

Antibacterial Activity of *Thymus capitatus*, *Artemisia herba-alba* and *Silybum marianum* Extracts Against Potato Soft Rot Bacteria

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Abstract

Potato soft rot, caused by *Pectobacterium* and *Dickeya* species, poses a serious threat to crop productivity worldwide. While chemical pesticides and antibiotics are traditionally used for disease management, their effectiveness is variable, and overuse has raised significant concerns regarding environmental toxicity, health risks, and the acceleration of antibiotic resistance in human pathogens. This study investigates the antibacterial potential of hexane and ethanolic extracts from *Thymus capitatus*, *Artemisia herba-alba*, and *Silybum marianum* against three soft rot pathogens: *P. atrosepticum*, *D. dadantii*, and *P. carotovorum*. Using the disc diffusion method, all plant extracts exhibited inhibitory effects, with hexane extracts consistently outperforming ethanolic ones. *T. capitatus* hexane extract demonstrated the highest activity, particularly against *P. carotovorum*, achieving a 15.33 mm inhibition zone at 5 mg/ml and a low MIC of 0.625 mg/ml. These results support the potential of lipophilic plant-derived compounds as effective and eco-friendly alternatives to synthetic antimicrobials for controlling bacterial soft rot in potatoes.

Keywords: Medicinal plants - Soft Rot bacteria - Potato diseases - Plant Extracts.

INTRODUCTION

Plant pathogenic bacteria are one of the most significant causes of crop damage and loss, causing massive losses, preventing or reducing crop production. Many chemicals, pesticides, and antibiotics have been widely used and commonly deployed to suppress plant diseases. Despite the spread of chemical pesticides in agricultural systems, efficiency in plant diseases management remains a challenge due to the side effects on human and farm animal health as well as the environment (Kotan et al., 2014; Abdullahi et al., 2020; Shaheen, and Issa, 2020). Excessive use of chemical pesticides has negative impacts on the environment and humans, such as soil and water pollution, accumulation of residues in the food chain, and lower control effectiveness against pathogenic microbes with long-term use (Bhavaniramy et al., 2019). Globally, some existing antibiotics have been banned from use in agriculture due to adverse effects of antibiotics such as severe pathogen resistance, high production cost, and environmental pollution (Abdullahi et al., 2020; Buttimer et al., 2017).

Potato soft rot caused by *Dickeya* spp. and *Pectobacterium* spp. bacteria are one of the most destructive bacterial diseases affecting a wide range of crops, especially potatoes, leading to a deterioration in their productivity worldwide. The distribution and outbreak of bacteria that cause the prevalence of soft rot in potato fields are significantly affected by climatic conditions.

Therefore, alternative effective and safe antimicrobial agents are urgently needed. Currently, the search for natural products that can be used for the management of plant

diseases is very challenging. Medicinal plants have drawn attention as possible alternatives that may be used in plant disease control. Awareness about the need for limiting the use of chemical agents is endorsed by the emergence of alternative policies or tools for modifying plant disease resistance and controlling pathogens. Thus, there have been increasing efforts in the research for alternative pesticides and antimicrobials, including plant extracts (Kotan et al., 2014). Plant extracts with antimicrobial properties that contain a range of secondary metabolites such as alkaloids, quinones, terpenoids, saponins, glycosides, flavonoids and tannins are the point of focus (Shaheen, and Issa, 2020). The concentrations of these bioactive compounds in this respect depend on the environmental conditions and the Specific plant pathogen system (Balakumar et al., 2011).

Thymus capitatus L. is one of *Thymus* species plants, commonly known as (Zaatar), which belongs to family Lamiaceae (Labiatae). It contains 7,534 species, including the genus *Thymus* L., which includes 220 species (Harley, et al., 2003). This genus showed great differences in morphological characteristics and the volatile oils components (Jarić, et al., 2015). Thyme was traditionally used as a medicine to treat many conditions. It has recently transformed from a traditional herb into a medicine that has a major role in phytotherapy and various medical applications (Dauqan, and Abdullah 2017). It is also used as an antiseptic and antimicrobial agent (Prasanth Reddy, et al., 2014).

T. capitatus showed broad activity, as antimicrobial (antibacterial) agent against both Gram-positive and Gram-negative bacteria, also acid fast bacteria and also as an

antifungal agent (El-Jalel, et al., 2018; Abbaszadeh, et al., 2014).

