IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

# "FORMULATION AND EVALUATION OF HERBAL ANTIBIOTIC TABLETS FOR INFECTION MANAGEMENT"

**Mr. Vishal P. Ladole[1], Mr. Vaibhav V. Deshpande[2], Miss. Anjali G. Chopade[3], Miss. Anita V. Manekar[4]**

**Research Scholar[1], Assistant Professor[2], Research Scholar[3], Research Scholar[4]**

**Ishwar Deshmukh Institute of Pharmacy, Digars, Yavatmal, Maharashtra, India[1,2,3,4]**

***Abstract:***

Global health is severely hampered by infectious diseases, which makes it necessary to investigate alternate strategies for efficient treatment. The potential medicinal effects of herbal treatments have drawn attention, especially in their ability to combat infections. Five natural substances garlic (Allium sativum), cloves (Syzygium aromaticum), turmeric (Curcuma longa), ginger (Zingiber officinale), and gum arabic (Acacia senegal, Acacia seyal) are the subject of this study. These compounds are well-known for their antibacterial and traditional therapeutic benefits. Comprehending the chemical and botanical compositions of these components is crucial to maximizing their medicinal capabilities in herbal antibiotic concoctions. To investigate their synergistic effects, improve formulations, and confirm their safety and efficacy in clinical settings, more research is necessary. Herbal antibiotics are a viable substitute for traditional medical interventions and have the ability to tackle the increasing issue of antimicrobial resistance.

***Keywords:*** Herbal antibiotics, Ginger, Garlic, Turmeric, Cloves, Gum arabic, antimicrobial activity, Therapeutic application, Infectious diseases.

## Introduction:

The advent and spread of antibiotic-resistant bacteria has made infectious illnesses a major global health burden. Once heralded as "miracle medications," conventional antibiotics are slowly losing their ability to treat a wide range of common infections, which is causing a recurrence of formerly curable illnesses and prolonging hospital stays. Antibiotic resistance is one of the biggest risks to world health, according to the World Health Organization (WHO), which emphasizes the critical need for creative approaches to battle infectious diseases.

The limitations and difficulties of using traditional antibiotics have sparked a paradigm shift in recent years toward the investigation of alternate approaches to infection treatment. The use of herbal treatments, which have long been valued in traditional medical systems for their safety and effectiveness, has sparked new interest as a possible source of innovative antimicrobial agents. Over millions of years, plants have developed sophisticated defense systems against infections, which have produced a wide range of bioactive chemicals with various pharmacological characteristics.

Because of their historical medical applications and potential therapeutic effects, ginger, garlic, turmeric, cloves, and gum arabic have become prominent subjects of scientific investigation among the wide range of natural substances with suggested antibacterial qualities. Numerous bioactive substances found in these plants, such as flavonoids, terpenoids, polyphenols, and alkaloids, have a broad range of antibacterial activity against bacteria, fungi, viruses, and parasites.

**Mechanisms of Action of Herbal Antibiotic Tablets:**

1. **Antimicrobial Activity:**

   Herbal antibiotic tablets work against bacteria in a number of ways, such as:

   - **Disruption of microbial cell membranes:** Some bioactive substances found in herbal components have the potential to damage microbial cell membrane integrity, which can result in cellular leakage and microbial death.
   - **Inhibition of microbial enzyme activity:** The growth and proliferation of microorganisms may be hampered by the presence of herbal ingredients that inhibit the activity of microbial enzymes necessary for a number of cellular functions, including metabolism and replication.
   - **Interference with microbial DNA/RNA synthesis:** Certain components found in herbs have the potential to disrupt vital biological functions and prevent microbial replication by interfering with the synthesis of microbial nucleic acids, such as DNA and RNA
   - **Modulation of microbial gene expression:** Reduced microbial fitness and sensitivity to antimicrobial drugs can result from herbal components' modulation of the expression of microbial genes linked to virulence, pathogenicity, and antibiotic resistance.

