Evaluation of nutritional value, antioxidant activities, and anti-inflammatory properties of Sidr (Ziziphus Spina-Christi) Leaves

By

Mona Y. Mostafa
Home Economic Dept.,
Faculty of Specific Education,
Mansoura University

Hend M. Hassan
Human Anatomy and Embryology Department,
Faculty of Medicine,
Mansoura University

Zeinab S. Abdou
Home Economic Dept.,
Faculty of Specific Education,
Mansoura University

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*Mona Y. Mostafa** *Hend M. Hassan* ** *Zeinab S. Abdou* *

Abstract

The present study aims to determine the chemical composition, minerals, vitamins, total phenols, total flavonoids, phenolic compounds, antioxidant activities, and anti-inflammatory properties of Sidr "Ziziphus spina-christi" leaves. The results revealed that leaf is a good source of protein, calcium, potassium, and magnesium. Ziziphus spina-christi leaves contain a high amount of Menadione (Vit. K), Ascorbic acid (Vit. C), and Pyridoxine (Vit.B6). Also, it is considered a good source of total phenols and flavonoid contents as recorded 102.4± 0.4 mg (GAE)/g and 35.2± 0.4 mg (QE)/g, respectively. The results showed that the leaves contain high phenolic compounds " rutin, quercetin, catechin, and gallic acid ". The leaf extract is a good effective antioxidant, which recorded 352.37± 0.352 µg/mg for ferric reducing antioxidant power (FRAP). The anti-inflammatory activity of Ziziphus spina-christi leaves extract was evaluated using HRBC hemolysis and membrane stabilization in vitro. The hemolysis inhibition percentage of sidr leaves is very similar to the hemolysis inhibition percentage of Indomethacin as a standard which confirms the high anti-inflammatory activity of sdir leaves. Therefore, the Ziziphus spina-christi leaf extract had anti-inflammatory qualities. These results supported that the Ziziphus spina-christi plant is thought to be a promising tree for the future creation of various medications due to its easy cultivation and active components.

Key words: Ziziphus spina-christi, chemical composition, phenolic compound, antioxidant activities and anti-inflammatory

* Home Economic Dept., Faculty of Specific Education, Mansoura University

** Human Anatomy and Embryology Department, Faculty of Medicine, Mansoura University

1. Introduction

Figure (1): *Zizyphus spina-christi (L.) Leaves (*Moustafa *et al*., 2016).

Ziziphus spina-christi is a plant that thrives in South and East Asia. As described in the Holy Quran, the *Ziziphus spina-christi* tree is known as "Sidr" throughout nearly all Arabic nations, the Levant, and Saudi Arabia. It has nutritive elements that make the plant one of the main sources of sustenance. The plant has a variety of active phytochemicals, with spinanine A, -sitosterol, rutin, quercetin, betulinic acid, and rutin dominating the list (**Saaty et al., 2019)**. Egyptians utilized the wild *tree Ziziphus spina-christi (L.)* as a medicine **(Dkhil *et al*., 2018)**. The tree's leaf extract contains a large number of phytochemical compounds such phenols, flavonoids, and tannins. Additionally, it was discovered that this plant's leaves have a significant biological potential due to the presence of a large number of polyphenolic chemicals **(Abdulrahman *et al*., 2022)**.

In alternative medicine, *Z. spina-christi* has been used to treat a variety of ailments, including fever, pain, dandruff, wounds and ulcers, inflammatory problems, asthma, and eye disorders. Recent research has demonstrated the antibacterial, antifungal, antioxidant, anti-hyperglycemic, and antinociceptive properties of *Z. spina-christi*. The principal phytochemicals found in this plant that have been reported are flavonoids, alkaloids, and saponins. The main constituents of the volatile oil found in leaves are geranyl acetone, methyl hexadecanoate, methyl octadecanoate, farnesyl acetone C, hexadecanol, and ethyl octadecanoate. In certain regions

of the world, particularly the Middle East, this plant has been used as food and medicine due to its extraordinary biological activities, easy gathering of plant materials, low cost, and widespread availability in many nations **(Asgarpanah and Haghigha, 2012)**.

Z. spina-christi plant's leaves contain significant amounts of vitamins B1, B12, B2, and folic acid **(Moustafa *et al.*, 2016).** It contains tannins, flavonoids, terpernoids, saponin glycosides, and alkaloids, based on phytochemical study **(Ads *et al*., 2017)**. The GC-MS analysis also revealed the presence of substances with antiproliferative action, such as flavonoids **(Abu-Raghif *et al*., 2016)**. **Dilla *et al.* (2021)** mentioned that calcium, potassium, magnesium, active flavonoid components, and antioxidant activity are all present in bidara (*Ziziphus spinachristi*), which helps to scavenge free radicals.