Artemisia herba-alba, commonly known as desert (wormwood), also known in folk medicine as (Sheeh), belongs to the Asteraceae family. It is short wild shrub grows in arid regions of the Mediterranean basin, and extending into northwestern Himalayas, also abundant in the Iberian Peninsula, spreading over the eastern, southern, and southeastern Spain, and reaches the highest population in the Centre of Spain, these plant grows on the nitrofilous and gypsum-rich substrata (Mohamed, et al., 2010). Medicine as the treatment of colds, coughing, intestinal disturbances, including intestinal worms, and for the treatment of human and livestock wounds, also reported that *Artemisia herba-alba* extracts have been shown to possess antifungal, antibacterial, antileishmanicidal, antipyretic, antioxidant and allelopathic activity (Qnais, et al., 2016).

Silybum marianum (L.) is an important herbal medicine; the main active components of this plant are Flavonolignans collectively known as Silymarin, which is known for its antioxidant and antimicrobial activity (Rad, et al., 2021; Shah, et al., 2011). The *Silybum marianum* plant belongs to the Asteraceae family and is commonly called (milk thistle) or Mary's thistle. It is a small tree that with up to one meter high. These plants are widely spread in the Mediterranean basin (Lahlah, et al., 2012), and in northwest and south of Iran (Sidhu, and Saini. 2012). *Silybum marianum* is used for medicinal treatment of many diseases due to the presence total phenolics, flavonoids and antioxidants, also silymarin seed oil has biological activities such as, ability to scavenge free radicals, and it contains linoleic and oleic acids which are involved in preventing atherosclerosis, diabetes, and cancer, especially lung and hepatocellular

cancers (Jiang, et al., 2015, Orsavova, et al., 2015 and Javeed, et al., 2022).

The chemical composition of the extracts of plant parts varies, as some studies have indicated the presence of flavonoids, alkaloids, glycosides, steroids, terpenoids, and catholytic tannins in extracts of seeds, stems, and leaves, except for saponins and Gallic tannins, as well as the chemical compound dibutyl phthalate. On the other hand, only the seed and leaf extract contained hexadecanoic acid, methyl ester, silane (1,1-dimethylethyl), and dimethyl (phenylmethoxy). Moreover, methyl stearates and phenols were major compounds in all extracts except seed extracts. It is clear that extracts from different parts of *S. marianum* possess significant antioxidant activity (Fahmy, et al., 2021 and Javeed, et al., 2022).

Many studies reported that the antibacterial activity of Silymarin was evident against Gram-positive bacteria such as *Staphylococcus aureus*, *Bacillus subtilis*, *Bacillus cereus*, and *Proteus vulgaris*. A study by (Das 2006) highlighted the antimicrobial effects of linoleic acid, particularly against Gram-negative bacteria. The mechanism involves the integration of linoleic acid into bacterial membranes, disrupting their structural integrity and increasing permeability, which leads to leakage of intracellular contents and eventual cell death. Additionally, linoleic acid interferes with enzymatic systems vital for bacterial metabolism, further inhibiting growth and survival. These findings underscore the potential of unsaturated fatty acids as natural antimicrobial agents targeting both membrane integrity and metabolic functions in Gram-negative pathogens. Hence, the objective of this study is to evaluate the effectiveness of Hexane and Ethanol 70% extracts of *Thymus capitatus*, *Artemisia herba-alba* and *Silybum marianum* extracts against potato soft rot bacteria.

2. Material and Methods

2.1 Collection and preparation of the medicinal plants

The aerial parts of the medicinal plants: *Artemisia herba-alba*, *Thymus capitatus* were collected from the sides of wadi habes, whereas *Silybum marianum* were collected from the road sides of Elkasr region Matrouh governorate, during springtime. The plants were cleaned, dried in air shading and ground to a fine powder.

One hundred grams of the ground plant material were extracted using the organic solvents Hexane and Ethanol 70%. The mixtures (1: 3 w/v) were mechanically shaken for three hours using an orbital shaker. The extracts were then filtered through Whatman No.1 filter paper. the extracts were concentrated at 50°C using a rotary vacuum evaporator. The resulting crude extracts were weighed and kept in a refrigerator until evaluation. yield percentages were calculated using the following formula: Extract yield% = $\frac{R}{S} \times 100$ (where R; weight of extracted plants residues and S; weight of plant raw sample).

2.2 Soft rot bacteria

The soft rot bacterial pathogens *Pectobacterium atrosepticum*, *Dickeya dadantii* and *Pectobacterium carotovorum* were collected from naturally infected potato plants from Elhamam region, Matrouh governorate, purified and identified through single colony isolation technique (Tille 2021), and then preserve it in 20% glycerol in -20°C. the bacteria were activated in nutrient broth medium.

