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Research Article

Antibacterial Activity & Phytochemical Screening of *Chenopodium Album* Leaves Against *Listeria Monocytogene* and *Yersinia Enterocolitica*

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Abstract

The increasing incident of multidrug-resistant bacterial strains has promote a search of natural alternatives with excellent antibacterial activities. *Chenopodium album*, commonly known as lamb's quarters is a medicinal plant with traditional uses in many disease. This review examine the antibacterial activity and phytochemical composition of *Chenopodium album* leaves and its effect on *Listeria monocytogenes* and *Yersinia enterocolitica*, two important foodborne pathogens connect with severe infection. Phytochemical analysis of *Chenopodium album* has identified the presence of bioactive compounds such as flavonoids, alkaloids, saponins, tannins and phenolic acids which all have antimicrobial activity. These compound are responsible for their antibacterial activity and also able to damage bacterial membranes, disrupt metabolism and inhibit enzyme activity. Verification from studies using agar diffusion, minimum inhibitory concentration (MIC) tests and bioassay-guided fractionation indicate that *Chenopodium album* is effective against these pathogens. This review has also presented the proposed mechanisms by which *Chenopodium album* have antibacterial activity including disruption of bacterial cell walls and inhibition of quorum sensing. To summarize, *Chenopodium album* is a natural antibacterial candidate which target the *Listeria monocytogenes* and *Yersinia enterocolitica*. Future investigation can include clinical trials for CNB formulation to potentially fight against multidrug-resistant bacterial infections.

Keywords: *Chenopodium album*, Antibacterial activity, Phytochemical screening, *Listeria monocytogenes*, *Yersinia enterocolitica*

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1. Introduction

In 21st century Antimicrobial resistance has become one of the biggest global health problem. Overuse of antibiotics by the population in health care, agriculture, and animal husbandry has obsessed the multidrug-resistant (MDR) bacteria thus, failing the use of traditional antibiotics.[1] Bacterial infections such as

such as pneumonia, tuberculosis, and gonorrhoea etc., have a bigger risk to public health. This partial antibiotic effectiveness has major public health crash including increase the risk of morbidity and mortality. The World Health Organization (WHO) has reported that if there is no change in current situation then there is cross the number of 10 million deaths annually in the

year 2050 by the drug-resistant pathogens.[2] In the environment, all plants produce different types of secondary metabolites including alkaloids, flavonoids, phenolics, terpenoids, and other compounds which have antimicrobial and anti-inflammatory activity. Secondary metabolites have the ability to attack the basic mechanisms such as disrupting bacterial membranes, inactivate biofilm formation and inhibit bacterial proteins which is necessary for replication. As we know, antimicrobials derived from plant sources have less side effects than other compounds, and these are used in different areas of research and therapeutic development. [3]

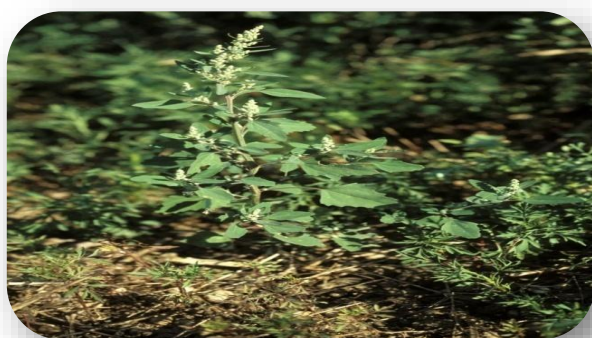


Figure: 1 – *Chenopodium Album* Plant,

1.2 Significance of Studying *Listeria monocytogenes* and *Yersinia enterocolitica* as Pathogens - *Listeria monocytogenes* [Figure : 3(a) & 3(b)] and *Yersinia enterocolitica* are major foodborne pathogens cause severe illness in human. *L. monocytogene* is a Gram-positive bacteria responsible for listeriosis which affecting pregnant women and new born child with weak immune systems. It is mainly present in the

1.1 Significance of *Chenopodium album* - *Chenopodium album* or lamb's quarters or goosefoot (figure- 1& 2) is a nutrient plant which is used as food source and medicinal plant from the traditional time. This plant will be growing in most the types of soils.[4] In Ayurveda, *Chenopodium album* plant's leaves used for digestive ailments, dermatological infections, breathing problems and parasitic infections. Its leaves are known for their diuretic, antihelmintic and anti-inflammatory properties.[5] Thus, evaluate the antibacterial activity of *Chenopodium album* may produce clarity about its biosynthetic potential as a naturally mixed supplement as an alternative for synthetic antibiotics of the traditional medicinal plant.[6]