2. **Anti-biofilm Activity:**

   The creation of microbial biofilms, which are organised populations of bacteria covered in an extracellular matrix that they manufacture on their own, may be inhibited or disturbed by herbal antibiotic tablets. By shielding bacteria from human immunological reactions and antibiotic drugs, biofilms contribute to both chronic infections and antimicrobial resistance. Herbal components have the potential to disrupt the production of biofilms, disrupt already-existing biofilms, or increase the sensitivity of bacteria entrenched in biofilms to antimicrobial treatments.

3. **Immunomodulatory Effects:**
   - **Enhancing innate immune responses:** Herbal ingredients may increase the activity of immune cells, including natural killer cells, neutrophils, and macrophages, improving their capacity to identify and eradicate microbial intruders.
   - **Modulating inflammatory responses:** Certain components included in herbal remedies have anti-inflammatory qualities that can help reduce tissue damage and excessive inflammation brought on by illnesses while maintaining the body's defences against infections.
   - **Promoting adaptive immune responses:** Herbal remedies have the potential to boost long-term immunity to microbial infections by promoting the development of adaptive immunological responses, such as the synthesis of certain antibodies and the activation of T cells.

4. **Antioxidant Effects:**

   Herbal antioxidants protect host cells from oxidative damage, which may improve immune function and promote tissue repair and recovery from infections. Some herbal ingredients in antibiotic tablets may have antioxidant effects, scavenging reactive oxygen species (ROS) and reducing oxidative stress associated with infections.

5. **Blood Purification:**

   Herbal antibiotic tablets can help eliminate toxins, metabolic waste products, and infectious agents from the bloodstream, which can enhance blood purification processes. Due to their blood-purifying qualities, several herbal substances, like ginger and turmeric, are traditionally used to boost overall metabolic health, improve circulation, and strengthen detoxification pathways.

6. **Synergistic Interactions:**

   The antibacterial activity of herbal antibiotic tablets can be increased by the combined action of several botanical components. The potential for additive or potentiated antimicrobial effects resulting from synergistic interactions among herbal elements can facilitate the use of lower doses of individual ingredients and mitigate the danger of resistance development.

**Advantages:**

1. **Broad-Spectrum Antimicrobial Activity:** Herbal antibiotics can target a variety of pathogens, including as bacteria, fungi, viruses, and parasites, and frequently show a broad spectrum of antimicrobial action. Numerous infectious disorders can benefit from this extensive coverage in their treatment.

2. **Reduced Risk of Antibiotic Resistance:** Herbal medicines have the potential to function through a variety of mechanisms, reducing the likelihood that pathogens will become resistant to them. This is in contrast to conventional antibiotics, which have the potential to help bacteria become resistant to certain antibiotics.
3. **Enhanced Immune Modulation:** Numerous components found in herbal remedies have immunomodulatory qualities, which support the body's natural defences against infections and enhance general health and toughness.
4. **Fewer Side Effects:** Compared to synthetic medications, herbal antibiotics are frequently well-tolerated and linked to fewer side effects, which lowers the risk of problems and increases patient adherence to treatment plans.

**Disadvantages:**

1. **Variability in Efficacy:** A number of variables, including plant genetics, cultivation circumstances, extraction strategies, and formulation procedures, might affect how effective herbal antibiotics are. This fluctuation could result in uneven therapeutic results and difficulties in establishing dose standards.
2. **Limited Clinical Evidence:** Although interest in the use of herbal antibiotics is growing, there is frequently less clinical evidence available to support their safety and efficacy when compared to traditional antibiotics. Additional comprehensive investigations, such as randomised controlled trials, are required to verify their therapeutic advantages.
3. **Possibility of Drug Interactions:** The safety or effectiveness of herbal remedies may be impacted by interactions with prescription drugs and other herbal supplements. Potential drug interactions should be recognised by healthcare professionals, and patients should be monitored accordingly.
4. **Regulatory Challenges:** Compared to pharmaceutical pharmaceuticals, herbal products might be subject to less strict regulatory scrutiny, raising questions regarding quality control, purity, and standardised dosages. The regulatory environments around herbal medicines differ greatly throughout nations, which makes it difficult to guarantee the safety and quality of the products.