Ziziphus spina-christi is a plant with favorable agricultural economics that can be used as a dietary supplement and food source of high calcium, phosphorus, potassium, and magnesium **(Alhmoudi *et al*., 2022)**. Most biologically active substances have been found in *Ziziphus spina-christi*, including alkaloids, sterols including sitosterol, flavonoids, triterpenoids, sapogenins, and saponins **(Hussein, 2019).**

Because of its chemical compounds, *Ziziphus spina-christi* has strong antioxidant properties and can be used medicinally. The results of the FT-IR method showed that *Z. spina-christi* surrounds 11 functional groups **(Magbool *et al*., 2023)**.

Through phytochemical research conducted on plants in the genus Ziziphus, around 431 chemical compounds have been found. Flavonoids and cyclopeptide alkaloids are the two primary classes. The crude extracts and isolated compounds exhibit a broad range of pharmacologic activity both in vitro and in vivo, such as antibacterial, anticancer, antidiabetic, antidiarrheal, anti-inflammatory, antipyretic, antioxidant, and hepatoprotective properties. Toxicology studies indicate that Ziziphus species don't seem to be harmful at standard therapeutic dosages **(El Maaiden *et al*., 2020)**.

The plant offers potential in the traditional medicine sector. It has anti-inflammatory, antibacterial, antifungal, and antioxidant properties that can help prevent tumors **(Hastiana *et al.*, 2022)**. The *Z. spina leaf extracts* had promising antioxidant properties that might be used by pharmaceutical companies to produce treatments for diseases that are caused by free radicals **(Ogbiko *et al.*, 2020)** . *Zizyphusspina-Christi Z. SC*'s high antioxidant content may help to mitigate scopolamine-induced brain and memory deficits **(Noutarki *et al.*, 2017)**. Sidr leaf ethanolic extract's strong antimicrobial and antioxidant properties against a wide range of microbial strains that cause serious illnesses in both humans and animals validate the traditional uses of herbal remedies and give sidr leaf ethanolic extract a scientific foundation for those traditional uses in primary healthcare **(Al-Zaemey *et al.*, 2021)**. *Z. spina-christi leaves* extracts are used in the pharmaceutical and medical industries. These extracts can be employed as anti-oxidants, insecticides, and allelopathic agents because of their high phenolic content. In addition to industrial uses, *Z. spina-christi leaves* may make a promising candidate for food and medicinal supplement formulations **(Elaloui *et al.*, 2022)**. The leaf extract has the capacity to be a very effective antioxidant. The leaf extract can be applied topically or orally as an antioxidant candidate in pharmaceutical and cosmetic preparations **(Darusman *et al.*, 2023)**.

Anti-inflammatory properties of *Z. spina-christi* may exist, as suggested by ancient Egyptian remedies. As demonstrated in vitro and in silico, five substances—namely, epigallocatechin, gallocatechin, spinosin, 6-feruloylspinosin, and 6-sinapoylspinosin—contributed to this bioactivity **(Kadioglu *et al.*, 2016).** Natural flavonoids found in the leaves have been shown in studies to have antioxidant, anti-inflammatory, and antibacterial properties that make them useful for treating acne **(Shakiba *et al.*, 2019)**. As a result of producing anti-inflammatory and antioxidant effects, *Ziziphus spina-christi leaf* extract may act as a therapeutic agent for sepsis **(Dkhil *et al.*, 2018)**. It demonstrated potent therapeutic effect against *diethylnitrosamine* -induced hepatocellular cancer **(Salah El-Din *et al.*, 2019)**. In addition to having a pleasant flavour, sidr contains hypoglycemic,

sedative, antidiabetic, anti-inflammatory, and analgesic properties **(Atwaa *et al.*, 2022)**. Therefore, the present study aims to determine the chemical composition, minerals, vitamins, total phenols, total flavonoids, phenolic compounds, antioxidant activities, and anti-inflammatory properties of Sidr "*Ziziphus spina-christi*" leaves

2. Materials and methods

2.1. Materials:

***Ziziphus spina-christi* leaves** was obtained from the local market at Minyat AL-Nasr, Dakahlia, Egypt. The *Ziziphus spina-christi* leaves identity was kindly authenticated by staff members at Department of Pomology, Faculty of Agriculture, Mansoura University. A voucher specimen (P-5-17) was deposited at the Department of Pharmacognosy, Mansoura University, Mansoura, Egypt.

2.2. Methods

2.2.1. Preparation of Ziziphus spina-christi leaves powder and ethanolic extract:

*** Leaves powder**: leaves were ground into a powder and kept under freezing till analysis (for every kg of the basal diet, 35g of cellulose were replaced by 35g of the powder in the powder- treated groups).

