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IN VITRO FREE RADICAL SCAVENGING ACTIVITY AND PHENOLIC CONTENT OF *CUSCUTA PENTAGONA* ENGELM. GROWING WILD IN NORTHEASTERN SYRIA

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Abstract

Cuscuta pentagona Engelm. (Cuscutaceae), a parasitic plant traditionally used in Syria for treating liver disorders and skin infections, remains phytochemically and pharmacologically underexplored. This study aimed to investigate the phytochemical composition and in vitro antioxidant potential of its aerial parts and fruits. Plant materials were collected from northeastern Syria, and extracts were prepared using 70% ethanol via maceration. Preliminary phytochemical screening of the aerial parts confirmed the presence of flavonoids and coumarins, while revealing the absence of saponins, anthraquinones, tannins, alkaloids, and cardiac glycosides. Quantitative analyses demonstrated that the aerial parts extract possessed significantly higher total phenolic and flavonoid contents (45.00 ± 0.041 mg GAE/g and 24.30 ± 0.033 mg QE/g dry weight, respectively) compared to the fruit extract (23.50 ± 0.080 mg GAE/g and 9.09 ± 0.047 mg QE/g). Consistent with this chemical profile, the aerial parts extract exhibited superior free radical scavenging activity in the DPPH assay, with an IC_{50} value of 64.00 ± 0.380 µg/mL, markedly lower than that of the fruit extract (168.70 ± 0.474 µg/mL). The results strongly indicate that the aerial parts of *C. pentagona*are a rich source of phenolic antioxidants, primarily flavonoids, which contribute to its significant radical scavenging capacity. This provides a scientific basis for its traditional use and underscores its potential as a source of natural antioxidant compounds.

Keywords: Cuscuta Pentagona Engelm., Phenolic Compounds, Flavonoids, Free Radical Scavenging Activity, DPPH, Phytochemical Screening.

INTRODUCTION

The escalating prevalence of chronic and degenerative diseases in modern society represents a significant global health challenge. A substantial body of evidence implicates oxidative stress as a pivotal etiological factor in the pathogenesis of a wide spectrum of

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these conditions, including cardiovascular diseases, cancer, neurodegenerative disorders, and diabetes mellitus [1-3]. Oxidative stress arises from a profound imbalance between the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS) and the biological system's capacity to detoxify these reactive intermediates or repair the subsequent damage [4,5]. Under physiological conditions, endogenous enzymatic antioxidants, such as superoxide dismutase and peroxidase, in concert with non-enzymatic antioxidants like ascorbic acid and tocopherols, maintain redox homeostasis [6]. However, exposure to exogenous stressors, including environmental pollutants, radiation, and certain lifestyle factors, can lead to an overproduction of free radicals, overwhelming these intrinsic defense mechanisms [7,8]. The ensuing molecular havoc wrought by unquenched free radicals is extensive. Lipids in cellular membranes are particularly susceptible to peroxidation, leading to a loss of membrane integrity and function. Proteins can undergo oxidative modification, resulting in enzyme inactivation and disruption of critical signaling pathways. Perhaps most critically, oxidative damage to DNA can induce mutations, strand breaks, and genomic instability, which are initiating events in carcinogenesis and accelerated aging [9-11]. Consequently, the strategic attenuation of oxidative stress through the augmentation of antioxidant defenses has emerged as a compelling therapeutic and preventive approach. [12,13]