Figure : 2 – Leaves of *Chenopodium album* plant

environment and can contaminate different types of foods including dairy, processed meats and fresh product sometime. *L. monocytogene* have ability to grow and survive in extreme environment such as high salt concentration and high temperatures, so sometime it difficult to control the presence of this bacteria in items.[7]



Figure: - 3(a), 3(b) –A visual image of bacteria *Listeria monocytogenes*

Yersinia enterocolitica[Figure : 4(a) & 4(b)] is a Gram-negative bacteria which cause yersiniosis, a gastrointestinal disease has symptoms just like diarrhea, abdominal pain and fever. This pathogen is mainly zoonotic and infections occur after consumption of contaminated food, pork and raw or unpasteurized

milk. *Y. enterocolitica* is capable of cold tolerance can grow and survive at very low temperatures. Both bacteria not only characterize risk to public health but they increase the economic burden and food recall from producer.[8]

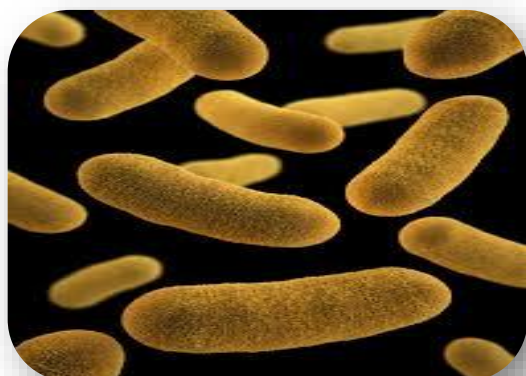


Figure: - 4(a), 4(b) – A visual image of bacteria *Yersinia enterocolitica*

The increasing resistance of *L. monocytogenes* and *Y. enterocolitica* to natural antibiotics increase the need for novel antimicrobial agents. The exploration of natural products' antibacterial activity whose derive from *Chenopodium album* could provide a long-term

solution to neutralize these bacteria. Ensuring the chemical constituents of *Chenopodium album* is understand which play a role in disrupting the pathogenic bacteria which play a role in foodborne illness.[9]

Table (1) show the main differences between *Listeria monocytogenes* and *Yersinia enterocolitica*:

Feature	<i>Listeria monocytogenes</i>	<i>Yersinia enterocolitica</i>
1.Gram Stain	Gram-positive rod	Gram-negative rod
2.Shape	Rod-shaped (coccobacillus)	Rod-shaped (coccobacillus)
3.Reservoir	Soil, water, animals (especially dairy, meat)	Animals (pigs are main reservoir), contaminated food
4.Transmission Route	Contaminated food (e.g., dairy, deli meats)	Contaminated food and water
5.Disease Caused	Listeriosis (meningitis, septicemia, miscarriage)	Yersiniosis (gastroenteritis, mesenteric lymphadenitis)
6.Virulence Factors	Listeriolysin O, Internalins, ActA	Yersinia outer proteins (Yops), type III secretion system
7.Symptoms	Fever, chills, muscle aches, headache, stiff neck, etc.	Fever, abdominal pain, diarrhea, mesenteric lymphadenitis etc.
8.Hemolysis	β-hemolytic on blood agar	Usually non-hemolytic
9.Selective Media	PALCAM, Oxford agar	CIN (Cefsulodin-Irgasan-Novobiocin) agar
10.Associated with Cold Foods?	Yes (can grow in refrigerated food)	Yes (can survive in cold storage)
11.Treatment	Ampicillin and gentamicin are often used.	Antibiotics may be used for severe cases.

2.Literature Review -

2.1 Phytochemistry of *Chenopodium album* - *Chenopodium album* is mainly occupied secondary metabolites such as alkaloids, flavonoids, saponins, phenolic acids, tannins and terpenoids. These secondary metabolites are responsible for the plant's pharmacological properties such as antibacterial, antioxidant and anti-inflammatory effects. Most of the flavonoids and phenolic compounds are present *Chenopodium album* leaves which are direct relate to *Chenopodium album* plant's antibacterial activity. The

role of flavonoids and phenolic compounds is synergistic which inhibit bacterial growth and disruption microbial cell membranes.[10]

2.2 Bioactive Compounds in *Chenopodium album* -

The bioactive compounds of *Chenopodium album* are important for medicinal benefits. Flavonoids such as quercetin and kaempferol having possess strong antibacterial property against bacterial enzymes and DNA. Phenolic acids such as ferulic acid and gallic acid having antioxidant and antimicrobial activity of

this plant. Saponins are another large class of compounds from *Chenopodium album*, which show the property like lysis i.e. damage the bacterial cell membrane. Alkaloid and tannin also give the antimicrobial spectrum by inhibiting bacterial adhesion and potential biofilm formation. These compounds provide a natural source for discover plant derive antimicrobial molecules.[11]