* **Leaves extract:** The dried powdered leaves (500 g) were extracted by maceration with Ethanol (3 x 500 mL). The combined extract was dried in a desiccator over anhydrous CaCl2 to a constant weight (77.8 g; 15.56% w/w yield) after being concentrated to a syrupy consistency using a rotary evaporator under reduced pressure **(Elbadrawy and Mostafa, 2024).**

2.2.2. Gross chemicals composition:

* Moisture, crude protein, crude fat and ash were determined according to **AOAC (2019)**.

* Minerals (Ca, Fe, Mg, k and Na) were measured according to **Bettinelli *et al.* (2000).**

* Vitamins (D, K, A, C, B6, B1 and B5) were determined by high performance liquid chromatography (HPLC), according to **Saad *et al*. (2015).**

2.2.3. Determination of total phenolic content:

Total phenolic content of the extract was evaluated by a colorimetric method utilizing Folin-Ciocalteu reagent by the method of **Sembiring *et al.* (2018), and Marinova *et al*. (2005).**

2.2.4. Determination of total flavonoid content :

Modified AlCl3 calorimetric method was used according to the method outlined by **Sembiring *et al*. (2018), Marinova *et al.* (2005), and Chang *et al*. (2002)** to determine the flavonoid content.

2.2.5. Fractionation and identification of phenolic compounds:

HPLC analysis was carried out according to **Skehan *et al*. (1990)**, using an Agilent 1260 series.

2.2.6. Antioxidant activity using Ferric reducing antioxidant power (FRAP) assay:

To investigate the impact of solvent polarity on the total reducing power of extract, potassium ferricyanide, trichloroacetic acid method was used **Bouzid *et al*. (2022)** with some modifications and adaptation for microplate method of **Athamena *et al*. (2019**).

2.2.7. In vitro anti-inflammatory assay:

Preparation of erythrocyte suspension:

Fresh whole blood (3 ml) collected from healthy volunteers into heparinized tubes was centrifuged at 3000 rpm for 10 min. A volume of normal saline equivalent to that of the supernatant was used to dissolve the red blood pellets. The volume of the dissolved red blood pellets obtained was measured and reconstituted as a 40% v/v suspension with isotonic buffer solution (10 mM sodium phosphate buffer, pH 7.4). The buffer solution contained 0.2 g of NaH2PO4, 1.15 g of Na2HPO4 and 9 g of NaCl in 1 liter of distilled water. The reconstituted red blood cells (resuspended supernatant) were used as such.

Hypotonicity induced hemolysis:

Samples of the extract used in this test were dissolved in distilled water (hypotonic solution) outlined by **Shinede *et al*. (1989)**. The hypotonic solution (5 ml) containing graded doses of the extracts (100, 200, 400, 600, 800 and 1000 µg/ml) were put into duplicate pairs (per dose) of the centrifuge tubes. Isotonic solution (5 ml) containing graded doses of the extracts (100 – 1000 µg/ml) were also put into duplicate pairs (per dose) of the centrifuge tubes. Control tubes contained 5 ml of the vehicle (distilled water) and 5 ml of 200 µg/ml of indomethacin respectively. Erythrocyte suspension (0.1 ml) was added to each of the tubes and mixed gently. The mixtures were incubated for 1 hr at room temperature (37°C), and afterwards, centrifuged for 3 min at 1300 g. Absorbance (OD) of the haemoglobin content of the supernatant was estimated at 540 nm using Spectronic (Milton Roy) spectrophotometer. The percentage heamolysis was calculated by assuming the heamolysis produced in the presence of distilled water as 100%. The percent inhibition of haemolysis by the extract was calculated thus:

% Inhibition of haemolysis = 1-((OD2-OD1)/ (OD3-OD1)) ×100

Where OD1 = absorbance of test sample in isotonic solution

OD2 = absorbance of test sample in hypotonic solution

OD3 = absorbance of control sample in hypotonic solution

3.2.8. Statistical analysis:

Version 26.0 of IBM SPSS for Windows was used to analyze the data. The data were found to be normally distributed according to the results of the Shapiro-Wright test for normality. The significance level was set at the (0.05) level, and the data were reported as mean ±SD. The study groups' means were compared using the one-way ANOVA test, and pairwise comparisons were made using the Post Hoc Games-Howell test.

4. Results and discussion

4.1. Physiochemical composition of Ziziphus spina-christi leaves:

Moisture, ash, fat, protein and carbohydrates in *Ziziphus spina-christi* leaves were determined and recorded in **Table (1) and Fig. (2).** *Ziziphus spina-christi* leaves powder recorded 9.73±0.13, 6.11±0.03, 3.37±0.06, 16.34±0.07 and 64.45±0.11**%** for moisture, ash, fat, protein and carbohydrates, respectively. The results revealed that *Ziziphus spina-christi* is a good source of protein, ash, and carbohydrates that are a good source of energy.

