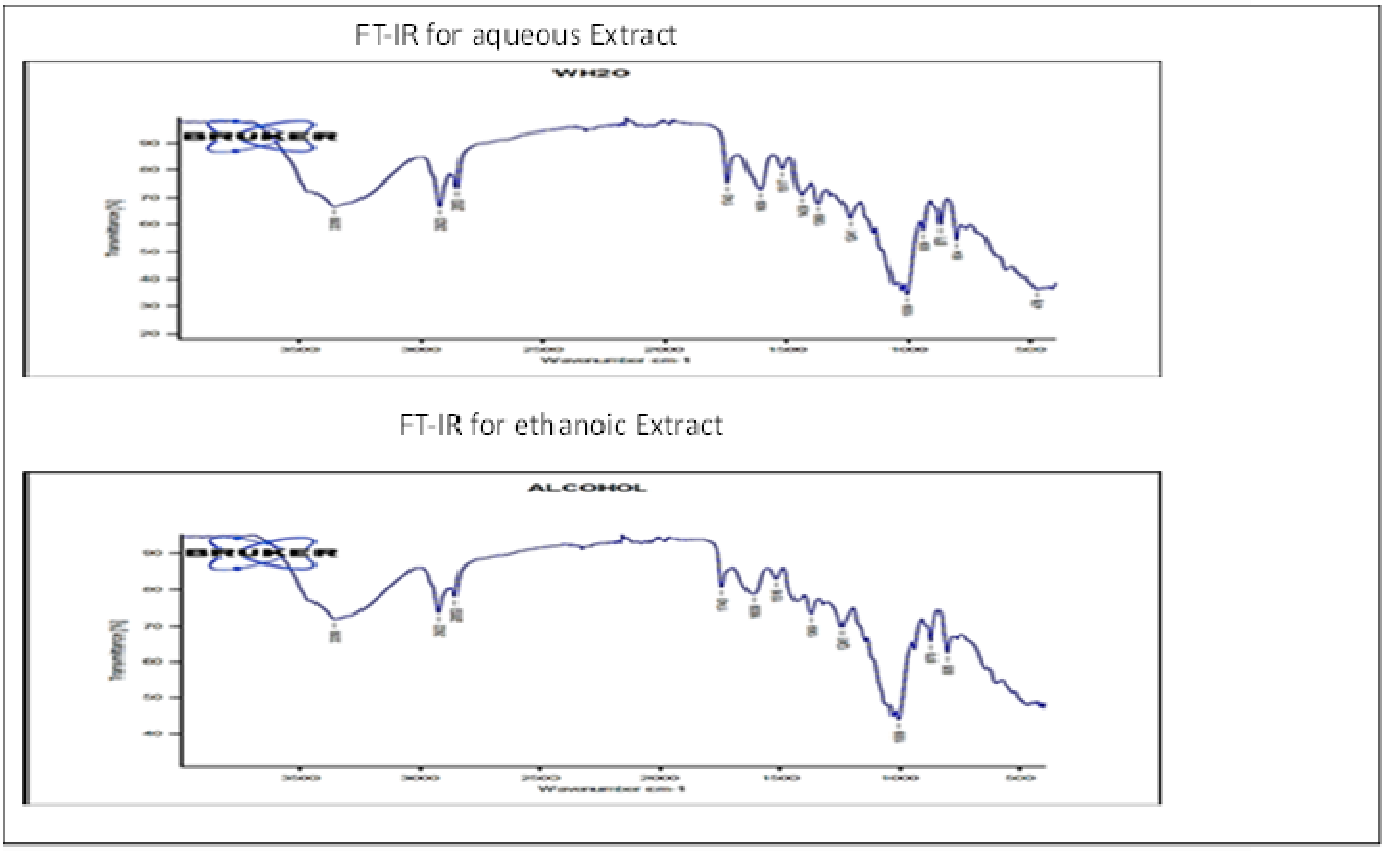


Figure 1: FT-IR for ethanoic and aqueous Extract.