2.3 Previous Studies on Phytochemical Screening -

A number of studies have occurs the phytochemical constituents of *Chenopodium album* and the connection to antibacterial activity. Firstly, we confirm the presence of alkaloids, flavonoids, saponins, phenolics, and tannins in various extracts. For example, methanol and ethanol extracts of *Chenopodium album* have showing antibacterial activity against Gram-positive and Gram-negative bacteria. Bioassay driven fractionation studies have also show that flavonoid-profliecant fraction that have highest antimicrobial activity. These results give emphasis to the significance of various phytochemicals in *Chenopodium album* and expose its opportunity as a natural antibiotic molecules.[12] The interest in plant antimicrobial increase the drawback of synthetic antibiotics such as toxicity and drug resistance. For example: plant extracts from neem (*Azadirachta indica*), turmeric (*Curcuma longa*) and garlic (*Allium sativum*) exhibit

broad-spectrum antimicrobial activity against Gram-positive and Gram-negative bacteria.[13][14]

Methanol and ethanol can dissolve many types of phytochemicals so it is the good solvents for the extraction of bioactive compounds. Studies have shown that extracts containing particularly high concentration of flavonoids and phenols which is effective against food borne pathogens such as *Escherichia coli*, *Salmonella* spp, and *Staphylococcus aureus*. [15]

2.4 Specific Reports on Chenopodium album and Related Species –

Chenopodium album and it's related species has latent therapeutic antibacterial agents. Phytochemical studies of *Chenopodium album* shows that quercetin, kaempferol and gallic acid having antimicrobial activity & methanolic and ethanolic extracts of *Chenopodium album* have antibacterial activity against both of Gram-positive and Gram-negative bacteria. It show that extracts of *Chenopodium album* have inhibitory action towards *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Bacillus subtilis*. Other species of *Chenopodium album* such as *Chenopodium murale* have equally report antimicrobial activity following the possible therapeutic agents from this genus. It gives a good reason for research of antibacterial activity on the *Chenopodium album* plant against *Listeria monocytogenes* and *Yersinia enterocolitica*. [16]

Table 2: Differences between chenopodium album plant and their other species of chenopodium genus

Species Name	Common Name	Botanical Traits	Uses	Distribution
1.Chenopodium album	Bathua, Lamb's Quarters	Annual herb, green leaves, mealy coating, up to 1.5 m tall	Edible leaves, rich in vitamins & minerals, fodder	Widely distributed in Asia, Europe, America
2.Chenopodium quinoa	Quinoa	Annual herb, seeds are edible grains, broad leaves	Seeds used as pseudo-cereal, gluten-free protein	Native to Andes, now global
3.Chenopodium ambrosioides	Epazote	Aromatic herb, serrated leaves, pungent smell	Medicinal (anthelmintic), culinary herb in Mexico	Native to Central & South America
4.Chenopodium murale	Nettle-leaved goosefoot	Smaller herb, reddish stem, toothed leaves	Fodder, minor edible use	Mediterranean, Asia, naturalized elsewhere
5.Chenopodium berlandieri	Pitseed goosefoot	Resembles quinoa, used by Native Americans	Edible seeds, ancient food crop	North America
6.Chenopodium botrys	Jerusalem oak	Glandular hairs, aromatic, deeply lobed leaves	Traditional medicine, ornamental	Europe, Asia, naturalized in N. America
7.Chenopodium ficifolium	Fig-leaved goosefoot	Annual, fig-like leaves, fast-growing	Sometimes used as green manure	Eurasia, introduced elsewhere

3. Pathogens of Interest -

3.1 Characteristics and Pathogenicity of *Listeria monocytogenes* -

Listeria monocytogenes is a Gram-positive and anaerobic bacteria which cause listeriosis, a potentially foodborne illness. This pathogen easily survive in all environmental condition such as high salinity, low pH

and a very low temperatures. Pathogen of *L. monocytogenes* can be certified to many virulence factors including internalins, listeriolysin O as well as actin-assembly-inducing proteins which a group that help in host cell invasion, intracellular survival and intercellular spread.[17]

Listeriosis firstly affects immune system of persons, pregnant women, neonates, and the elderly patients leading to outcome with septicemia, meningitis and fetal loss. The presence of this bacteria in various type of eating foods in combination with its conflict to traditional food preservation methods include the overall public health significance.[18]