In this context, the search for potent and safe antioxidants from natural sources has gained considerable momentum. Among the vast array of plant secondary metabolites, phenolic compounds constitute one of the most ubiquitous and pharmacologically promising groups. This diverse class, which includes flavonoids, phenolic acids, tannins, and coumarins, exerts its antioxidant effects through multiple, often synergistic, mechanisms [14]. These include: (i) direct scavenging or neutralization of free radicals by donating hydrogen atoms or electrons; (ii) chelation of pro-oxidant transition metal ions, such as iron and copper, thereby preventing their participation in Fenton-type reactions that generate highly reactive hydroxyl radicals; (iii) inhibition of enzymes responsible for ROS generation; and (iv) upregulation of the body's endogenous antioxidant defense systems [15, 16]. The efficacy of plant-derived phenolics in mitigating oxidative damage has positioned them as lead compounds for the development of functional foods, nutraceuticals, and adjunct therapeutic agents. The genus *Cuscuta* (family: Cuscutaceae), commonly known as dodder, comprises approximately 70-100 species of obligate parasitic plants characterized by their slender, leafless, and often brightly colored stems [17]. Despite their parasitic nature, various *Cuscuta* species have been entrenched in traditional medicine systems across different cultures. Notably, they have been employed for centuries to treat hepatic disorders and various skin infections [10]. Modern phytochemical investigations have begun to validate this traditional use, revealing that these plants are a rich reservoir of bioactive constituents, including flavonoids, lignans, phenolic acids, alkaloids, and volatile oils [18]. This chemical richness underpins a broad spectrum of documented pharmacological activities for different *Cuscuta* species, such as hepatoprotective [19, 20], antioxidant [21], diuretic [22], anti-inflammatory [23], neuroprotective [24], and antiulcer effects [25].

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Cuscuta pentagona Engelm. Figure 1, a species distributed in various regions including northeastern Syria, remains markedly under-investigated compared to its congeners like *C. reflexa*.[26] While traditional use suggests therapeutic potential, a comprehensive scientific profile of *C. pentagona*—encompassing its detailed phytochemical constitution and quantitative bioactivities—is largely absent from the literature. Establishing this profile is crucial for validating its ethnobotanical applications and unlocking its potential as a source of novel antioxidants.[27]

Figure 1: Cuscuta pentagona

Therefore, the present study was designed to systematically evaluate the phytochemical composition and in vitro antioxidant potential of *Cuscuta pentagona* Engelm.[28] The specific objectives were to: (i) conduct a preliminary phytochemical screening of its aerial parts and fruits to identify major classes of secondary metabolites; (ii) quantitatively determine the total phenolic and flavonoid contents in 70% ethanolic extracts of these plant parts; and (iii) assess their free radical scavenging capacity using the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical assay. This work aims to contribute foundational data that could justify further exploration of *C. pentagona* for its therapeutic applications in oxidative stress-related pathologies.[29]

MATERIALS AND METHODS

1. Plant Material Collection and Preparation

The aerial parts and fruits of *Cuscuta pentagona* Engelm. were collected from their natural habitat in Hassakah city, located in northeastern Syria, during October 2024. Botanical identification was confirmed with reference to the taxonomic authority of Costea *et al.* (2006) at the Department of Pharmacognosy, Faculty of Pharmacy, Damascus University. A voucher specimen was deposited in the department's herbarium for future reference. The collected plant materials were air-dried in the shade at ambient

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temperature. Subsequently, the dried aerial parts and fruits were separately ground to a fine powder using an electric grinder and stored in airtight containers at room temperature until extraction.

2. Chemicals and Reagents

All chemicals and solvents utilized were of analytical grade. Absolute ethanol, quercetin, and DPPH (2,2-diphenyl-1-picrylhydrazyl) were procured from Sigma-Aldrich (Germany). Absolute methanol and ascorbic acid were obtained from Panreac (Spain).

Gallic acid and anhydrous sodium carbonate were sourced from AvonChem (United Kingdom). Folin-Ciocalteu reagent was acquired from Merck (Darmstadt, Germany). Sodium acetate and aluminum chloride were purchased from Riedel-de Haën (Germany).

3. Preparation of Plant Extracts

The extraction was performed using maceration. Precisely, 10 g of the powdered plant material (aerial parts or fruits) was separately extracted with 250 mL of 70% (v/v) aqueous ethanol. The mixture was subjected to magnetic stirring for 48 hours at room temperature, protected from light to prevent photodegradation of light-sensitive compounds.

This extraction procedure was repeated three times for each sample to ensure exhaustive extraction. The resulting extracts were combined, filtered, and concentrated under reduced pressure using a rotary evaporator (Heidolph, Germany).