UV- visible

Figure 2 showed because phenolic compounds have conjugated π-electron systems, their UV-Vis spectra usually exhibit distinctive absorption. While the Figure 3 spectrum displays a broader and less intense peak, perhaps due to lower concentrations or minor structural changes, the Figure 4 spectrum seems to have a sharper and more intense peak, which may indicate a higher concentration of the phenolic compound or increased conjugation. These spectra were taken in different solvents, water, and alcohol, and absorption shifts may have occurred. It was observed that deprotonation of the phenolic group (-OH) at higher pH could lead to a bathochromic shift (redshift) in the alcoholic extract (Al-khazraji and Al-jubouri, 2016)

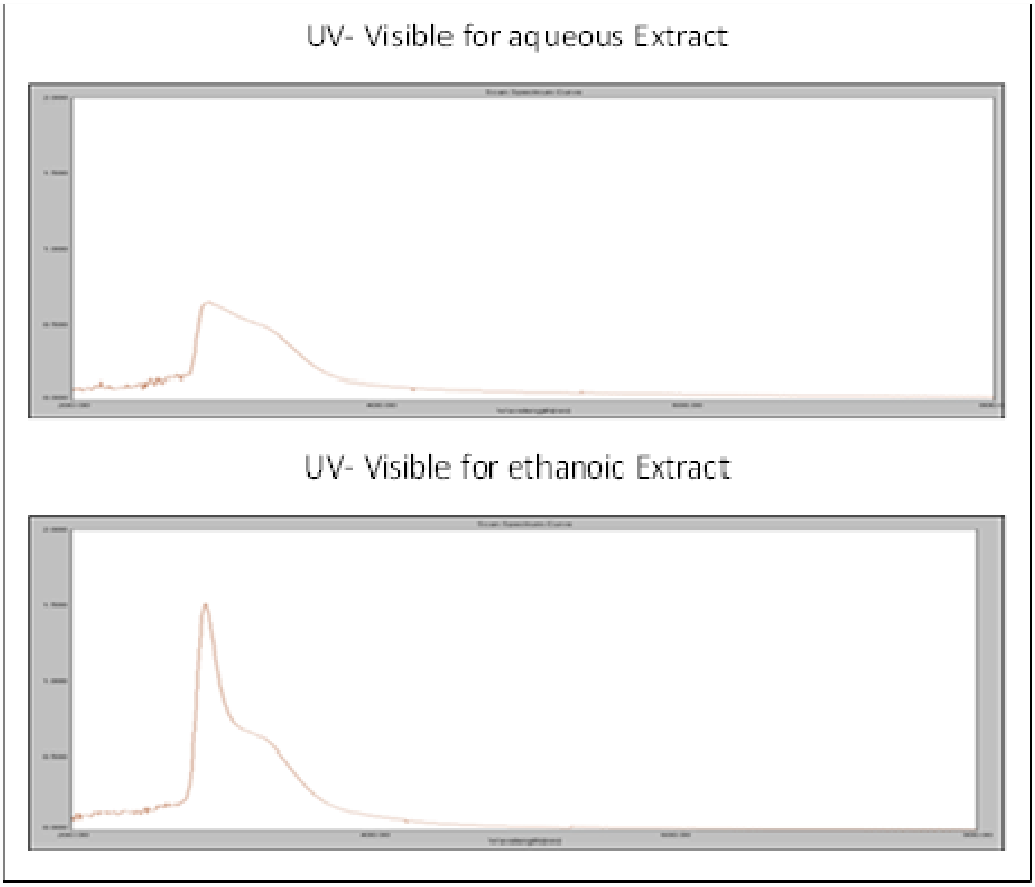


Figure 2: UV- Visible for aqueous and ethanol Extract

Figure 3 displayed a chromatogram from an HPLC (High-Performance Liquid Chromatography) analysis, which is frequently used for phenolic compounds, including flavonoids, with a detector set at 280 nm. This pertains to measuring total phenols in alcoholic and aqueous extracts. It was noted that alcoholic extraction is better than aqueous extraction because flavonoids are phenolic

Alcohols are preferred in extraction because, through the Figures, it was noticed that alcoholic extraction gave a higher number of flavonoids and a larger quantity through the area under the peak, which represents the concentration of flavonoids.