2.3 Bio-assay of Minimum Inhibitory Concentration (MIC) using Disc Diffusion Technique

The antibacterial activity was assessed using the disc diffusion method (CLSI, 2023). The Muller-Hinton agar plates were inoculated with the pathogenic bacteria using sterile cotton swabs. Six mm filter papers diameter were soaked with 10µl of the following concentrations (5, 2.5, 1.25, and 0.625mg/ml) of the plant extract dissolved in Dimethyl sulfoxide (DMSO), and placed down in the prepared medium. The plates were kept in the fridge at 4°C for 2 hr to allow the tested extracts to diffuse, Then the plates were incubated at 25°C for 16-24 hr in an incubator. after the incubation period the agar plates were examined. The minimum inhibitory concentration (MIC) was defined as the lowest concentration that produced a visible zone of inhibition. DMSO was used as a negative control.

2.4 Statistical Analysis

The data were subjected to statistical analysis using R: A language and environment for statistical computing (2025). ANOVA was performed, and the standard error was calculated using the Least Significant Difference (LSD) test at the 1% significance level.

3. Results and Discussion

Three medicinal plant species (*Thymus capitatus*, *Artemisia herba-alba* and *Silybum marianum*) were investigated to evaluate their antibacterial activity against some pathogenic strains of soft rot bacteria, namely (*Pectobacterium atrosepticum*, *Dickeya dadantii* formerly known as *Dickeya*

chrysanthemi and *Pectobacterium carotovorum*), using the disc diffusion method. The extraction yield percentages were calculated in table (1). Evaluation of antibacterial activity of these plant extracts was recorded in tables (2,3 and4).

3.1 Plant extraction yield

The botanical data of the studied plants and their extract percentage yield are

reported in **Table (1)**. One hundred grams of prepared plant materials were extracted using hexane and ethanol 70%. The yield % of the plant extracts ranged from 1.14 to 2.751 % for the hexane extract, whereas it was 2.3560 % to 3.230 % for the ethanolic extraction. The ethanolic extraction of *Silybum marianum* produced the highest yield of plant extract (3.230 %), followed by *Thymus capitatus* (3.0034%), while *Artemisia herba-alba* produced the lowest yield.

Table 1: Scientific and local names with the extract yield percentage of the plants used in the present study.

Family	Scientific Name	Local Name	Used Part	solvent	Extract yield (%)
Lamiaceae	<i>Thymus capitatus</i>	Zatar	Aerial parts	Hexane	2.3264
				Ethanol	3.0034
Asteraceae	<i>Artemisia herba-alba</i>	Shieh	Aerial parts	Hexane	1.1386
				Ethanol	2.3560
Asteraceae	<i>Silybum marianum</i>	Shok	Aerial parts	Hexane	2.751
				Ethanol	3.230

3.2. Antibacterial Activity

a) *Thymus capitatus* Extracts

The antibacterial effects of *Thymus capitatus* hexane and ethanolic extract against soft rot bacteria are presented in **Table (2)**. Data showed that, the hexane extract had a significant inhibitory effect against the tested pathogenic bacteria. In contrast, ethanol extract showed a no significant effect against the tested pathogenic bacteria.

Minimum inhibitory concentrations for ethanol were 2.5 and 5 mg/ml, while for the hexane extract MIC was 0.625mg/ml. The

pathogenic strain *P. carotovorum* was more sensitive and recorded a good response to hexane extract at various concentrations. while *P. atrosepticum* showed a moderate response to hexane extract at various concentrations. *P. atrosepticum* and *D. dadantii* showed intermediate response to different Hexane concentrations. Antibacterial effect of *Thymus* extract with hexane increased with increasing concentration, 5 mg/ml recorded the greatest inhibition zone (15.33mm) for *P. carotovorum* compared to the same concentration that gave (11.67mm) for *D. dadantii* and (13.33mm) *P. atrosepticum*.

A study revealed that ethanolic extracts were most effective against respiratory bacteria (Hassan, et al., 2017). while it showed limited activity against potato pathogenic bacteria in the current study, these results were compatible with the findings of (Aldosarya, 2023) they reported that hexane extraction of *Thymus vulgaris* was outperformed than ethanol or water extraction against some gram-negative bacteria. In another study for (Haitham et al. 2009) indicates that the majority of active compounds in this plant are hydrophobic organic molecules. This implies that the essential oil, being non-polar organic compounds, may serve as the primary active constituents A study by (Burt 2004) revealed that *Thymus capitatus* essential oil, which is rich in the monoterpenes **carvacrol** and

thymol, demonstrates strong antibacterial activity against Gram-negative bacteria through multiple mechanisms. The study showed that these compounds disrupt both the outer and inner bacterial membranes, increasing their permeability and causing the leakage of vital intracellular components such as ATP and potassium ions, ultimately leading to cell lysis. Supporting these findings, (Ksouri et al. 2012) confirmed that the essential oil of *T. capitatus* compromises membrane integrity, contributing to bacterial death through membrane destabilization. Furthermore, a review by (Ultee et al. 2002) indicate that thymol can bind to the minor groove of bacterial DNA, altering its secondary structure and impairing transcription.