**Applications:**

1. **Respiratory Infections:** Colds, the flu, bronchitis, and sinusitis can all be effectively treated with herbal antibiotics that contain components like garlic, ginger, and cloves.
2. **Gastrointestinal Disorders:** Garlic and ginger are good additions to herbal antibiotics that target digestive tract infections because they are traditionally used to treat gastrointestinal conditions like gastritis, indigestion, and diarrhoea.
3. **Dermatological disorders:** The possibility of topical formulations comprising extracts of garlic and turmeric to treat wounds, inflammatory disorders like eczema and acne, and skin infections has been investigated.
4. **Urinary Tract Infections:** For the treatment and maintenance of urinary tract health, herbal antibiotics containing diuretic and antibacterial components like turmeric and ginger may be helpful.

5. **Immune Support:** Herbal antibiotics, especially in those with weakened immune systems or long-term medical disorders, can be used as a preventative or supplementary measure to boost immune function and avoid repeated infections.
6. **Oral Health:** Herbal antibiotics with components like garlic and cloves may be good for your mouth, preventing periodontal disease, gingivitis, and tooth infections. In dental treatment, clove oil in particular has long been utilised for its analgesic and antibacterial qualities.
7. **Women's Health:** By treating gynaecological illnesses including bacterial vaginosis and yeast infections (candidiasis), herbal antibiotics can help improve women's health. Due to their antibacterial and anti-inflammatory qualities, garlic and turmeric may help reduce symptoms and balance the vaginal flora.
8. **Wound Healing:** Topical herbal antibiotic formulations that are enhanced with gum arabic and turmeric help hasten the healing of wounds and guard against infection in burns, abrasions, and cuts. The anti-inflammatory qualities of turmeric and the wound-healing qualities of gum arabic promote quicker healing and a lower chance of problems.
9. **Chronic Inflammatory Conditions:** The use of herbal antibiotics as adjuvant therapy can be beneficial for chronic inflammatory disorders such psoriasis, inflammatory bowel disease, and rheumatoid arthritis. Due to its strong anti-inflammatory properties, turmeric has demonstrated potential in lowering inflammation and easing symptoms associated with various illnesses.

**Ingredients used in Herbal Antibiotic Tablets:**

1. **Ginger:**

Zingiber officinale, the formal name for ginger, is a member of the Zingiberaceae family and is widely used as a medicinal herb, especially the rhizome. Many bioactive chemical compounds, including zingerone, shogaol, and gingerol, as well as essential oils like β-bisabolene, α-farnesene, and zingiberene, are present in it. Due to the numerous health advantages these chemicals provide, ginger is a useful component in herbal antibiotic compositions.

Strong anti-inflammatory and antioxidant characteristics of gingerol and shogaol aid in lowering inflammation and shielding cells from oxidative damage. Additional anti-inflammatory properties of dry or cooked ginger come from the formation of gingerone. Moreover, ginger is a great contender for incorporation into antibiotic formulations due to its antibacterial qualities, which are efficient against a wide range of bacteria, fungi, and viruses.

**Fig: Ginger**

In addition to its antibacterial properties, ginger is well recognised for its digestive advantages, including boosting digestive enzymes, reducing nausea, and improving gastrointestinal health in general. The body's immunological response is further strengthened by its immunomodulatory effects, strengthening its defences against infections. Ginger is typically harmless, but if taken in excess, it might cause gastrointestinal distress and interfere with several drugs, including antidiabetics and anticoagulants. Although rare, allergic responses might happen, thus when pregnant, especially in the first trimester, excessive doses should be avoided. To preserve its potency, store it properly in a cool, dry location. With these qualities, adding ginger to herbal antibiotic tablets increases their medicinal potential as well as their general safety and efficacy.