3.2 Characteristics and Pathogenicity of *Yersinia enterocolitica* -

Yersinia enterocolitica is a Gram-negative bacteria responsible for yersiniosis which cause gastrointestinal infection with symptoms like mild diarrhea to severe abdominal pain mimic appendicitis. It's ability to survive at a very low temperatures and form biofilms which support resolution within food supply chains mainly in raw or under-cooked pork, unpasteurized milk and contaminated water. The virulence of *Y. enterocolitica* is recognized to a plasmid-encoded type III secretion system that inject effector proteins into host cells, shifting cellular functions and escaping immune responses. The emerging nature of the bacteria and it's conflict with the antibiotics further make overall management and the right way of pathogen for novel antimicrobial strategy development.[19]

4. Methodology -

The present review paper covers the antibacterial activity and phytochemical content of *Chenopodium album* leaves against the food-borne pathogens *Listeria monocytogenes* and *Yersinia enterocolitica*. The methodology cover the existing literature and research

paper relating to the antibacterial effects of *Chenopodium album* and methods used to identify, characterize and isolate active phytochemicals.

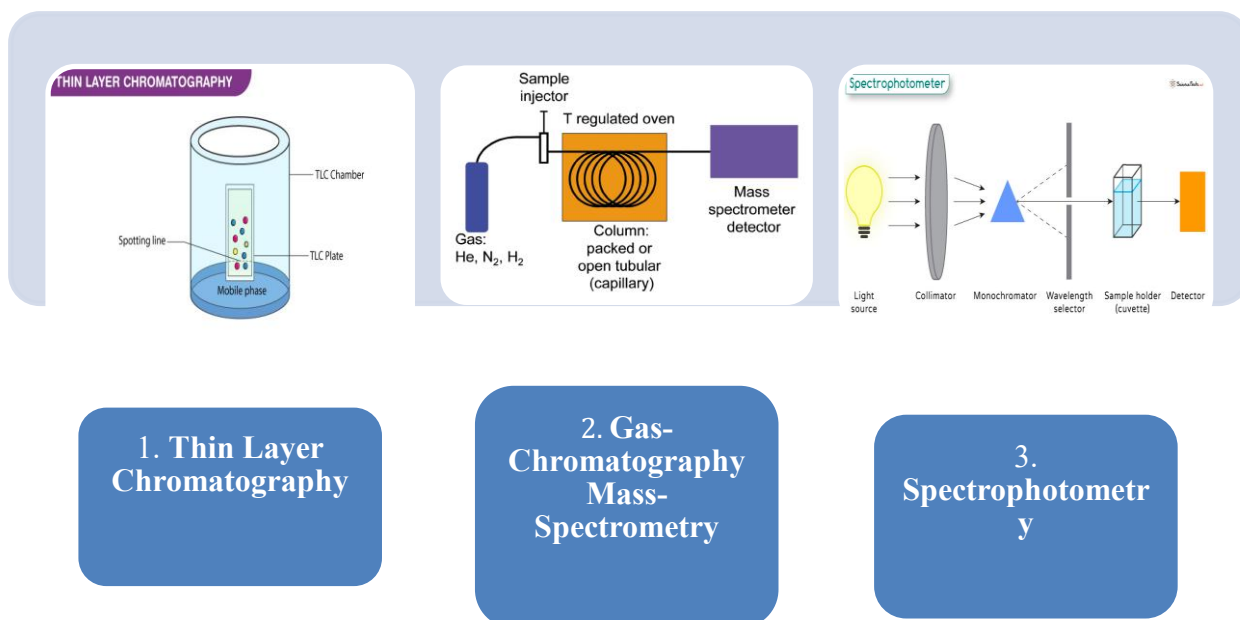
The method of phytochemical screening is necessary for identifying bioactive compound which is found in plant and responsible for medicinal activity. Qualitative and Quantitative types of screening mainly used for this assessment.[20]

I. Qualitative Phytochemical Screening - It consists the testing of plant extracts for different groups of phytochemicals. Tests that are common includes the dragendorff's test for alkaloids, the froth test for saponins and the ferric chloride test for phenols. Usually, these tests are perform using simple reagents to show characteristic colors or precipitate which indicate the presence of certain class of phytochemicals.

II. Quantitative Phytochemical Screening - This screening method determine the concentration of phytochemicals in plant extracts. Methods such as colorimetry titration is commonly used to quantify certain bioactive compounds such as alkaloids, tannins and flavonoids.[21]

4.2 Common Methods for Detecting Phytochemicals

For the examination of phytochemical composition in *Chenopodium album* leaves, mainly chromatographic and spectroscopic techniques are used mutually. These analytical methods make a profile of the chemical constituents in the leaves and gives the information about the therapeutic effects.