Table (2) Antibacterial activity of Hexane and Ethanolic extract of *Thymus capitatus* against the growth of some soft rot bacteria

Plant Pathogenic Bacteria	Conc. (mg/mL)	Hexane Extract		Ethanol 70% Extract		DMSO
		IZ $\pm$ SE	MIC mg/mL	IZ $\pm$ SE	MIC mg/mL	
<i>P. atrosepticum</i>	0.625	8.33 $\pm$ 0.33	0.625	0.00 $\pm$ 0.00	2.5	N.A
	1.25	9.33 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	2.5	10.67 $\pm$ 0.33		7.00 $\pm$ 0.00		N.A
	5	13.33 $\pm$ 0.33		8.00 $\pm$ 0.00		N.A
<i>D. dadantii</i>	0.625	8.67 $\pm$ 0.33	0.625	0.00 $\pm$ 0.00	5	N.A
	1.25	9.33 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	2.5	9.67 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	5	11.67 $\pm$ 0.33		7.00 $\pm$ 0.00		N.A
<i>P. carotovorum</i>	0.625	9.00 $\pm$ 0.00	0.625	0.00 $\pm$ 0.00	5	N.A
	1.25	9.67 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	2.5	11.67 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	5	15.33 $\pm$ 0.67		7.00 $\pm$ 0.00		N.A

Values are means $\pm$ SE: standard error of three replicates. IZ: Inhibition zone diameter including 6mm disc (mm). MIC: Minimum inhibitory concentration (mg/ml). DMSO: Dimethyl sulfoxide [(CH₃)₂SO]. (N.A): Not active.

b) *Artemisia herba-alba* Extracts

Data presented in **Table (3)** revealed that Minimum inhibitory concentration for hexane extracts was 0.625mg/ml for *P. atrosepticum*, while *P. carotovorum* was (1.25mg/ml). In case of Ethanolic extracts, the MIC was mostly 5 mg/ml. (Bhat et al., 2017) study showed that effectiveness of ethanolic extracts of *Artemisia absinthium* leaves at 25% concentration showed lower inhibition zone (9.5mm). *D. dadantii* was not affected by the three concentrations of hexane (0.625, 1.25, 2.5mg/ml), while 5mg/ml recorded the minimum response (7mm inhibition zone). *P. atrosepticum* strains showed good response to all concentrations, and as concentrations increased inhibition increased, recorded 10.67mm with 5mg/ml hexane extract concentration.

The data indicated that the antibacterial activity of *Artemisia herba-alba* extracts (hexane and ethanolic) against soft rot bacteria suggested that *D. dadantii* was the most resistant strain to plant extracts, showing an inhibition zone (7mm) at a concentration (5mg/ml), followed by *P. carotovorum*, while *P. atrosepticum* was the most susceptible strain to the extracted plants, respectively. Also, data revealed that *Artemisia herba-alba* hexane extract was superior in inhibitory activity than ethanol, which could be because of the essential oils. According to (Bougatsou et al. 2020), its essential oil rich in monoterpenes such as α -thujone, β -thujone, camphor, and piperitone can integrate into bacterial membranes, disrupting membrane integrity, increasing permeability, and ultimately causing cell lysis.

Table (3) Antibacterial activity of Hexane, and Ethanolic extract of *Artemisia herba-alba* against the growth of some soft rot bacteria.

Plant Pathogenic Bacteria	Conc. (mg/mL)	Hexane Extract		Ethanol 70% Extract		DMSO
		IZ $\pm$ SE	MIC mg/mL	IZ $\pm$ SE	MIC mg/mL	
<i>P. atrosepticum</i>	0.625	7.67 $\pm$ 0.67	0.625	0.00 $\pm$ 0.00	2.5	N.A
	1.25	9.00 $\pm$ 0.58		0.00 $\pm$ 0.00		N.A
	2.5	9.33 $\pm$ 0.33		7.00 $\pm$ 0.00		N.A
	5	10.67 $\pm$ 0.33		7.00 $\pm$ 0.00		N.A
<i>D. dadantii</i>	0.625	0.00 $\pm$ 0.00	5	0.00 $\pm$ 0.00	5	N.A
	1.25	0.00 $\pm$ 0.00		0.00 $\pm$ 0.00		N.A
	2.5	0.00 $\pm$ 0.00		0.00 $\pm$ 0.00		N.A
	5	7.00 $\pm$ 0.00		7.00 $\pm$ 0.00		N.A
<i>P. carotovorum</i>	0.625	0.00 $\pm$ 0.00	1.25	0.00 $\pm$ 0.00	5	N.A
	1.25	7.00 $\pm$ 0.00		0.00 $\pm$ 0.00		N.A
	2.5	7.67 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	5	10.67 $\pm$ 0.33		7.00 $\pm$ 0.00		N.A