In Figure 3, gallic acid is most likely the primary peak at 4.028 minutes, based on known retention times from previous studies using similar chromatographic conditions. Smaller peaks at 4.441, 5.902, 7.383, and 8.033 minutes indicate the presence of other phenolic compounds, degradation products, or trace amounts of impurities. The strongest peak, which occurs at 4.028 minutes, shows that gallic acid is the main substance present in the sample. Gallic acid is present in considerable amounts, as indicated by the high response of the intensity (y recognized -axis, in mV). The retention time (RT) of gallic acid in High-Performance Liquid Chromatography (HPLC) analysis is highly influenced by certain chromatographic conditions such as temperature, column type, flow rate, and mobile phase composition.

The peak very clearly observed at 4.028 minutes in the chromatogram is gallic acid. This RT value is congruent with that of a study that analyzed ethyl acetate extracts of strawberry fruits and under the same HPLC conditions, gallic acid was found to have a retention time of 4.028 minutes (Singh, 2019; Suhail, 2024).

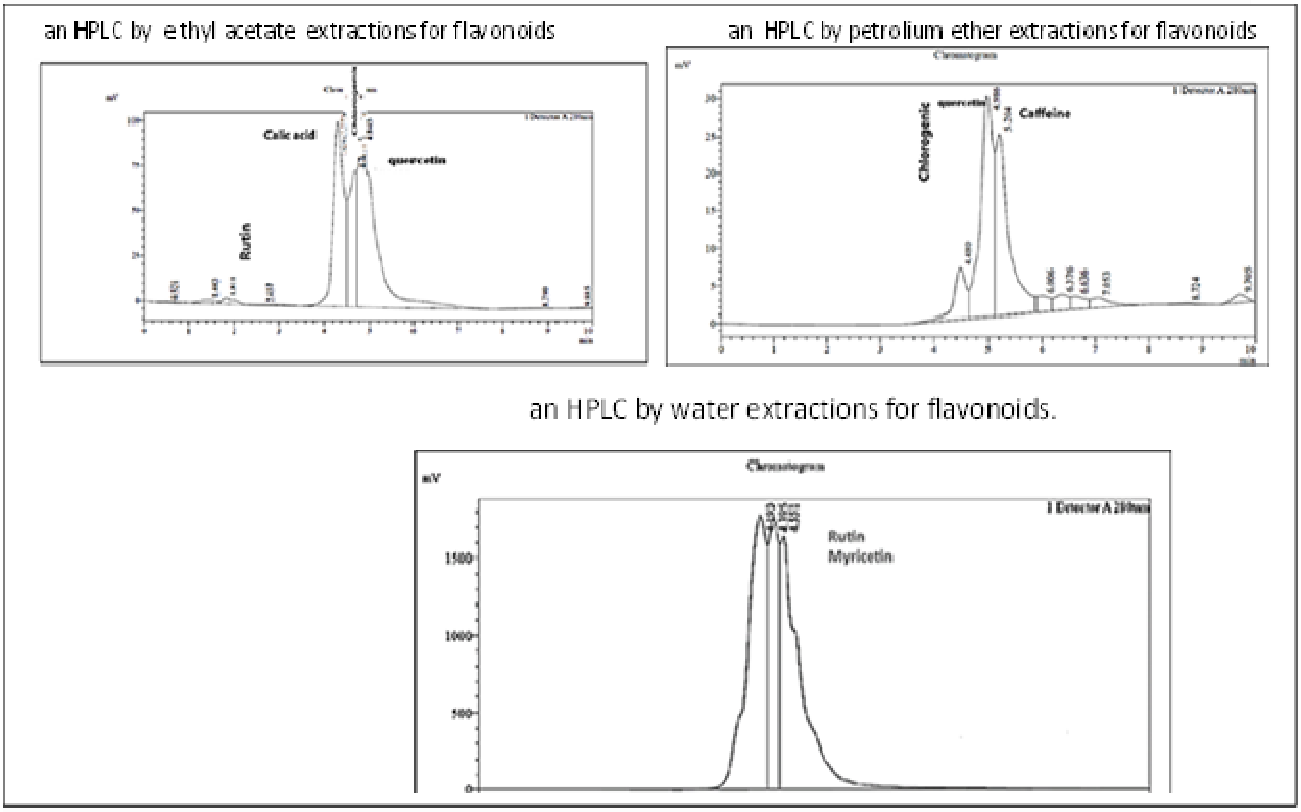


Figure 3: HPLC for date seeds of Al-Khastawy

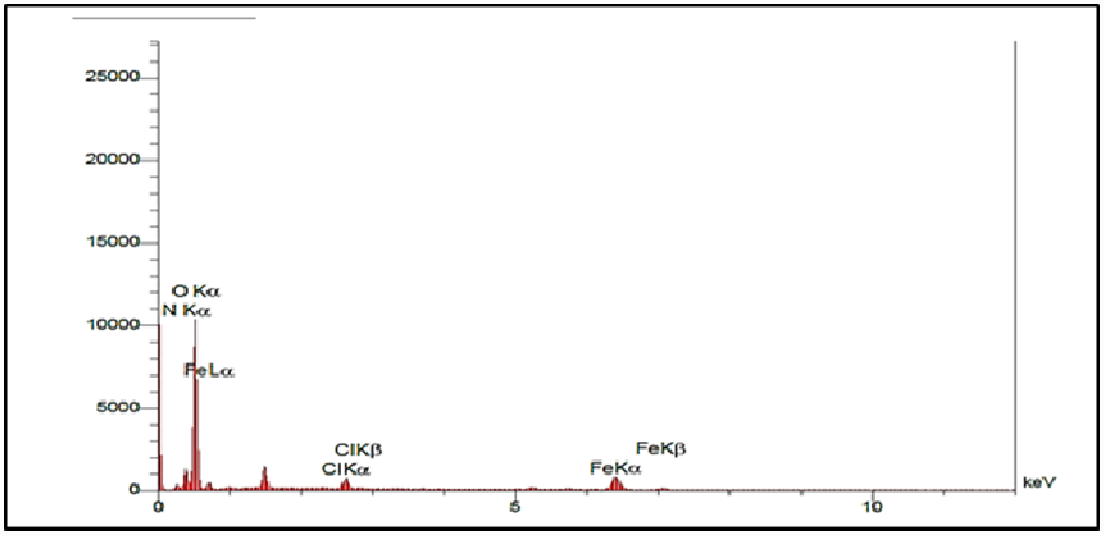


Figure 4: Edx for date seeds of Al-Khastawy.