The obtained crude extracts were then lyophilized to complete dryness. The extraction yield was calculated as a percentage using the following formula:

Extraction Yield (%) = (Weight of Dry Extract / Weight of Dry Plant Material) × 100

The dried extracts were stored in hermetically sealed amber vials at 6°C until further analysis.

4. Preliminary Phytochemical Screening

A qualitative phytochemical analysis of the aerial parts powder was conducted using standard chemical protocols to detect the presence or absence of major secondary metabolite classes [19]. The tests performed included:

- **Saponins:** Foam test and reaction with aromatic aldehydes.
- **Flavonoids:** Aluminum chloride test, Shinoda test, and Wilson-Taubouk test.
- **Coumarins:** Fluorescence test under UV light.
- **Anthraquinones:** Borntrager’s test.
- **Tannins:** Ferric chloride test, reaction with lead acetate, and gelatin precipitation test.
- **Alkaloids:** Dragendorff’s, Mayer’s, Wagner’s, and Hager’s reagents.
- **Cardiac Glycosides:** Keller-Kiliani, Kedde, and Baljet tests.

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5. Determination of Total Phenolic Content (TPC)

The total phenolic content was determined spectrophotometrically using the Folin-Ciocalteu method [20], with minor modifications. A stock solution of gallic acid (1000 mg/L) in distilled water was prepared and serially diluted to construct a calibration curve with concentrations ranging from 0 to 500 mg/L. The plant extracts were dissolved in ethanol to a final concentration of 1000 mg/L. The assay was performed by mixing 1 mL of the sample (gallic acid standard or plant extract), 4.8 mL of distilled water, 0.2 mL of undiluted Folin-Ciocalteu reagent, and 4 mL of a 20% (w/v) sodium carbonate (Na_2CO_3) solution. The mixture was vortexed thoroughly, incubated in the dark for 1 hour at room temperature, and the absorbance was measured at 762 nm against a reagent blank using a UV-Vis spectrophotometer (Optizen 3220UV, Mecasys Ltd., KOREA). All analyses were conducted in triplicate. The total phenolic content was expressed as milligrams of Gallic Acid Equivalents (GAE) per gram of dry plant material (mg GAE/g).

6. Determination of Total Flavonoid Content (TFC)

The total flavonoid content was estimated by the aluminum chloride colorimetric method [21, 22]. A quercetin stock solution (1000 mg/L) in absolute methanol was used to prepare a standard curve with concentrations ranging from 0 to 80 mg/L. The plant extracts were prepared at a concentration of 200 mg/L in ethanol. For the assay, 0.5 mL of the sample (quercetin standard or plant extract) was mixed with 0.1 mL of 1 M sodium acetate, 0.1 mL of a 10% (w/v) methanolic aluminum chloride solution, and 2.8 mL of distilled water. The reaction mixture was vortexed, incubated in the dark for 30 minutes at room temperature, and the absorbance of the resulting yellow complex was measured at 415 nm against a methanol blank. All measurements were performed in triplicate. The total flavonoid content was calculated and expressed as milligrams of Quercetin Equivalents (QE) per gram of dry plant material (mg QE/g).

7. Evaluation of DPPH Free Radical Scavenging Activity

The free radical scavenging activity of the extracts was evaluated using the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical, following an established protocol [23, 24] with modifications. A stock solution of the extracts was prepared and serially diluted to yield eight final test concentrations (1, 2, 5, 10, 20, 30, 40, 50, and 200 µg/mL). Ascorbic acid, used as a positive control, was prepared in water at an initial concentration of 1000 mg/L and diluted to a range of 0.001 to 2 mg/L. A fresh DPPH solution was prepared in ethanol at a concentration of 45 mg/L. The reaction was initiated by adding 1 mL of each sample concentration to 3 mL of the DPPH solution. A control was prepared by mixing 1 mL of ethanol with 3 mL of DPPH solution. The mixtures were shaken vigorously and incubated in the dark for 30 minutes. The decrease in absorbance was then measured at 517 nm. The radical scavenging activity (RSA%) was calculated using the formula:

$$\mathbf{RSA\% = [(A\_c - A\_s) / A\_c] \times 100}$$

where A_c is the absorbance of the control and A_s is the absorbance of the sample. The half-maximal inhibitory concentration (IC_{50}), defined as the concentration of extract

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required to scavenge 50% of the DPPH radicals, was determined from the plot of RSA% against log concentration.