**2. Garlic:**

The medicinal benefits of garlic, which belongs to the Amaryllidaceae family and is botanically known as Allium sativum, have been utilised for millennia, especially the bulb section. Its abundance of bioactive substances, including ajoene, allicin, and alliin, add to its health advantages and antibacterial qualities. Garlic's distinct smell comes from allicin, which is produced when it is chopped or crushed and has potent antiviral, antibacterial, and antifungal properties. The enzyme alliinase transforms the sulfur-containing molecule alliin into allicin. Garlic's medicinal potential is increased by ajoene, which is produced from allicin and possesses strong antibacterial properties as well.

**Fig: Garlic**

The health advantages of garlic go beyond its antibacterial qualities. It has been demonstrated to strengthen immunity, making it easier for the body to fight against illnesses. Garlic also has antioxidant and anti-inflammatory qualities that guard against cellular damage and lower the chance of developing chronic illnesses. Garlic's benefits for the cardiovascular system are well-established; research indicates that it can lower cholesterol and blood pressure, which supports heart health. Garlic's broad-spectrum antibacterial action makes it a valuable addition in herbal antibiotic tablets. It is a flexible addition to natural health formulations, since it can be used to fight viral, bacterial, and fungal illnesses.

**3. Turmeric:**

Curcuma longa, the scientific name for turmeric, is a member of the Zingiberaceae family and is used medicinally, especially the rhizome. Curcumin, the main active ingredient in turmeric, is well known for having strong anti-inflammatory and antioxidant effects. Turmeric's medicinal profile also includes essential oils such as turmerone, atlantone, and zingiberene, as well as additional curcuminoids including demethoxycurcumin and bisdemethoxycurcumin.

Together, these substances improve turmeric's capacity to control inflammatory diseases, shield cells from oxidative damage, and accelerate the healing of wounds. Significant antimicrobial qualities such as antibacterial, antiviral, and antifungal activity are also exhibited by turmeric, which makes it an important component of herbal antibiotic compositions. Turmeric also strengthens the immune system, which helps to prevent and treat infections.

**Fig: Turmeric**

On the other hand, excessive use of turmeric may result in gastrointestinal problems such as nausea, diarrhoea, or upset stomach. Because of its bile-stimulating properties, it should be avoided by those with gallbladder illness or bile duct obstruction as it may interact with anticoagulant and antiplatelet drugs, increasing the risk of bleeding. It is recommended that women who are pregnant or nursing should speak with their doctor before taking turmeric supplements. All things considered, the addition of turmeric to herbal antibiotic tablets makes use of its many medicinal qualities, improving the potency and security of these combinations for successful infection control.

**4. Cloves:**

Syzygium aromaticum, the formal name for cloves, are members of the Myrtaceae family and are prized for their therapeutic qualities, especially the dried flower buds. Eugenol, the main active ingredient in cloves, plays a major role in their medicinal properties. Cloves are useful for both pain management and infection prevention because of eugenol's strong analgesic, anti-inflammatory, and antibacterial qualities.

Caryophyllene and acetyleugenol are two other significant components that support the antibacterial and antioxidant properties of cloves. Widely recognised for their potent antibacterial qualities, cloves can effectively combat an array of bacterial, fungal, and viral infections. They are therefore a crucial component of natural antibiotic compositions. Cloves are utilised in dental treatment to reduce gum and toothache pain because of their analgesic qualities.Their use in treating infections and inflammatory disorders is further supported by their anti-inflammatory properties, which assist to reduce swelling and inflammation. Cloves are added to herbal antibiotic pills to increase their overall effectiveness and offer a natural way to fight infections and relieve pain. But there are some safety measures to think about. Clove oil can be harmful in high concentrations and irritate mucous membranes and the skin.

**Fig: Cloves**

Additionally, it might interfere with anticoagulants and antiplatelet treatments, which inhibit blood clotting, raising the chance of bleeding. Women who are nursing or pregnant should use cloves carefully and should see a doctor before using them.

**5. Gum Arabic:**

Gum Arabic is a member of the Fabaceae family and is made from the exudate of Acacia senegal and Acacia seyal plants. It is a naturally occurring gum composed mostly of polysaccharides and glycoproteins, of which arabinogalactan makes up a significant portion. Its distinct qualities are attributed to this complex blend of carbohydrates, which contains glucuronic acid, galactose, rhamnose, and arabinose.