Elsheshetawy and Faid (2015) found that *Ziziphus Spina Christi* fruits contain (per 100 g) 9.3% water, 4.8% protein, 0.9% fat, 80.6% carbohydrates and 4.4% ash on a dry matter basis. **Salih and Yahia (2015)** reported that the proximate values of *Ziziphus Spina Christi* fruit pulp on a dry matter basis recorded 10.53% water, 2.55% fat, 4.34% protein, 5.16% ash, 74.31% carbohydrates and 3.11% fiber. According to the data of **Abubakar (2021),** the percentages (%) of moisture, ash, crude fat, crude protein, crude fiber, and total carbohydrate content in *Z.spina* fruit were 3.13, 15.22, 3.11, 11.12, 6.45, and 64.10, respectively. On the other hand, **Alhmoudi *et al*. (2022)** found that about 75.92%, 6.08%, <0.1%, 16.82%, 4.38%, and 2.11% were the results for dry matter, crude protein, crude fat, crude fiber, ash, and total sugar from *Ziziphus spina-christi* plant "a sample from the United Arab Emirates (Fujairah)", respectively.

Table (1): Physiochemical composition of *Ziziphus spina-christi* leaves:

Sample	Proximate analysis (%)				
	Moisture	**Ash**	**Fat**	**Protein**	**Carbohydrate**
***Ziziphus spina-christi* leaves**	9.73±0.13	6.11±0.03	3.37±0.06	16.34±0.07	64.45±0.11
Each value is the mean ± SD					

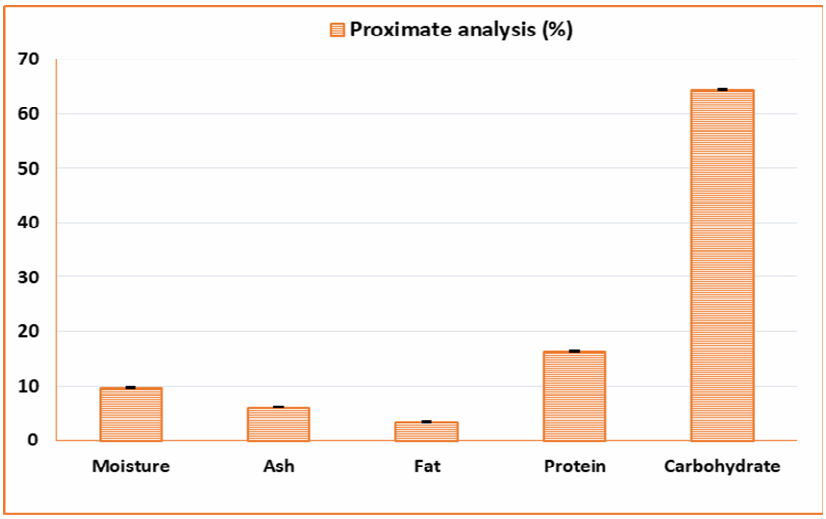

Figure (2): Physiochemical composition of Ziziphus spina-christi leaves

4.2. Mineral content of Ziziphus spina-christi leaves:

Results represented in **Table (2) and Fig. (3)**, show that *Ziziphus spina-christi* powder recorded 1669.09± 4.07, 34.838± 0.10, 252.696± 1.07, 962.665± 2.65 and 56.211± 1.36 mg/100g for calcium (Ca), iron (Fe), magnesium (Mg), potassium (K) and sodium (Na), respectively. It's noticed that *Ziziphus spina-christi* is a good supply of calcium, potassium, and magnesium.

Results were in harmony with previous results such as the study of **Osman and Ahmed (2009)** who reported that *Zizyphus spina-christi* "nabag" fruit is rich in Mg, Ca, Fe and Zn. Also, **Salih and Yahia (2015)** found that mineral contents (per 100 g DW) of *Ziziphus spina-christi* fruit recorded 173 mg calcium, 840 mg potassium, 73 mg magnesium, 9.54 mg sodium, 1.1 mg iron, 0.25 mg, 0.33 mg zinc, 0.36 mg manganese, 0.218 mg aluminium. According to the study of **Abubakar (2021)**, the most and least abundant elements in *Z. spina* fruit were potassium and copper, with concentrations of 256.12 and 2.37 mg/100 g dry weight, respectively. Their results show that *Z. spina* fruit contains significant mineral components that, if used appropriately, may enhance appropriate metabolic activity and, thus, improve health standards. Also, **Dilla *et al.* (2021)** stated that calcium,

potassium, and magnesium are all present in bidara (*Ziziphus spinachristi*), which helps to prevent free radical damage. Also, our results were in the same line with the results of **Alhmoudi *et al.* (2022)** who reported that the *Ziziphus Spina Christi* plant's mineral content (mg/100g) for calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) was 444.26, 139.29, 109.95, and 41.30, respectively.