8. Statistical Analysis

All experiments, including extraction, phytochemical quantification, and antioxidant assays, were performed in triplicate (n=3). The results are presented as the mean ± standard deviation (SD). Statistical analysis was performed using Microsoft Excel 2016.

RESULTS

1. Phytochemical Screening

Preliminary qualitative phytochemical analysis of the aerial parts of *Cuscuta* Preliminary qualitative phytochemical analysis of the aerial parts of *Cuscuta pentagona* revealed the presence of specific classes of secondary metabolites (Table 1).

The screening yielded positive results for flavonoids, confirmed by multiple tests (aluminum chloride, Shinoda, and Wilson-Taubouk), and for coumarins, as indicated by a positive fluorescence test. Conversely, tests for saponins, anthraquinones, alkaloids, and cardiac glycosides were negative.

The results for tannins were ambiguous; a positive Ferric chloride test suggested the presence of phenolic hydroxyl groups, but negative results from the lead acetate and gelatin precipitation tests indicated the absence of true hydrolyzable or condensed tannins. [30-33]

Table 1: Results of the preliminary phytochemical screening of *Cuscuta pentagona* aerial parts.

Secondary Metabolite	Test Name	Result
Saponins	Foam Test	-
	Reaction with Aromatic Aldehydes	-
Flavonoids	Reaction with Aluminum Chloride	+
	Shinoda Test	+
	Wilson-Taubouk Test	+
Coumarins	Fluorescence Test	+
Anthraquinones	Borntrager's Test	-
Tannins	Ferric Chloride	+
	Reaction with Lead Acetate	-
	Gelatin Precipitation	-
Alkaloids	Dragendorff's Test	-
	Mayer's Test	-
	Wagner's Test	-
	Hager's Test	-
Cardiac Glycosides	Keller-Kiliani Test	-
	Kedde Test	-
	Baljet Test	-

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2. Extraction Yield

The extraction efficiency varied between the different plant parts. The 70% ethanolic extract of the aerial parts yielded 30% (w/w) of dry extract, whereas the extract from the fruits yielded 15% (w/w).

3. Quantification of Phenolic and Flavonoid Contents

The total phenolic content (TPC) and total flavonoid content (TFC) were determined using validated calibration curves. The gallic acid standard curve Figure 2 (y = 0.0021x + 0.0344, R^2 = 0.9908) and the quercetin standard curve Figure 3(y = 0.0036x - 0.00396, R^2 = 0.996) Figure 3 demonstrated excellent linearity.

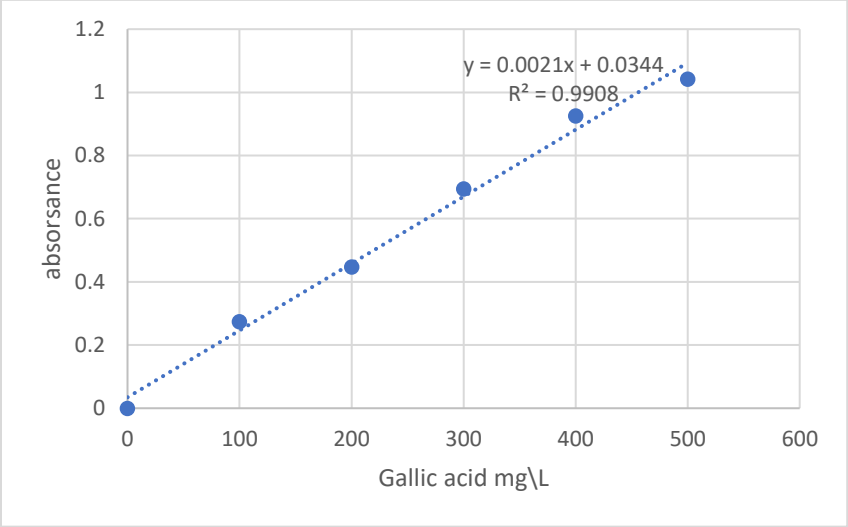

Figure 2: Standard calibration curve for total phenolic content for standard gallic acid