The chromatogram in Figure 3 shows an HPLC analysis at 272 nm, giving rise to a single and distinct peak at 5.790 minutes of retention time. A single and distinct peak means that the sample is pure and probably contains only one major component with minor impurities. Common phenolic compounds, like caffeine, absorb strongly at 272 nm, making it the perfect wavelength for detection.

In Figure 3, flavonoids and phenolic compounds, which absorb in the UV range, are frequently measured at 280 nm. At this wavelength, it is frequently examined. Quercetin is most likely responsible for the abrupt and strong peak at 4.639 minutes. Peaks at 1.232, 1.863, 3.154, 3.492, 3.881, and 4.220 minutes could be signs of other phenolic compounds, impurities, or degradation products in the sample. The extract may contain polymeric phenolics or additional flavonoids (Abuelgassim, 2020).

Figure 3, Potential candidates for Rutin include flavonoid glycosides with peaks at 1.964 and 2.252 minutes. Rutin's aromatic rings cause it to absorb strongly at 280 nm. The largest peak (Area: 8.124.732 at Rt 2.252 min) indicates a significant component, which could be Rutin (Chen, 2018).

As shown in Figure 3 at 4.531 minutes, the chromatogram displays a single, distinct peak that most likely represents Chlorogenic acid, which is identified at 280 nm. The peak symmetry and absence of extra peaks suggest high purity and effective chromatographic separation. Chlorogenic acid in natural extracts and formulations can be identified, measured, and its purity evaluated with the use of this technique.