Table (2): Mineral content of *Ziziphus spina-christi* leaves.

Sample	Minerals (mg/100g)				
	Ca	**Fe**	**Mg**	**K**	**Na**
***Ziziphus spina-christi* leaves**	1669.09±4.07	34.838±0.10	252.696±1.07	962.665±2.65	56.211±1.36
Each value is the mean ± SD Ca: calcium, Fe: ferritin, Mg: magnesium, K: potassium and Na: sodium.					

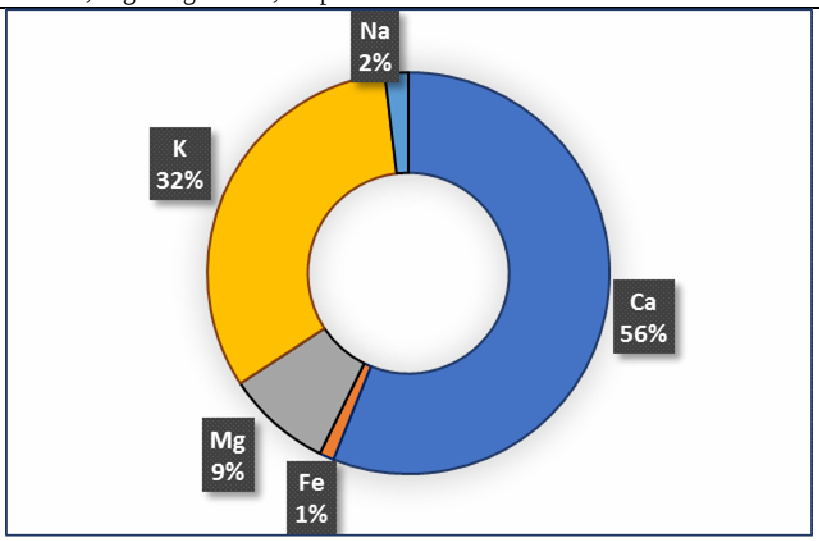

Figure (3): Mineral content of *Ziziphus spina-christi* leaves

4.3. Vitamin content of Ziziphus spina-christi leaves:

Some vitamins help protect against various diseases and increase the body's immunity, especially vitamin C, which also works as an effective antioxidant. As shown in **Table (3) and Fig (4),** it is clear that *Ziziphus spina-christi* leaves powder contain a high amount of Menadione (Vit. K), Ascorbic acid (Vit. C) and Pyridoxine (Vit.B6) (13.46±0.08, 11.98±0.08 and

10.59±0.12 µg/gm), respectively. Other vitamins recorded 8.56± 0.11, 2.30± 0.06, 6.69± 0.17 and 5.85± 0.11 µg/gm for Calciferol (Vit.D), Retinoids (Vit. A), Thiamin (Vit.B1) and Pantothenic acid (Vit.B5), respectively.

Our results were in line with the results of **Elsheshetawy and Faid (2015)** who said that *Ziziphus spina Christi* fruits are a good source of carotene, retinol and ascorbic acid, 0.13 mg riboflavin, 3.7 mg niacin and 30 mg ascorbic acid. Also, **Moustafa *et al.* (2016)** found that the *Z. spina-christi* plant's leaves contain significant amounts of vitamin B1.

Our results proved that *Z. spina-christi* leaves are rich in vitamins, which are closely related to fertility, as proven by **Clagett-Dame and Knutson (2011)** who mentioned that Lack of vitamin A causes damage to the seminal vesicle, prostate, and epididymis' seminiferous epithelium, which stops spermatogenesis. **Angelis *et al* (2017)** said that in fact, it has been demonstrated that vitamin D directly affects spermatozoa, positively regulating their motility by non-genomic control of intracellular calcium homeostasis and activating the molecular pathways responsible for sperm motility, capacitation, and acrosome response. **Güngör *et al* (2022)** reported that reduced serum vitamin D levels and higher sperm DNA damage are observed in men with infertility that cannot be explained.

Table (3): Vitamin content of *Ziziphus spina-christi* leaves.