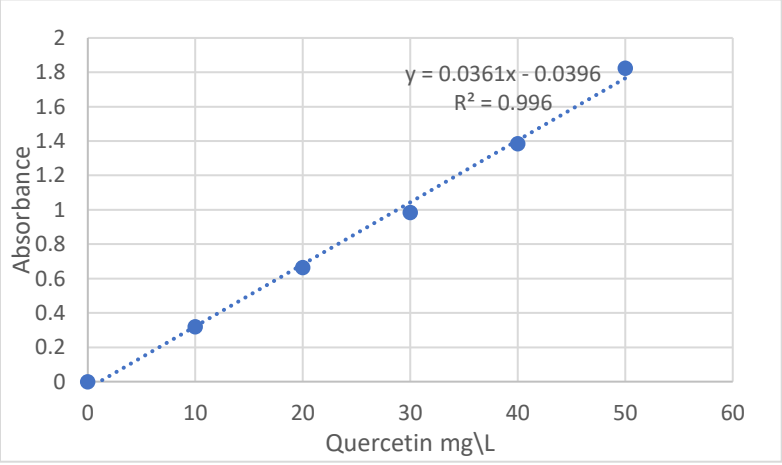

Figure 3: Standard calibration curve for total flavanoids content for standard quercetin

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As summarized in Table 2, the aerial parts extract contained a significantly higher TPC of **45.00 ± 0.041 mg GAE/g** of dry plant material compared to the fruits extract, which contained **23.50 ± 0.080 mg GAE/g**. Similarly, the TFC was substantially greater in the aerial parts extract (**24.30 ± 0.033 mg QE/g**) than in the fruits extract (**9.09 ± 0.047 mg QE/g**).

4. DPPH Free Radical Scavenging Activity

The in vitro antioxidant potential of the extracts was evaluated by measuring their ability to scavenge the stable DPPH free radical. The results, expressed as the half-maximal inhibitory concentration (IC_{50}), are presented in Table 2. The positive control, ascorbic acid, exhibited a potent IC_{50} value of **0.116 µg/mL**. Among the plant extracts, the aerial parts demonstrated markedly stronger radical scavenging activity, with an IC_{50} of **64.00 ± 0.380 µg/mL**. In contrast, the fruits extract showed considerably weaker activity, with an IC_{50} of **168.70 ± 0.474 µg/mL**. The concentration-dependent scavenging response for both extracts is illustrated in Figures 4 and 5.