I. Thin Layer Chromatography (TLC): TLC is a widely used chromatography technique to separate and identify phytochemicals. In this chromatography method, plant extracts are spotted on a thin layer of adsorbent material and a solvent is allowed to freely move through the adsorbent material via capillary

action. After sometime, the separation of the compounds can be visualized through proper reagents or UV light. TLC is useful technique for detection and characterization of a wide range of compounds due to their differential mobility.

II. Gas-Chromatography Mass-Spectrometry (GC-MS): GC-MS is a widely engaged and powerful analytical technique that identify and quantify volatile compounds. The overall procedure of this technique involves separating the chemical components using a gas-chromatograph. GC-MS is mainly useful for essential oils and volatile compound which are obtain from *Chenopodium album* or its extract.

III. Spectrophotometry: Spectrophotometric techniques such as UV spectroscopy are commonly utilize to identify compound based upon its absorption values. For example - flavonoids and phenolic compounds is quantify with a spectrophotometer through its certain wavelength absorbance. UV spectroscopy offer a immediate and non-destructive way to measure the concentration of selective bioactive compounds in plant extracts.[22]

4.3 Methodology -

The goal of this paper is learn the different approaches use to test the antibacterial activity of this plant and discover the phytochemical compound which inhibit of bacterial growth. The method discussed in this review paper are limited to principally antibacterial assays, bioassay-guided fractionation and testing methodologies.

I. Antibacterial Assay - Antibacterial assays is the prime method to determine the antimicrobial capacity of plant extracts. The antibacterial assay normally have the research prepared plant extracts then to calculate the efficacy against specific bacterial strains by measuring inhibition growth in the bacteria.[23]

II. Plant Extraction: *Chenopodium album* leaves are collect, dried and then grind into the powder. Aftermaking the powder, we are extracting the sample using many solvents like methanol, ethanol or acetone by the maceration process. After the extraction, this concentrated sample is used in the antibacterial testing.[24]

III. Bacterial inoculum: Strains of *Listeria monocytogenes* and *Yersinia enterocolitica* are culturing in suitable media and bacterial suspension are prepared at a specific concentration. These strains are chosen in the area of food borne illness and evaluate the antibacterial effect of plant extracts. [25]

4.4 Overview of Antibacterial Testing Method -

Some method which are commonly used in assess the antibacterial activity of *Chenopodium album* leaves against *Listeria monocytogenes* and *Yersinia enterocolitica*:

I. Agar Well Diffusion Method: In this method, solid agar plates are plated with bacterial suspension, after which well are bored into the agar plates. The plant extract is placed into the wells, incubated, and the zone of inhibition around the well is measured. If the zone of inhibition is larger then the extract have greater antimicrobial activity.[26]

II. Minimum Inhibitory Concentration (MIC) Determination: The MIC is the lowest concentration of the plant extract that inhibit visible growth of bacteria. In this method, plant extract are diluted in a

successive manner and each dilution is dispense into the test tube contain a bacterial culture. The MIC is the lowest concentration at which the bacterial culture shows no visible growth or turbidity. This method provides quantitative information on the antibacterial activity of the plant extract.

III. Disc Diffusion Method: This method is same as agar well diffusion method. Antibiotic disc are soaked in plant extract those are inoculate with bacteria. After incubation, the zone of inhibition is measure as an antibacterial activity of the plant extract.[27]

5. Discussion

In the literature, the antibacterial activity of *Chenopodium album* leaves against *Listeria monocytogenes* and *Yersinia enterocolitica* is well familiar and demonstrates high potential for natural antimicrobial compounds. Phytochemical screening of *Chenopodium album* leaves have contain important classes of bioactive compounds, such as alkaloids, saponins, flavonoids, tannins and terpenes, which have antibacterial activity. [30]

The antibacterial activity of *Chenopodium album* leaf extracts is evaluate using methods like the agar well diffusion, disc diffusion and minimum inhibitory concentration (MIC) tests. Ethanol and methanol have generally most antibacterial action.[31] The data of the zone of inhibition through agar well and disc diffusion methods, is indicate high antibacterial activity against two these pathogens. The MIC ranged between 50 and 200 mg/mL against *Listeria monocytogenes* and *Yersinia enterocolitica*, which together indicated that *Chenopodium album* leaves have a high level of antimicrobial activity.[32]