Sample	**Vitamins (µg/gm)**						
	Vit.D	**Vit.K**	**Vit.A**	**Vit.C**	**Vit.B6**	**Vit.B1**	**Vit.B5**
***Ziziphus spina-christi* Leaves**	8.56 ±0.11	13.46 ±0.08	2.30 ±0.06	11.98 ±0.08	10.59 ±0.12	6.69 ±0.17	5.85 ±0.11
Each value is the mean ± SD Vit.D: Calciferol, Vit. K: Menadione, Vit. A: Retinoids, Vit. C: Ascorbic acid, Vit.B6: Pyridoxine, Vit.B1: Thiamin and Vit.B5: Pantothenic acid.							

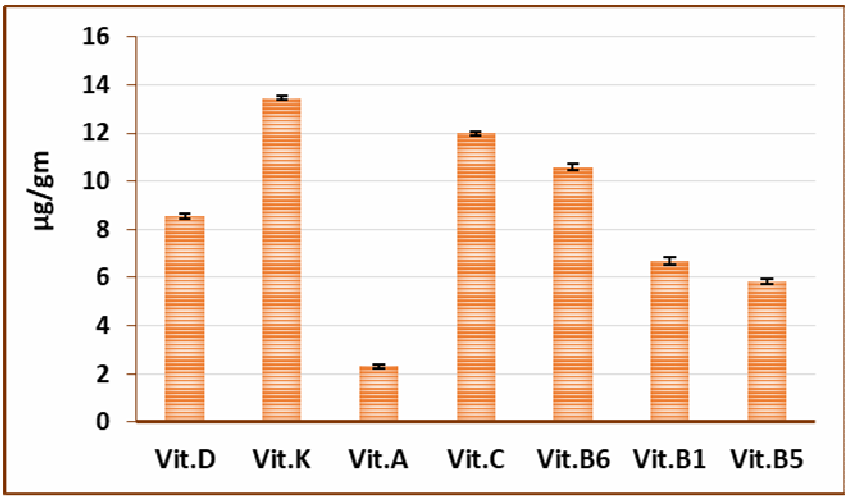

Figure (4): Vitamins of *Ziziphus spina-christi* leaves.

4.4. Total phenols and Flavonoids of Ziziphus spina-christi leaves:

Owing to their antioxidant qualities, phenolic compounds are a class of chemical compounds that are frequently present in plants and provide several health advantages. They prevent oxidative damage by acting as hydrogen donors, reducing agents, and quenchers of reactive oxygen species. Flavonoids protect the organism from oxidative stress by scavenging free radicals and controlling cellular function. Strong antioxidants are also present in flavonoids. Antioxidants aid the body's defense against chemicals that may be toxic if ingested.

The level of phenols and flavonoids content of *Ziziphus spina-christi* leaves extract are presented in **Table (4),** *Ziziphus spina-christi* leaves are considered a good source of total phenols and flavonoids contents as recorded 102.4± 0.4 mg (GAE)/g and 35.2± 0.4 mg (QE)/g, respectively.

According to **Zandiehvaki and Khadivi (2021)**, the total phenolic content of *Ziziphus Spina Christi* ranged from 4.84 to 49.58 mg/g fresh weight (FW). Total flavonoid content varied from 0.45 to 2.29 mg/g FW. **Dilla *et al.* (2021)** mentioned that active flavonoid components are present in bidara (*Ziziphus spinachristi*), which helps to prevent free radical damage.

Also, **Hussein (2019)** mentioned that most biologically active substances have been found in *Ziziphus spina-christi*, including flavonoids. Natural flavonoids found in the leaves of *Ziziphus spina-christi* have been shown in studies to have antioxidant, anti-inflammatory, and antibacterial properties that make them useful for treating acne **(Shakiba *et al*., 2019)**.

Table (4): Total phenols, and total flavonoids of *Ziziphus spina-christi* leaves.

Sample	Total phenols con. mg (GAE)/g	Total flavonoid con. mg (QE)/g
***Ziziphus spina-christi* leaves**	102.4±0.4	35.2±0.4
Each value is the mean ± SD mg (GAE)/g: phenolic content expressed as milligrams of gallic acid equivalents per gram. the total flavonoids were determined as quercetin equivalents (mg QE)/g of dry mass		

4.5. Fractionation and identification of phenolic compounds of Ziziphus spina-christi leaves:

As seen in **Table (5),** *Ziziphus spina-christi* leaves extract is a rich source of phenolic compounds, it recorded the highest amount of Quercetin, Gallic acid and Rutin 261.81, 64.19 and 56.55µg/ml respectively. Other values recorded 10.75, 30.90, 3.03, 10.19, 0.00, 6.84, 6.38, 25.87, 5.52, 0.39, 31.94, 2.67, 2.61, 0.79, 6.64 and 0.00 µg/ml for chlorogenic acid, catechin, methyl gallate, coffee acid, syringic acid, pyro catechol, ellagic acid, coumaric acid, vanillin, ferulic acid, naringenin, rosmarinic acid, daidzein, cinnamic acid, kaempferol and hesperetin, respectively.