Values are means $\pm$ SE: standard error of three replicates. IZ: Inhibition zone diameter including 6mm disc (mm). MIC: Minimum inhibitory concentration (mg/ml). DMSO: Dimethyl sulfoxide [(CH₃)₂SO]. (N.A): Not active.

c) *Silybum marianum* Extracts

Antagonistic activity of *Silybum marianum* extract (hexane and ethanolic) against soft rot bacteria was tested and the data are presented in **Table (4)**. The obtained data clearly showed that *Silybum marianum* ethanolic extract had no activity against *P. carotovorum* at the four tested concentrations, while *P. atrosepticum* strains recorded minimum inhibitory effect (7mm) at 2.5 and 5mg/ml and *D. dadantii* showed an inhibition zone (7mm at 5mg/ml). Otherwise, all tested pathogenic bacterial isolates were affected by the four hexane extract concentrations. The maximum inhibitory effect (10.00mm) was recorded with *P. atrosepticum* and *D. dadantii* at 5mg/ml, while the minimum inhibitory effect (9.33 mm) was obtained with *P. carotovorum* at the same concentration. A study by (Górnaś et al. 2015) revealed that *Silybum marianum* seed oil is rich in linoleic acid (50–60%) and also contains significant amounts of gamma-linolenic acid (GLA), alongside tocopherols, which contribute to its potent antioxidant properties. Subsequent research by (Knapp and Melly 1986), as well as (Huang and Ebersole 2010), demonstrated that both linoleic acid and GLA exhibit antibacterial activity against Gram-negative bacteria such as *Escherichia coli*. (Zheng et al. 2005) showed that linoleic acid exerts its antimicrobial effects primarily through

disruption of the bacterial membrane and inhibition of fatty acid biosynthesis via the enoyl-acyl carrier protein reductase (FabI) enzyme. Additionally, (Knapp and Melly 1986) reported that GLA possesses multiple modes of action, including intercalation into bacterial DNA, leading to interference with DNA replication and transcription. (Huang and Ebersole 2010) further demonstrated that GLA compromises the integrity of the bacterial cell wall and membrane, increasing permeability and resulting in cellular leakage and lysis. Collectively, these findings highlight the potential of *S. marianum* fixed oils as natural, multifunctional agents with antioxidant and antimicrobial activity. (Ahmad, et al., 2015 and Abed, et al., 2015) Studies revealed that Methanol, n-hexane, and chloroform extracts of *S. marianum* from 10 different areas of Pakistan were effective against *E. coli*, *Salmonella* spp., *Shigella* spp., *S. aureus* and *V. cholerae* at various concentrations.

In another study for (Mohammed, et al. 2019) showed that ethanol, methanol, and Dichloromethane extracts from the fruit parts of *S. marianum* were utilized. The ethanol extracts exhibited the highest activity. Generally, plant extracts were found to be more effective against gram-negative bacteria (*Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii*).

Table (4) Antibacterial activity of Hexane, and Ethanolic extract of *Silybum marianum* against the growth of some soft rot bacteria

Plant Pathogenic Bacteria	Conc. (mg/mL)	Hexane Extract		Ethanol 70% Extract		DMSO
		IZ $\pm$ SE	MIC mg/mL	IZ $\pm$ SE	MIC mg/mL	
P. atrosepticum	0.625	8.00 $\pm$ 0.00	0.625	0.00 $\pm$ 0.00	2.5	N.A
	1.25	8.67 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	2.5	9.00 $\pm$ 0.00		7.00 $\pm$ 0.00		N.A
	5	10.00 $\pm$ 0.00		7.00 $\pm$ 0.00		N.A
D. chrysanthemi	0.625	7.00 $\pm$ 0.00	0.625	0.00 $\pm$ 0.00	5	N.A
	1.25	7.00 $\pm$ 0.00		0.00 $\pm$ 0.00		N.A
	2.5	7.67 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	5	10.00 $\pm$ 0.00		7.00 $\pm$ 0.00		N.A
P. carotovorum	0.625	8.00 $\pm$ 0.00	0.625	0.00 $\pm$ 0.00	N.A	N.A
	1.25	8.33 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	2.5	8.33 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A
	5	9.33 $\pm$ 0.33		0.00 $\pm$ 0.00		N.A

Values are means $\pm$ SE: standard error of three replicates. IZ: Inhibition zone diameter including 6mm disc (mm). MIC: Minimum inhibitory concentration (mg/ml). DMSO: Dimethyl sulfoxide [(CH₃)₂SO]. (N.A): Not active.