6. Mechanisms of Actions -

The antibacterial properties of leaves of *Chenopodium album* are involving different mechanisms processes in bacterial cells. One of most, important mechanism is the disruption of the bacterial cell wall. Additional others mechanism of action is involve the inhibition of enzyme activity. For example, saponins and tannins have a counter function of destabilizing the bacterial cell membrane itself, which can limit the growth due to a compromise membrane. Compound like terpenoid will likely inhibit the enzyme systems which affecting cellular metabolism, cell wall inhibition, cell membranes being damaged or disrupting metabolic processes, these synergistic effects of multiple phytochemicals can enhance the total antibacterial capacity of *Chenopodium album* which indicate its potential use against foodborne pathogen such as *Listeria monocytogenes* and *Yersinia enterocolitica*. [34]

In addition, flavonoid and alkaloid also inhibit the bacterial enzymes which is required for cell wall biosynthesis and after disrupts the bacterial cell structure. For example, alkaloid may interact with the bacterial ribosome and inhibiting the translation of protein synthesis while flavonoids may interact with bacterial enzymes such as DNA gyrase or topoisomerase which are involved in DNA repair and

replication. Jointly, these all action contribute in the inhibition of bacterial growth and finally cell death which is dependable on the antimicrobial activity identified in *Chenopodium album* extracts.[35]

7. Challenges and Limitations -

There are some challenges and limitations comes when it consider as a therapeutic agent. The main challenge is the differences in antibacterial efficacy between different extracts of the same plant which is vary due to the extraction method, solvent and the geographical region i.e. where the plant grow.

An additional limitation is the identification and quantification of active compounds which is responsible for their antibacterial activity. Phytochemical screening techniques such as TLC, GC-MS or HPLC are not sufficient for examining the complex mixture of compound. The complexity of the plant extracts make it tricky to isolate a specific bioactive molecules. There may be some synergistic properties among compound that make difficult for potential physical bioactivity.[36]

The antibacterial activity of *Chenopodium album* against two bacterial pathogens, *Listeria monocytogenes* and *Yersinia enterocolitica* has been only measured in vitro. In vivo studies is compulsory to measure pharmacokinetics, bioavailability and safety of plant-based antibacterial compounds. Limited information on these point acts as a barrier for developing *Chenopodium album* as a therapeutic agent. The main limitation is antimicrobial resistance (AMR), which is a challenging limitation for plant-based antibacterial agents because resistance mechanisms found in pathogens and it also decrease the efficacy of plant extracts. Therefore, it is important to continue research on the resistant strains development and the effective use of plant-joint antimicrobial.[37]

8.Future Perspectives -

Chenopodium album is gifted antibacterial agent from the nature which requires more evaluation for known its possible therapeutic value. Future studies also focus on isolation and identification of its bioactive compounds and linked to its antibacterial effects. These studies are mainly help to understand the therapeutic uses of *Chenopodium album* leaves to reach therapeutic concentrations at a site of infection, maintain the concentrations over time and formulate the compounds to improve delivery. Researcher is investigates synergistic effects of *Chenopodium album* leaves with standard antibiotics which is unique and high scope to fight antibiotic resistant bacteria.[38] Additionally, clinical trials are required to evaluate the safety and efficacy of *Chenopodium album* extracts as natural antimicrobial agents. Combining strategies from current pharmacology with traditional knowledge of plants may lead to *Chenopodium album* becoming an attractive collection of antimicrobial agents towards address foodborne pathogens and antimicrobial resistance. [39]

9. Conclusion -

This review says that these phytochemicals can act upon bacterial physiology with multiple mechanisms such as damaging the integrity of the bacterial cell wall, inhibiting enzymes, and interfering with cellular metabolism and make *Chenopodium album* a natural antimicrobial agents. Fortunately, methods like bioassay-guided separation and bioavailability studies are advance the extraction of active compounds along with safety and acceptability of bioactive plants with industrial interests in-vitro and in-vivo. The potential of effective natural antimicrobial is becoming more vital with the enhance in drug resistant microbes.

To conclude, *Chenopodium album* has great promise as a natural antibacterial agent. Further research about standardization, clinical assessment and pharmacological development would sustain the integration of *Chenopodium album* into a current medical model to well manage food-borne pathogens or other bacterial infections.