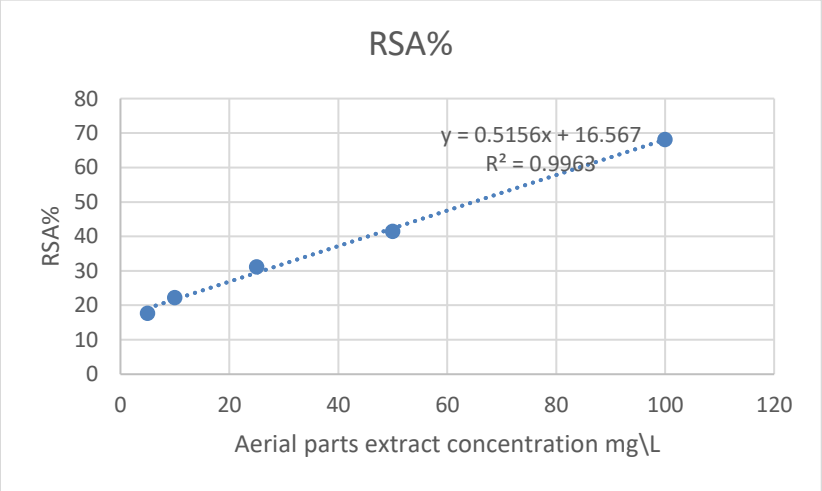

Figure 4: scavenging DPPH• by Aerial part extract

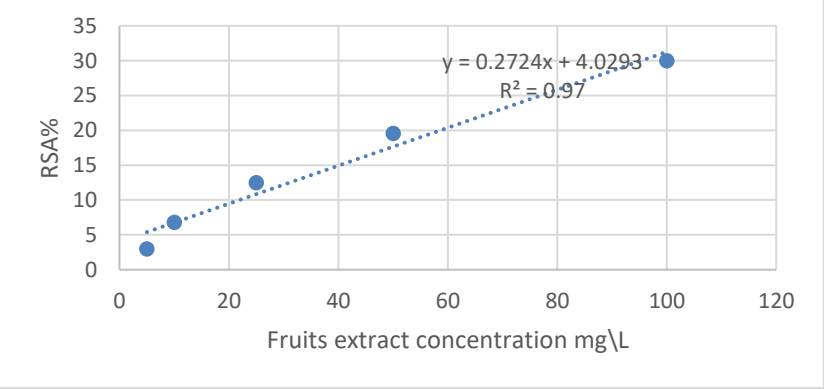

Figure 5: scavenging DPPH• by fruits extract

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Table 2: Extraction yield, total phenolic content (TPC), total flavonoid content (TFC), and DPPH radical scavenging activity (IC_{50}) of *Cuscuta pentagona* extracts and ascorbic acid.

Sample	Yield (%)	TPC (mg GAE/g Dry Plant)	TFC (mg QE/g Dry Plant)	IC_{50} (µg/mL)
Aerial Parts	30	45.00 ± 0.041	24.30 ± 0.033	64.00 ± 0.380
Fruits	15	23.50 ± 0.080	9.09 ± 0.047	168.70 ± 0.474
Ascorbic Acid	-	-	-	0.116

*Values are expressed as mean ± standard deviation (n=3). GAE: Gallic Acid Equivalents; QE: Quercetin Equivalents. *

DISCUSSION

The present study provides a comprehensive phytochemical and pharmacological profile of *Cuscuta pentagona* Engelm. growing wild in northeastern Syria, with a particular focus on its antioxidant potential. The findings indicate that the aerial parts of this parasitic plant are a significant source of phenolic antioxidants, notably flavonoids, which correlate with its observed free radical scavenging activity.

1. Phytochemical Composition and Its Implications

The preliminary phytochemical screening of the aerial parts confirmed the presence of flavonoids and coumarins, while ruling out the presence of saponins, anthraquinones, alkaloids, and cardiac glycosides. The consistent positive results across multiple tests ($AlCl_3$, Shinoda, Wilson-Taubouk) provide robust evidence for a rich flavonoid content. Flavonoids are well-documented for their broad-spectrum biological activities, primarily due to their potent antioxidant properties mediated by their redox chemistry, which allows them to act as hydrogen donors and singlet oxygen quenchers [34]. The presence of coumarins, as indicated by the positive fluorescence test, is also of pharmacological interest. Coumarins are a class of compounds known for their diverse biological roles, including anti-inflammatory, antimicrobial, and anticoagulant activities [35]. Their presence in *C. pentagona* may synergistically contribute to the plant's traditional use in treating skin infections and suggests potential for multi-target therapeutic applications.[36] The absence of alkaloids and cardiac glycosides is noteworthy from a safety perspective, as these compound classes are often associated with toxicity. This phytochemical profile aligns *C. pentagona* with other *Cuscuta* species reported to be rich in phenolics but generally lacking in toxic alkaloids [37], supporting its potential as a relatively safe source of natural antioxidants.