4. Conclusion

The present study highlights the potential of medicinal plant extracts *Thymus capitatus*, *Artemisia herba-alba*, and *Silybum marianum* as effective antibacterial agents against soft rot pathogens affecting potatoes. Among the tested extracts, hexane extracts consistently demonstrated greater inhibitory activity than their ethanolic counterparts, suggesting that non-polar bioactive compounds play a significant role in antibacterial efficacy. *Thymus capitatus* hexane extract was particularly effective, exhibiting the largest inhibition zones and the lowest minimum inhibitory concentrations against *Pectobacterium carotovorum*. These findings support the use of plant-based natural products as sustainable, eco-friendly alternatives to conventional chemical pesticides and antibiotics, which pose risks of toxicity and antimicrobial resistance. Further research is recommended to isolate and identify the specific active compounds

responsible for the antibacterial effects and to evaluate their efficacy under field conditions.

References

- Abbaszadeh, S., Sharifzadeh, A., Shokri, H., Khosravi, A. R., and Abbaszadeh, A. (2014). Antifungal efficacy of thymol, carvacrol, eugenol and menthol as alternative agents to control the growth of food-relevant fungi. *Journal de mycologie medicale*, 24(2), e51-e56.
- Abdullahi, A., Khairulmazmi, A., Yasmeen, S., Ismail, I. S., Norhayu, A., Sulaiman, M. R. and Ismail, M. R. (2020). Phytochemical profiling and antimicrobial activity of ginger (*Zingiber officinale*) essential oils against important phytopathogens. *Arabian Journal of Chemistry*, 13(11), 8012-8025.
- Abed, I. J., Al-Moula, R., and Abdulhasan, G. A. (2015). Antibacterial effect of

- flavonoids extracted from seeds of *Silybum marianum* against common pathogenic bacteria.** *World Journal of Experimental Biosciences*, 3(1), 36–39.
- Ahmad, N., Perveen, R., Jamil, M., Naeem, R., and Ilyas, M. (2015).** Comparison of antimicrobial properties of *Silybum marianum* (L.) collected from ten different localities of Khyber Pakhtunkhwa, Pakistan, and diversity analysis through RAPD patterns. *International Journal of Plant Science and Ecology*, 1(6), 241–245.
- Aldosarya, S. K., El-Rahman, S. N. A., Al-Jameel, S. S., and Alromihi, N. M. (2023).** Antioxidant and antimicrobial activities of *Thymus vulgaris* essential oil contained and synthesis of *Thymus vulgaris* silver nanoparticles. *Brazilian Journal of Biology*, 83, e244675.
- Balakumar, S., Rajan, S., Thirunalasundari, T., and Jeeva, S. (2011).** Antifungal activity of *Aegle marmelos* (L.) Correa (Rutaceae) leaf extract on dermatophytes. *Asian Pacific Journal of Tropical Biomedicine*, 1(4), 309-312.
- Bhat, K. A., Viswanath, H. S., Bhat, N. A., and Wani, T. A. (2017).** Bioactivity of various ethanolic plant extracts against *Pectobacterium carotovorum* subsp. *carotovorum* causing soft rot of potato tubers. *Indian Phytopathology*, 70(4), 463–470.
- Bhavaniramy, S., Vishnupriya, S., Al-Aboody, M.S., Vijayakumar, R., Baskaran, D., (2019).** Role of essential oils in food safety: Antimicrobial and antioxidant applications. *Grain Oil Sci. Technol.* 2, 49–55.
- Bougatsou, M., Tsioutsou, E. E., Pateraki, C., Magiatis, P., & Skaltsounis, A. L. (2020).** Antibacterial activity and mechanism of action of essential oils from Greek aromatic plants against *Escherichia coli*. *Natural Product Communications*, 15(6), 1–7.
- Burt, S. (2004).** Essential oils: Their antibacterial properties and potential applications in foods—A review. *International Journal of Food Microbiology*, 94(3), 223–253. <https://doi.org/10.1016/j.ijfoodmicro.2004.03.022>
- Buttimer, C., McAuliffe, O., Ross, R.P., Hill, C., O'Mahony, J., Coffey, A., (2017).** Bacteriophages and bacterial plant diseases. *Front. Microbiol.* 8, 1–15
- Clinical and Laboratory Standards Institute. (2023).** *Performance standards for antimicrobial disk susceptibility tests; approved standard—eleventh edition* (CLSI document M02). CLSI.
- Darnis, D., Qarreleh, H. N., Abboud, M. M., Khleifat, K. M., Tarawneh, K. A., and Althunibat, O. Y. (2009).** Chemical composition and antibacterial activities of essential oil of *Thymus capitatus* from Jordan. *Pakistan Journal of Pharmaceutical Sciences*, 22(3), 247–251.
- Das, U.N. (2006).** Essential fatty acids: biochemistry, physiology and pathology. *Biotechnology Journal*, 1(4), 420–439. <https://doi.org/10.1002/biot.200600015>
- Dauqan, E. M., and Abdullah, A. (2017).** Medicinal and functional values of thyme (*Thymus vulgaris* L.) herb. *Journal of applied biology and biotechnology*, 5(2), 017-022.
- El-Jalel, L. F., Elkady, W. M., Gonaïd, M. H., and El-Gareeb, K. A. (2018).** Difference in chemical composition and antimicrobial activity of *Thymus capitatus* L. essential oil at different