10. References -

1. Rana S, Rahman S, Sana S, Biswas TK, Hashem AK, Parvin S, Mazumder K. Anticancer potential of *Chenopodium album* leaf extract against Ehrlich ascites carcinoma cells in Swiss albino mice. *Future Journal of Pharmaceutical Sciences*. 2020 Dec;6:1-9. [25]
2. Akbaş P, Kaya E, Makav M, Yıldız G. Investigation of antimicrobial and antioxidant activities of *Chenopodium album* extracts and their effects on gentamicin nephrotoxicity in rats. *Food Science & Nutrition*. 2023 Dec;11(12):8121-30.[3]
3. Das A, Borthakur MK. *Chenopodium album* Linn.: a review on various pharmacological activities.[2]
4. Arora SK, Itankar PR, Yende SR. Phytochemical screening and TLC studies of different extracts of *Chenopodium album*. *J. Ayurvedic Herb. Med*. 2020;6:15-20.[8]
5. Singh S, Singh A, Hallan SS, Brangule A, Kumar B, Bhatia R. A compiled update on nutrition, phytochemicals, processing effects, analytical testing and health effects of *Chenopodium album*: A non-conventional edible plant (NCEP). *Molecules*. 2023 Jun 21;28(13):4902.[18]
6. Akbaş P, Kaya E, Makav M, Yıldız G. Investigation of antimicrobial and antioxidant activities of *Chenopodium album* extracts and their effects on gentamicin nephrotoxicity in rats. *Food Science & Nutrition*. 2023 Dec;11(12):8121-30.[3]
7. Pandey S, Gupta RK. Screening of nutritional, phytochemical, antioxidant and antibacterial activity of *Chenopodium album* (Bathua). *Journal of Pharmacognosy and Phytochemistry*. 2014;3(3):1-9.
8. Rana S, Rahman S, Sana S, Biswas TK, Hashem AK, Parvin S, Mazumder K. Anticancer potential of *Chenopodium album* leaf extract against Ehrlich ascites carcinoma cells in Swiss albino