Natural bioactive substances called phenolic compounds are mostly present in plant tissues and have been demonstrated to exhibit intriguing bioactivities, anti-inflammatory and antioxidant**.** The results showed that the *Ziziphus spina-christi* leaves contain high levels of phenolic compounds " rutin, quercetin, catechin, and gallic acid ". In the same trend, **Marengo (2021)** reported that gallic acid is a phenolic acid or bioactive compound, it has antioxidant properties and may offer other health benefits**.**

On the other hand, **Ghafoor *et al.* (2012)** found that in the fresh stems and fruits of *Ziziphus spina-christi* methanolic extract of the stem contained and isolated the following compounds: coumaric acid, rutin, apigenin, quercetin, chlorogenic acid, and syringic acid. Of these, rutin was found to have a higher concentration (325.0 mg/100g) and apigenin (122.90 mg/100g). While **Abdelaziz *et al.* (2023)** said that *Ziziphus spina-christi* leaves extract contains potent antimicrobial compounds such as rutin, naringin, myricetin, quercetin, kaempferol, hesperidin, eugenol, pyrogallol, gallic, and ferulic.

Table (5): Phenolic compound of *Ziziphus spina-christi* leaves.

***Ziziphus spina-christi* leaves extract**	
Phenolic compound	**Conc. (µg/ml)**
Gallic acid	64.19
Chlorogenic acid	10.75
Catechin	30.90
Methyl gallate	3.03
Coffeic acid	10.19
Syringic acid	0.00
Pyro catechol	6.84
Rutin	56.55
Ellagic acid	6.38
Coumaric acid	25.87
Vanillin	5.52
Ferulic acid	0.39
Naringenin	31.94
Rosmarinic acid	2.67
Daidzein	2.61
Quercetin	261.81
Cinnamic acid	0.79
Kaempferol	6.64
Hesperetin	0.00

4.6. Antioxidant activity using ferric reducing antioxidant power (FRAP) of Ziziphus spina-christi leaves.

The ferric-reducing antioxidant capacity (FRAP) test is an ET-based technique that quantifies the amount of antioxidant molecules that reduce ferric ions in the Fe (TPTZ) 2Cl3 complex, which produces the strongly blue-colored ferrous (Fe (II)) complex in an acidic medium.

As seen in **Table (6),** *Ziziphus spina-christi* extract recorded 352.37± 0.352 µg/mg for ferric reducing antioxidant power (FRAP). According to **Zandiehvaki and Khadivi (2021)**, the antioxidant activity measured 6.64 to 84.15 µM FeSO4 FW with the FRAP method.

Results were in line with **Darusman *et al.* (2023)** who reported that *Ziziphus spina-christi* leaf extract can be a very effective antioxidant. *Ziziphus spina-christi* leaf extract can be applied topically or orally as an antioxidant candidate in pharmaceutical and cosmetic preparations. because of its chemical compounds, while, **Magbool *et al*. (2023)** found that *Ziziphus spina-christi* has strong antioxidant properties and can be used medicinally**.** The results of the FT-IR method showed that *Z. spina-christi* surrounds 11 functional groups. The antioxidant potential of the methanolic extract of *Z. spina-christi* was 7 mmol Fe2+/L.

Table (6): Ferric reducing antioxidant power (FRAP) of *Ziziphus spina-christi* leaves.

Sample	FRAP (Equivalent (AAE) µg/mg of Sample)
***Ziziphus spina-christi* leaves extract**	**352.37±0.352**

4.7. In vitro anti-inflammatory activity:

Anti-inflammatory medications work to lessen some of the symptoms of inflammation, including pain, fever, oedema, and tenderness. The extract from *Ziziphus spina-christi* leaves was investigated for its anti-inflammatory properties using the in vitro HRBC (human red blood cell) technique. *Ziziphus spina-Christi* leaf extract may stabilize the lysosomal

membrane by stabilizing the erythrocyte membrane since the procedure indicates that the erythrocyte and lysosomal membranes are similar.

Table (8) showed that all the extract concentrations exhibited a significant reduction in the hemolysis of red blood cells: the maximal inhibition percentage reached 99.4% at 1000 µg/mL which was equal to the standard percent (99.5%) at the same concentration. Also, it is noticeable that hemolysis inhibition percentage of *Ziziphus spina-christi* leaves are very similar to the hemolysis inhibition percentages of Indomethacin as a standard which confirms the high anti-inflammatory activity of *Ziziphus spina-christi* leaves.