- altitudes. *Future Journal of Pharmaceutical Sciences*, 4(2), 156-160.
- Górnaś, P., Siger, A., Segliņa, D., & Dēmbreņa, D. (2015).** Physicochemical properties of cold-pressed oil from milk thistle (*Silybum marianum*) seeds. *Food Chemistry*, 170, 10–14.
- Harley, R. M., Paton, A. J., and Ryding, O. (2003).** New synonymy and taxonomic changes in the Labiatae. *Kew Bulletin*, 485-489.
- Hassan, G. O., Karamova, N., Mraheil, M. A., Mohamed, W., Chakraborty, T., & Ilinskaya, O. (2017).** A comparative evaluation of antimicrobial effect of *Thymus capitatus* ethanolic extract on the different respiratory tract infections isolates. *BioNanoScience*, 7(4), 644-647.
- Huang, C. B., & Ebersole, J. L. (2010).** A novel bioactivity of omega-6 polyunsaturated fatty acid: antimicrobial activity. *Archives of Oral Biology*, 55(8), 555–564.
- Jarić, S., Mitrović, M., and Pavlović, P. (2015).** Review of ethnobotanical, phytochemical, and pharmacological study of *Thymus serpyllum* L. Evidence-based complementary and alternative medicine, 2015.
- Javeed, A., Ahmed, M., Sajid, A. R., Sikandar, A., Aslam, M., Hassan, T. U. and Li, C. (2022).** Comparative Assessment of Phytoconstituents, Antioxidant Activity and Chemical Analysis of Different Parts of Milk Thistle *Silybum marianum* L. *Molecules*, 27(9), 2641.
- Jiang, K., Wang, W., Jin, X., Wang, Z., Ji, Z., and Meng, G. (2015).** Silibinin, a natural flavonoid, induces autophagy via ROS-dependent mitochondrial dysfunction and loss of ATP involving BNIP3 in human MCF7 breast cancer cells. *Oncology reports*, 33(6), 2711-2718.
- Knapp, H. R., & Melly, M. A. (1986).** Bactericidal effects of polyunsaturated fatty acids. *Journal of Infectious Diseases*, 154(1), 84–94. <https://doi.org/10.1093/infdis/154.1.84>
- Kotan, R., Cakir, A., Ozer, H., Kordali, S., Cakmakci, R., Dadasoglu, F., Neslihan D., Tuba A., and Kazaz, C. (2014).** Antibacterial effects of *Origanum onites* against phytopathogenic bacteria: Possible use of the extracts from protection of disease caused by some phytopathogenic bacteria. *Scientia Horticulturae*, 172, 210-220.
- Ksouri, R., Medini, F., Mkadmini, K., Legault, J., Magne, C., & Abdelly, C. (2012).** LC-ESI-TOF-MS and GC analyses of *Thymus capitatus* extracts: Polyphenol and essential oil composition, antioxidant, antibacterial, and cytotoxic effects. *Food and Chemical Toxicology*, 49(5), 1266–1275.
- Lahlah, Z. F., Meziani, M., and Maza, A. (2012).** Silymarin natural antimicrobial agent extracted from *Silybum marianum*. *J. Acad*, 2, 164-169.
- Mohamed, A. E. H. H., El-Sayed, M., Hegazy, M. E., Helaly, S. E., Esmail, A. M., and Mohamed, N. S. (2010).** Chemical constituents and biological activities of *Artemisia herba-alba*. *Records of Natural Products*, 4(1).
- Mohammed, F. S., Pehlivan, M., and Sevindik, M. (2019).** Antioxidant, antibacterial and antifungal activities of different extracts of *Silybum marianum* collected from Duhok (Iraq). *International Journal of Secondary Metabolite*, 6(4), 317-322.
- Orsavova, J., Misurcova, L., Vavra Ambrozova, J., Vicha, R., and**