Gum Arabic's superior emulsifying, stabilising, and thickening qualities make it a popular ingredient in pharmaceutical formulations. In addition to acting as a binding agent to assist keep the powdered ingredients together, it improves the texture and consistency of tablets. Gum Arabic helps to ensure consistent efficacy and stability of the final product by assisting in the homogeneous distribution of active components in herbal antibiotic tablets.

**Fig: Gum Arabic**

Gum Arabic has many benefits, one of which is its high-water solubility, which makes it simple to incorporate into a variety of compositions. Additionally, it is well known for its prebiotic properties, which encourage the development of advantageous gut flora and improve digestive health in general. Furthermore, gum Arabic's anti-inflammatory qualities have been discovered, which may bolster its application in medical products.

**Formulation Consideration:**

| Sr. no. | Ingredients | Quantity in gram |
|---|---|---|
| 1. | Ginger | 5 g |
| 2. | Garlic | 5 g |
| 3. | Turmeric | 2 g |
| 4. | Cloves | 3 g |
| 5. | Gum Arabic | 5g |

**Procedure:**

1. **Choosing Herbal Ingredients:**
   - Pick herbs like ginger, garlic, turmeric, cloves, and gum arabic that have been shown to have antibacterial qualities.
   - Review the literature and carry out exploratory research to evaluate the safety, compatibility, and antibacterial activity of particular herbs.
2. **Formulation Development:**
   - Choose the best combination of herbal components, excipients, and binders for your formulation.

- Carry out pilot studies to assess the hardness, disintegration, and dissolving properties of various tablet formulations.
- Modify formulation parameters to maximise tablet qualities by taking into account experimental results.

**3. Tablet Compression:**

**A. Preparation of Powder Blend:**

- The active pharmaceutical ingredients (APIs), excipients, and additives are usually combined in the powder blend, which is made up of the first step in tablet compression.
- The ingredients are precisely weighed and blended to guarantee homogeneity and uniform distribution of the formulation.

**B. Feeding of Powder mix:**

- The single punch tablet press's hopper is filled with the prepared powder mix.
- The powder is moved from the hopper into the die chamber by a feeding system, such as a mechanical feeder or gravity feeder.

**C. Filling the Die Cavity:**

- The powder is compacted into tablets inside a die cavity, which has a predetermined size and shape.
- Throughout the die chamber, the powder is dispersed uniformly to guarantee consistency and uniformity in tablet thickness and weight.

**Fig: Tablet Compression Machine**

**D. Compression Cycle:**

- The compression cycle starts as soon as the powder blend is placed within the die cavity.
- One punch comes down from the top and presses down on the powder inside the die cavity.
- The compression force generated by the punch is precisely regulated to provide uniform compression throughout all tablets.
- The pressure compacts the powder particles, shaping them into a solid tablet of appropriate size, shape, and weight.

**E. Dropping the Tablet:**

- The produced tablet stays in the die cavity after the compression cycle is finished.
- The tablet can be easily ejected from the die cavity thanks to a mechanism installed in the single punch tablet press, such as a cam or turret.
- After being expelled from the die cavity, the tablet is gathered for additional processing or packing on a tray, conveyor belt, or chute.

**Results:**

1. **Physical Characteristics:**
   - **Colour:** The herbal antibiotic tablet has a light yellowish-brown hue, which is indicative of the natural pigments derived from the herbal components included in the formulation.
   - **Shape:** The tablet's rounded shape, smooth edges, and even surface make it simple to administer and swallow.
   - **Odour:** Upon closer examination, the tablet has a subtle herbal scent that is indicative of the natural components that went into its creation.
2. **pH Measurement:**
   - ± 0.1 was the pH of the herbal antibiotic pill dissolving medium, which indicates an acidic environment.
3. **Tablet Hardness:**
   - Using a tablet hardness tester, the herbal antibiotic tablet's hardness was determined to be 2.8 ± 0.2 kg/cm², which is a modest amount of hardness.
4. **Dissolution Testing:**
   - A dissolution tester fitted with USP equipment II (paddle method) was used to conduct the dissolution tests.
   - After 30 minutes, the herbal antibiotic pill showed a dissolving rate of 80% ± 5%, indicating a quick and effective drug release.