Therefore, the *Ziziphus spina-christi* leaves extract indeed possessed anti-inflammatory properties in the studied models. The extract of *Ziziphus spina-christi* leaves proved able to preserve the red blood cell membranes by preventing the oxidation of lipids in them. In addition, it stabilizes the red blood cell membrane by preventing the production of lytic enzymes and active inflammatory mediators. *Ziziphus spina-christi* leaves extract recorded 81.3, 87.0, 90.3, 93.2, 95.9 and 99.4 anti-inflammatory inhibition percentage for concentrations 100, 200, 400, 600,800 and 1000 µg/mL respectively.

Results were in the same trend as the study of **Shakiba *et al*. (2019)**, who mentioned that natural flavonoids found in the leaves of *Ziziphus spina-christi* have been shown in studies to have antioxidant, anti-inflammatory, and antibacterial properties that make them useful for treating diseases. Also, the study of **Nadi *et al*. (2018)** demonstrated a substantial anti-inflammatory effect, which was shown to be dose and time-dependent for both *Z. spina-christi* and *B. serrata's* dry distillates, which were shown to exhibit anti-inflammatory activity, however, *Z. spina-christi's* activity was found to be higher. According to **Kadioglu *et al*. (2016),** the anti-inflammatory properties of *Z. spina-christi* may exist, as suggested by ancient Egyptian remedies.

Table (8): Anti-inflammatory activity of *Ziziphus spina-christi* leaves extract using HRBC hemolysis and membrane stabilization in vitro

Standard (Indomethacin) Conc. µg /ml	Hemolysis Inhibition % Standard Indomethacin	Hemolysis Inhibition % *Ziziphus spina-christi* leaves
100	93.3	81.3
200	94.8	87.0
400	96.0	90.3
600	97.9	93.2
800	98.9	95.9
1000	99.5	99.4

Conclusion

It can be concluded that *Ziziphus spina-christi* leaves are a natural source of flavonoids, antioxidants, and anti-inflammatory compounds that can be used for nutritional purposes. They also include a variety of therapeutically active chemicals that can be used to successfully develop novel medications for the treatment of various diseases.

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تقييم القيمة الغذائية والنشاط المضاد للأكسدة والمضاد للالتهاب لأوراق نبات السدر (*Ziziphus spina-christi*)

منى ياسر عبد الخالق مصطفى* ، هند محمد حسن **، زينب صبري عبده يوسف*

الملخص العربي

تهدف الدراسة الحالية إلى تحديد التركيب الكيميائي ومحتوى الأملاح المعدنية والفيتامينات والفينولات والفلافونويدات الكلية والمركبات الفينولية والأنشطة المضادة للأكسدة والخصائص المضادة للالتهابات في أوراق نبات السدر (Ziziphus spina-christi). وقد أظهرت النتائج أن أوراق السدر مصدر جيد للبروتين والكالسيوم والبوتاسيوم والمغنيسيوم .كما تحتوي أوراق السدر على كمية عالية من فيتامين ك وفيتامين ج وفيتامين ب٦ .كما يعتبر مصدر جيد لإجمالي الفينولات ومحتوى الفلافونويد حيث سجل ١٠٢,٤ ± ٠,٤ مجم / (GAE) جم و ٣٥,٢ ± ٠,٤ مجم / (QE)جم على التوالي .أظهرت النتائج أن أوراق نبات السدر تحتوي على مركبات فينولية عالية " روتين وكيرسيتين وكاتشين وحمض الجاليك ." يمكن أن يكون مستخلص أوراق السدر مضادًا للأكسدة فعالًا للغاية، حيث سجل ٣٥٢,٣٧ ± ٠,٣٥٢ ميكروجرام / مجم لقوة مضادات الأكسدة (FRAP). تم تقييم النشاط المضاد للالتهابات لمستخلص أوراق نبات السدر باستخدام انحلال الدم HRBCوتثبيت الغشاء في المختبر .إن نسبة تثبيط انحلال الدم لأوراق نبات السدر تشبه إلى حد كبير نسبة تثبيط انحلال الدم للإندوميثاسين كمرجع قياسي مما يؤكد النشاط المضاد للالتهابات العالي لأوراق نبات السدر .لذلك، فإن مستخلص أوراق نبات السدر يمتلك بالفعل خصائص مضادة للالتهابات في النماذج المدروسة .وبحسب نتائج البحث فإن نبات السدر يعتبر شجرة ثمينة لتطوير العديد من الأدوية في المستقبل وذلك بسبب مكوناته الفعالة وسهولة زراعته.

الكلمات المفتاحية: نبات السدر، التركيب الكيميائي، المركبات الفينولية، مضادات الأكسدة، مضادات الالتهاب

* قسم الاقتصاد المنزلي - كلية التربية النوعية – جامعة المنصورة

** قسم التشريح البشري والأجنة - كلية الطب - جامعة المنصورة