- Mlcek, J. (2015).** Fatty acids composition of vegetable oils and its contribution to dietary energy intake and dependence of cardiovascular mortality on dietary intake of fatty acids. *International journal of molecular sciences*, 16(6), 12871-12890.
- Prasanth Reddy, V., Ravi Vital, K., Varsha, P. V., and Satyam, S. (2014).** Review on *Thymus vulgaris* traditional uses and pharmacological properties. *Med Aromat Plants*, 3(164), 2167-0412.
- Qnais, E. Y., Alatshan, A. Z., and Bseiso, Y. G. (2016).** Chemical composition, antinociceptive and anti-inflammatory effects of *Artemisia herba-alba* essential oil. *J Food Agric Environ*, 14, 20-7.
- R Core Team (2025).** *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>
- Rad, Z. M., Nourafcan, H., Mohebalipour, N., Assadi, A., and Jamshidi, S. (2021).** Effect of salicylic acid foliar application on phytochemical composition, antioxidant and antimicrobial activity of *Silybum marianum*. *Iraqi Journal of Agricultural Sciences*, 52(1), 63-69.
- Shah, S. M. M., Khan, F. A., Shah, S. M. H., Chishti, K. A., Pirzada, S. M. S., Khan, M. A., and Farid, A. (2011).** Evaluation of phytochemicals and antimicrobial activity of white and blue capitulum and whole plant of *Silybum marianum*. *World Appl Sci J*, 12(8), 1139-1144.
- Shaheen, H.A. and Issa, M.Y., (2020).** In vitro and in vivo activity of *Peganum harmala* L. alkaloids against phytopathogenic bacteria. *Sci. Hortic. (Amsterdam)*. 264, 108940.
- Sidhu, M. and P. Saini. (2012).** *Silybum marianum*: a plant of high medicinal importance a review. *World J Pharm Res*. 1(2): 72-86.
- Tille, P. M. (2021).** *Bailey & Scott's Diagnostic Microbiology* (15th ed.). Elsevier.
- Ultee, A., Kets, E. P. W., & Smid, E. J. (2002).** Mechanisms of action of carvacrol on the food-borne pathogen *Bacillus cereus*. *Applied and Environmental Microbiology*, 65(10), 4606–4610. <https://doi.org/10.1128/aem.65.10.4606-4610.1999>
- Zheng, C. J., Yoo, J. S., Lee, T. G., Cho, H. Y., Kim, Y. H., & Kim, W. G. (2005).** Fatty acid synthesis is a target for antibacterial activity of unsaturated fatty acids. *FEBS Letters*, 579(23), 5157–5162. <https://doi.org/10.1016/j.febslet.2005.08.028>

النشاط المضاد للبكتيريا لمستخلصات *Thymus capitatus* و *Artemisia herba-alba* و *Silybum marianum* ضد بكتيريا العفن الطري في البطاطس.

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الملخص العربي

ملخص البحث:

يشكل مرض العفن الطري في البطاطس والناتج عن أجناس *Pectobacterium* و *Dickeya* أحد أبرز التحديات التي تواجه إنتاجية المحصول على مستوى العالم. وعلى الرغم من اعتماد المبيدات الكيميائية والمضادات الحيوية في إدارة هذا المرض، إلا أن فعاليتها غالباً ما تكون محدودة، كما أن الإفراط في استخدامها أدى إلى ظهور مشكلات بيئية وصحية خطيرة، من أبرزها السمية البيئية، ومخاطر التأثير على صحة الإنسان، وتسارع تطور مقاومة المضادات الحيوية لدى مسببات الأمراض البشرية.

تهدف هذه الدراسة إلى تقييم الفعالية المضادة للبكتيريا لكل من مستخلصي الهيكسان والإيثانول من نباتات *Thymus capitatus* و *Artemisia herba-alba* و *Silybum marianum* ضد ثلاثة عزلات من مسببات العفن الطري في البطاطس وهي *Pectobacterium atrosepticum* و *Dickeya dadantii* و *Pectobacterium carotovorum* تم استخدام طريقة الانتشار القرصي (Disc Diffusion Method) لتقييم النشاط الحيوي لتلك المستخلصات، حيث أظهرت جميع المستخلصات النباتية تأثيراً مثبطاً ملحوظاً، مع تفوق مستخلصات الهيكسان بشكل عام على المستخلصات الإيثانولية. وبيّنت النتائج أن مستخلص الهيكسان لنبات *Thymus capitatus* أظهر أعلى فعالية، خاصة ضد العزلة *Pectobacterium carotovorum*، حيث بلغ قطر منطقة التثبيط (15.33) ملم عند تركيز 5 ملغم/مل، كما سجل أدنى تركيز مثبط فعال عند 0.625 ملغم/مل. تدعم هذه النتائج إمكانية استخدام المركبات النباتية ذات الأصل الدهني كمضادات ميكروبية طبيعية فعالة وصديقة للبيئة، تمثل بدائل واعدة للمواد الكيميائية والمضادات الحيوية التقليدية في مكافحة مرض العفن الطري في البطاطس.

الكلمات المفتاحية:

النباتات الطبية - بكتيريا العفن الطري - أمراض البطاطس - المستخلصات النباتية