Energy-dispersive X-ray spectroscopy

The intensity of the iron (Fe) sample is 136.2, and the measurement error is 0.9000. Iron has an atomic percentage of 2.77% and a weight percentage of 8.90%. To account for atomic number, absorption, and fluorescence effects, a ZAF correction factor of 0.8169 is used. 15.10 percent of the iron in the sample is oxidized. According to the EDS results, Al-Khastawy date seeds have a high oxygen content (76.83 weight percent), which suggests the presence of cellulose, hemicellulose, lignin, and organic compounds, all of which are common constituents of plant-based materials. Proteins or other nitrogen-containing substances may be present, as indicated by the nitrogen content (8.97 percent). Chlorine (5.30 weight percent) can originate from residual salts absorbed from the environment or natural mineral content. With a peak-to-background ratio of 1.0000, the analysis appears to have a balanced signal-to-noise ratio Table 1.

The most influential element in this spectrum is neodymium (Nd), appearing at 22.4 keV with a probability of 100%. Other elements exhibit varying energies with lower probability. Oxygen (O) appears at 610.1 keV with a probability of 0.54%, and fluorine (F) at 7.4 keV with a probability of 0.69%. Aluminum (Al) also appears at 406.0 keV, silicon (Si) at 4.7 keV, nitrogen (N) at 66.8 keV, and chlorine (Cl) at 68.0 keV. From this data it can be inferred that neodymium was the major element in the spectral analysis of the sample and the rest of the elements were only slightly involved in the X-ray interaction. The table provides a picture of the various reactions that different elements undergo with X-rays, which is very useful for ascertaining the chemical composition of the material being analyzed (Bearden, 1967).

Table 1 Contains X-ray spectral analysis data for various elements, with each element's reaction energy (keV) and probability of reaction (prob%).

Elt	Line	Int	Error	K	Kr	W%	A%	ZAF	Formula	Ox%	Pk/Bg	Class	LConf	HConf	Cat#
N	Ka	106.3	51.0645	0.0840	0.0407	8.97	11.14	0.4534		0.00	307.91	A	8.70	9.25	0.00
O	Ka	847.3	51.0645	0.6761	0.3273	76.83	83.49	0.4257		0.00	2929.95	A	76.00	77.66	0.00
Cl	Ka	98.9	20.0573	0.0897	0.0434	5.30	2.60	0.8193		0.00	14.94	A	5.13	5.47	0.00
Fe	Ka	136.2	0.9000	0.1502	0.0727	8.90	2.77	0.8169		0.00	15.10	A	8.66	9.14	0.00
				1.0000	0.4841	100.00	100.00			0.00					0.00

Table 2 shows the results of the automatic identification of elements extracted from the EDX analysis of the Khastawi date seed. The analysis revealed the presence of several elements at different energy levels, included Neodymium (Nd) had the highest probability of identification 100% at an energy of 5.250 ke/V, indicating a strong and clear signal in the spectrum, other elements; including oxygen (O), fluorine (F), aluminum (Al), silicon (Si), and nitrogen (N), were also detected, but with lower probabilities of identification approximately 21%. The presence of these elements reflects the mineral and organic composition of the date seed sample; which is consistent with the typical elemental composition of plant material.

Table 2 Automatic Identification Results.

Elt	Line	Int	keV	Prob%
Nd	La1	22.4	5.250	100
O	Ka1	610.1	0.540	21
F	Ka1	7.4	0.690	21
Al	Ka1	406.0	1.500	21
Si	Ka1	4.7	1.760	21
N	Ka1	66.8	0.400	21
Cl	Ka1	68.0	2.640	3

Biological activity

A total of 10g of crude date seeds of Al-Khastawy extract was obtained in this study through the use of ethanol and ethyl acetate as solvents in crude weight of 5.7g and 7 g respectively, achieving a recovery rate of 57.4% and 70%, respectively. Literature reports on recovery rates show a large variation. The use of polar solvents such as ethanol and methanol for extracting phenolic compounds has been supported by several studies due to the solvents' ability to dissolve a wide variety of plant tissues. For the secondary metabolites the type of solvent, the extraction technique, and the plant material are the main factors explaining the wide variations in the recovery rates. In our experiment, the ethanol extract provided the highest yield of active compounds indicating that there were a lot of soluble substances present, phenolics, flavonoids, and fatty acids among them.