2. Extraction Efficiency and Solvent Selectivity

The maceration process using 70% aqueous ethanol yielded a substantially higher extractable mass from the aerial parts (30%) compared to the fruits (15%). This discrepancy can be attributed to differences in the physicochemical composition of the

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plant tissues. Aqueous ethanol is a versatile solvent capable of extracting a wide range of medium- and high-polarity compounds, including phenolics, flavonoids, and some sugars. The higher yield from the aerial parts suggests a greater concentration of these polar, ethanol-soluble constituents. Conversely, the lower yield from the fruits may be due to a higher proportion of non-polar compounds, such as fixed oils, fatty acids, or waxy cuticles, which are poorly soluble in 70% ethanol. This hypothesis could be investigated in future work through successive extraction with solvents of decreasing polarity.[38]

3. Quantitative Analysis of Bioactive Constituents

The quantitative assays revealed a clear and significant gradient in bioactive content between the two plant parts. The TPC in the aerial parts (45.00 mg GAE/g) was nearly double that of the fruits (23.50 mg GAE/g). More strikingly, the TFC in the aerial parts (24.30 mg QE/g) was over 2.5 times higher than in the fruits (9.09 mg QE/g). This distribution indicates that the aerial parts are the primary site for the biosynthesis and/or accumulation of these antioxidant compounds in *C. pentagona*.[39] These findings are consistent with research on other species within the genus. For instance, the reported phenolic content in the aerial parts of *Cuscuta reflexa* [18]. falls within a comparable range, suggesting that a high phenolic load may be a characteristic feature of the aerial tissues of *Cuscuta* species. The substantial flavonoid content underscores the plant's capacity to produce these valuable secondary metabolites, potentially as a defense mechanism against the oxidative stress inherent to its parasitic lifestyle, which involves evading the host plant's defense systems.

4. Correlation Between Phytochemical Content and Antioxidant Activity

The DPPH radical scavenging assay provides direct evidence of the extracts' antioxidant efficacy. The results demonstrate a strong inverse correlation between the TPC/TFC and the IC_{50} values. The aerial parts extract, with its high phenolic and flavonoid content, exhibited a much lower IC_{50} (64.00 µg/mL), indicating superior radical scavenging capacity. In contrast, the fruits extract, with lower phenolic and flavonoid levels, showed a significantly higher IC_{50} (168.70 µg/mL), denoting weaker activity. This structure-activity relationship is well-established. Phenolic compounds scavenge free radicals primarily through the donation of a hydrogen atom from their hydroxyl groups, resulting in a more stable, delocalized phenoxyl radical [5]. The high concentration of these hydrogen-donating groups in the aerial parts extract directly explains its potent activity. While the antioxidant activity of *C. pentagona* extracts is moderate compared to the potent standard ascorbic acid (IC_{50} = 0.116 µg/mL), this is expected, as pure compounds typically exhibit greater potency than complex crude extracts. The observed activity is significant in the context of plant-based antioxidants and is comparable to many other medicinal plants investigated for their radical scavenging potential.[40]

5. Broader Implications and Future Perspectives

The demonstrated antioxidant capacity of *C. pentagona*, particularly in its aerial parts, holds significant implications for its potential therapeutic application. Oxidative stress is a

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fundamental contributor to the pathogenesis of numerous chronic diseases, including cardiovascular disorders, diabetes, cancer, and neurodegenerative conditions [1]. Natural antioxidants that can mitigate oxidative damage are therefore of immense interest in preventive and complementary medicine.

The traditional use of *Cuscuta* species for liver disorders finds a plausible scientific rationale in this antioxidant activity, given the liver's susceptibility to oxidative damage.

Future research should focus on several key areas:

1. **Bioassay-Guided Fractionation:** To isolate and identify the specific flavonoid and coumarin compounds responsible for the observed activity.
2. **Mechanistic Studies:** To elucidate the precise antioxidant mechanisms, such as metal chelation capacity and effects on endogenous antioxidant enzymes.
3. **In vivo Validation:** To confirm the antioxidant and hepatoprotective effects in animal models of oxidative stress.
4. **Comparative Analysis:** To investigate the impact of different host plants on the phytochemical profile and bioactivity of *C. pentagona*.