- mice. Future Journal of Pharmaceutical Sciences. 2020 Dec;6:1-9.
9. Akbaş P, Kaya E, Makav M, Yıldız G. Investigation of antimicrobial and antioxidant activities of Chenopodium album extracts and their effects on gentamicin nephrotoxicity in rats. Food Science & Nutrition. 2023 Dec;11(12):8121-30.
10. Chizhevskaya EP, Lapenko NG, Chebotar VK. Antibacterial and antifungal activity of Chenopodium album L. Russian Journal of Plant Physiology. 2023 Dec;70(8):194.
11. Singh KP, Dwevedi AK, Dhakre G. Evaluation of antibacterial activities of chenopodium album L..
12. Khomarlou N, Aberoomand-Azar P, Lashgari AP, Tebyanian H, Hakakian A, Ranjbar R, Ayatollahi SA. Essential oil composition and in vitro antibacterial activity of Chenopodium album subsp. striatum. Acta BiologicaHungarica. 2018 Jun;69(2):144-55.
13. Suleman M, Faiz AU, Abbas FI. Antibacterial, antiparasitic and phytochemical activities of Chenopodium album (Bathua) plant extract. Bangladesh Journal of Botany. 2021 Jun 18;50(2):417-21.
14. Hussain I, Janjua MR, Haq AU, Hassan SU, Albaqami FM, Alsuwat MA, Alrashdi BM, Alzwain S, Naqvi SA. Evaluation of Anti-Infection and Anti-Diabetic Activities in Methanolic and n-Hexane Plant Extracts of Indigenously Cultivated Chenopodium album. Agronomy. 2024 Jun 21;14(7):1340.
15. Pandey S, Gupta RK. Screening of nutritional, phytochemical, antioxidant and antibacterial activity of Chenopodium album (Bathua). Journal of Pharmacognosy and Phytochemistry. 2014;3(3):1-9.
16. Singh S, Singh A, Hallan SS, Brangule A, Kumar B, Bhatia R. A compiled update on nutrition, phytochemicals, processing effects, analytical testing and health effects of Chenopodium album: A non-conventional edible plant (NCEP). Molecules. 2023 Jun 21;28(13):4902.
17. Rana S, Rahman S, Sana S, Biswas TK, Hashem AK, Parvin S, Mazumder K. Anticancer potential of Chenopodium album leaf extract against Ehrlich ascites carcinoma cells in Swiss albino mice. Future Journal of Pharmaceutical Sciences. 2020 Dec;6:1-9.
18. Silva A, Silva V, Gomes JP, Coelho A, Batista R, Saraiva C, Esteves A, Martins Â, Contente D, Diaz-Formoso L, Cintas LM. Listeria monocytogenes from food products and food associated environments: Antimicrobial resistance, genetic clustering and biofilm Insights. Antibiotics. 2024 May 14;13(5):447.
19. Grigore-Gurgu L, Bucur FI, Mihalache OA, Nicolau AI. Comprehensive review on the biocontrol of Listeria monocytogenes in food products. Foods. 2024 Feb 28;13(5):734.
20. Liu X, Xia X, Liu Y, Li Z, Shi T, Zhang H, Dong Q. Recent advances on the formation, detection, resistance mechanism, and control technology of Listeria monocytogenes biofilm in food industry. Food Research International. 2024 Mar 1;180:114067.
21. Yang X, Peng Z, He M, Li Z, Fu G, Li S, Zhang J. Screening, probiotic properties, and inhibition mechanism of a Lactobacillus antagonistic to Listeria monocytogenes. Science of The Total Environment. 2024 Jan 1;906:167587.
22. Fredriksson-Ahomaa M, Grönthal T, Heljanko V, Johansson V, Rantala M, Heikinheimo A, Laukkanen-Ninios R. Enteropathogenic Yersinia with Public Health Relevance Found in Dogs and Cats in Finland. Pathogens. 2024 Jan 5;13(1):54.
23. Sotohy SA, Diab MS, Ewida RM, Aballah A, Eldin NK. An investigative study on Yersinia enterocolitica in animals, humans and dried milk in New Valley Governorate, Egypt. BMC microbiology. 2024 Oct 9;24(1):395.
24. Seabaugh JA, Anderson DM. Pathogenicity and virulence of Yersinia. Virulence. 2024 Dec 31;15(1):2316439.
25. Ezech PA, Olayinka BO, Bolaji RO, Babangida SA, Olowo-Okere A. Phenotypic antibiotic susceptibility profile of clinical Enterobacteriaceae isolates from Kaduna State, northwest Nigeria. Access Microbiology. 2024 Jun;6(6):000747-v5.
26. Ray LC, Payne DC, Rounds J, Trevejo RT, Wilson E, Burzlaff K, Garman KN, Lathrop S, Rissman T, Wymore K, Wozny S. Syndromic Gastrointestinal Panel Diagnostic Tests Have Changed our Understanding of the Epidemiology of Yersiniosis—Foodborne Diseases Active Surveillance Network, 2010–2021. InOpen Forum Infectious Diseases 2024 Jun (Vol. 11, No. 6, p. ofae199). US: Oxford University Press.
27. Le Guern AS, Savin C, Chereau F, Tessier S, Guglielmini J, Brémont S, Pizarro-Cerdá J. A novel cgMLST for genomic surveillance of Yersinia enterocolitica infections in France allowed the detection and investigation of outbreaks in 2017–2021. Microbiology Spectrum. 2024 Jun 4;12(6):e00504-24.
28. Platt-Samoraj A. Toxigenic properties of Yersinia enterocolitica biotype 1A. Toxins. 2022 Feb 5;14(2):118.
29. Fang X, Kang L, Qiu YF, Li ZS, Bai Y. Yersinia enterocolitica in Crohn's disease. Frontiers in Cellular and Infection Microbiology. 2023 Mar 8;13:1129996.
30. Al-Snafi AE. Therapeutic properties of medicinal plants: a review of their antibacterial activity (part 1). International Journal of Pharmacology and Toxicology. 2015;6(3):137-58.
31. Ullah F, Ayaz M, Sadiq A, Ullah F, Hussain I, Shahid M, Yessimbekov Z, Adhikari-Devkota A, Devkota HP. Potential role of plant extracts and phytochemicals against foodborne pathogens. Applied Sciences. 2020 Jul 2;10(13):4597.

32. Daglia M. Polyphenols as antimicrobial agents. Current opinion in biotechnology. 2012 Apr 1;23(2):174-81.
33. Laghari AH, Memon S, Nelofar A, Khan KM, Yasmin A. Determination of free phenolic acids and antioxidant activity of methanolic extracts obtained from fruits and leaves of *Chenopodium album*. Food chemistry. 2011 Jun 15;126(4):1850-5.
34. Poonia A, Upadhyay A. *Chenopodium album* Linn: review of nutritive value and biological properties. Journal of food science and technology. 2015 Jul;52:3977-85.
35. Xie Y, Yang W, Tang F, Chen X, Ren L. Antibacterial activities of flavonoids: structure-activity relationship and mechanism. Current medicinal chemistry. 2015 Jan 1;22(1):132-49.
36. <https://portal.wiktrop.org/species/show/58>
37. <https://azecs.az/thin-layer-chromatography-separation-technique/>
38. <https://spectroinlets.com/gas-chromatography-mass-spectrometry/>
39. <https://www.sciencefacts.net/spectrophotometry.html>