The biological activity of the fractions that were isolated at a concentration of 50 mg/ ml was tested on some Gram-positive bacteria (*Staphylococcus aureus*, *Staphylococcus epidermidis*) as well as on Gram-negative pathogens (*Acinetobacter*, *Proteus*). Variation in inhibition zone values was seen among the tested microorganisms. The Alkhastawy date seeds extract showed greater inhibition zones against the examined strains, as depicted in (Figure 5) the results indicated that both the alcoholic extract and ethyl acetate extract of Khastawi date seeds affected both gram positive and

negative bacteria, with inhibition values ranging between 10-15 mm. The inhibitory effect was equal in the inhibition zone values in all types of bacteria, except for bacteria with the highest inhibition zone estimated at 15 mm. These results are consistent with the findings of previous studies, due to their ability to penetrate the bacterial cytoplasmic membrane, date seeds have antimicrobial properties (Radfar *et al.*, 2019) Evaluated the antibacterial qualities of date seed powder (DSP) extracted using ethyl acetate and hexane (Alrajhi *et al*., 2019). With an inhibition zone of 20 mm in diameter, methicillin-resistant *Staphylococcus aureus* (MRSA) was found to have the highest sensitivity and extract from our study plant was found to be more effective than the common antibiotic gentamycin, which only displayed a 5 mm inhibition zone. Only *Proteus mirabilis* manifested a marked DSE inhibition among gram-negative bacteria tested. The antimicrobial properties of methanol Ajwa DSEs against both gram-positive and gram-negative bacteria were recently reported by (Anwar *et al*., 2022), at 19 mm, 15 mm, and 16 mm, significant inhibition zones against *S. aureus*, *Escherichia coli*, Klebsiella pneumoniae, Pseudomonas aeruginosa, and Enterococcus faecalis were noted by 100 mg/mL of Ajwa date seed The bacterial lysis was disrupted, the phage function was diminished, and the infectivity of Pseudomonas phage ATCC 14209-B1 to P. aeruginosa was inhibited (Jassim and Naji, 2010).

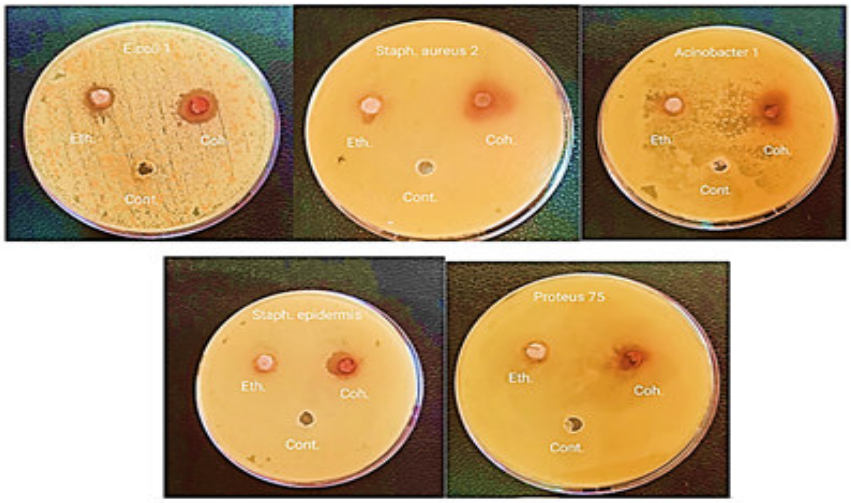


Figure 5 Inhibition zones of Alkhastawy date seeds extracts against various bacterial strains showing antibacterial activity.

Table 3: Inhibition diameter of Alkhastawy date seed extracts against various bacterial strains showing antibacterial activity.

Bacteria	*Staphylococcus aureus*	*Staphylococcus epidermis*	*Acinetobacter*	*Proteus*	*E. coli*
Ethanol	10mm	10mm	15mm	10mm	10mm
Ethyl Acetate	10mm	10mm	10mm	10mm	10mm

Conclusions

Alkhastawy date seed extracts, especially those that are rich in flavonoids and show promising antibacterial activity, could thus be developed into natural antimicrobial agents. Their effectiveness depends on the extraction method; they offer a sustainable alternative to synthetic antibiotics. However, a thorough analysis is necessary to describe polyphenols and other special bioactive substances, including how they work, and to determine safe and effective dosages.

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Competing Interests

The authors declare that there is no conflict of interest.

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