This study successfully establishes that *Cuscuta pentagona* is a rich source of natural antioxidants, with its aerial parts being the most promising repository. The strong correlation between its high phenolic and flavonoid content and its free radical scavenging activity provides a scientific basis for its ethnobotanical use and positions it as a candidate for further development as a nutraceutical or phytopharmaceutical agent.

Statistical analysis:

All experimental procedures, including phytochemical quantification and antioxidant assays, were performed in triplicate (n=3) to ensure the reliability and reproducibility of the data. The results for total phenolic content (TPC), total flavonoid content (TFC), and DPPH radical scavenging activity (IC_{50}) are expressed as the arithmetic mean ± standard deviation (SD). The standard deviation provides a measure of the dispersion of the individual data points around the mean, indicating the precision of the measurements.

To determine the statistical significance of the observed differences in phytochemical content between the aerial parts and fruit extracts, a one-way analysis of variance (ANOVA) was employed. This test was chosen to compare the means of the two independent groups.

The ANOVA results indicated that the difference in total flavonoid content between the aerial parts and fruit extracts was statistically significant, with a probability value of $P < 0.05$. This confirms that the higher flavonoid concentration in the aerial parts is unlikely to be due to random chance.

In contrast, the comparison of total phenolic content between the two extracts yielded a probability value of $P = 0.459$. As this value is greater than the conventional significance

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threshold of 0.05, the observed difference in TPC, while substantial in magnitude, was not deemed statistically significant within the confines of this experimental design and sample size. All statistical calculations were performed using Microsoft Excel 2016. A P-value of less than 0.05 ($P < 0.05$) was considered indicative of a statistically significant difference.

CONCLUSION

This study provides a foundational phytochemical and pharmacological characterization of the previously under-investigated parasitic plant, *Cuscuta pentagona* Engelm., from northeastern Syria. The findings conclusively demonstrate that this species, particularly its aerial parts, is a significant source of bioactive phenolic compounds with notable antioxidant properties.

The preliminary phytochemical screening established a distinct metabolic profile for the aerial parts, confirming the presence of flavonoids and coumarins while indicating the absence of several other metabolite classes, including alkaloids and cardiac glycosides. This profile not only aligns with the known chemistry of the *Cuscuta* genus but also suggests a potentially favorable safety profile for further exploration.

Quantitative analysis revealed a substantial concentration of phenolics and flavonoids, with the aerial parts extract containing 45.00 mg GAE/g and 24.30 mg QE/g of dry plant material, respectively, significantly surpassing the levels found in the fruit extract. The in vitro DPPH radical scavenging assay functionally validated these phytochemical findings. The aerial parts extract exhibited considerable antioxidant activity, with an IC_{50} value of 64.00 µg/mL, which was markedly more potent than the fruit extract (IC_{50} = 168.70 µg/mL).

The strong inverse correlation observed between the total phenolic/flavonoid content and the IC_{50} values underscores that the antioxidant capacity is primarily mediated by these compound classes. The documented presence of coumarins further enriches the extract's potential bioactivity, potentially contributing to anti-inflammatory or antimicrobial effects that align with its traditional uses.This research successfully validates the ethnobotanical use of *C. pentagona* and identifies its aerial parts as the most therapeutically promising plant organ.

The demonstrated free radical scavenging activity, driven by its rich phenolic and flavonoid content, provides a compelling scientific rationale for its traditional application in treating conditions like liver disorders, where oxidative stress is a key pathological factor.

Consequently, *Cuscuta pentagona* emerges as a viable candidate for development as a source of natural antioxidants for nutraceutical or phytopharmaceutical applications. Future research should focus on the bioassay-guided isolation of the specific active principles, mechanistic studies on their antioxidant pathways, and in vivo validation of their hepatoprotective and other therapeutic potentials.

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