- The tablet's dissolution profile showed a plateau phase, indicating sustained release properties after the initial dissolving time.

5. **Disintegration Testing:**
   - In accordance with USP criteria, a disintegration tester was used to conduct disintegration testing.
   - The herbal antibiotic pill met the USP standards for fast disintegration, dissolving entirely in 15 minutes ± 1 minutes.

**Conclusion:**

The goal of this study's experimental work was to create and describe a herbal antibiotic pill that would be used to treat infections. The following is a summary of the study's main conclusions and implications:

1. **Synthesis and Description:**
   - The natural ingredients known for their antimicrobial properties, such as ginger, garlic, turmeric, cloves, and gum arabic, were used in the formulation of the herbal antibiotic tablet.
   - The tablet's round shape and pale yellowish-brown colour were purposefully chosen to ensure patient compliance and acceptability.
2. **Pharmaceutical Properties:**
   - Dissolution testing revealed a high dissolution rate, indicating efficient drug release and potential for therapeutic efficacy.
   - The tablet demonstrated favourable pharmacological features, including moderate hardness and quick disintegration, permitting ease of administration and drug release.
3. **Antimicrobial Activity:**
   - In vitro antimicrobial tests showed the tablet to have strong antibacterial activity against a variety of bacterial and fungal strains, indicating its broad-spectrum effectiveness and possible therapeutic use.
4. **Implications for Infection Management:**
   - With its broad-spectrum antimicrobial activity and advantageous pharmaceutical properties, the herbal antibiotic tablet is a valuable addition to the arsenal of antimicrobial agents.
   - It offers a natural alternative to conventional antibiotics and represents a promising therapeutic option for the management of various infectious diseases.
5. **Prospective Routes:**
   - To improve treatment outcomes and patient compliance, more study is necessary to optimise the herbal antibiotic tablet's formulation, dose schedule, and delivery method.
   - Clinical investigations, such as pharmacokinetic assessments and randomised controlled trials, are required to confirm the tablet's safety, effectiveness, and clinical suitability in human subjects.

**Acknowledgement:**

We would like to express our sincere gratitude and appreciation to the **Ishwar Deshmukh Institute of Pharmacy, Digras,** its Principal, **Dr. Ranajit D. Tijare Sir**, Our Guide **Assistant Professor Mr. Vaibhav V. Deshpande** and all the other teaching and non-teaching staff members for their invaluable support and assistance during our research work.

Their guidance, encouragement, and cooperation have been instrumental in helping us achieve our research goals. Their expertise and knowledge have been invaluable in providing us with the necessary resources, facilities, and guidance to carry out our research work efficiently.

we are deeply grateful to the college and its staff members for their continuous support and motivation, which has helped us immensely in our academic pursuits. we would also like to extend our heartfelt thanks to fellow students who have always been there to offer their support and encouragement.

Once again, we express our heartfelt thanks to everyone at the Ishwar Deshmukh Institute of Pharmacy, Digras, for their invaluable contribution to my research work.

**References:**

1. Adams, R. P. (2007). Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry (4th ed.). Allured Publishing Corporation.

2. Bharti, S. K., & Roy, R. (2015). Quantitative structure-activity relationship studies on some sulfur drugs against multi-drug resistant bacteria. Journal of Advanced Pharmaceutical Technology & Research, 6(2), 52–61.

3. Chaudhary, S. A., Kaneria, M. J., & Raja, S. S. (2012). An evaluation of antioxidant, antimicrobial activity and bioactive compounds of some selected medicinal plants. Journal of Biologically Active Products from Nature, 2(5), 378–386.

4. Clinical and Laboratory Standards Institute. (2018). Performance Standards for Antimicrobial Susceptibility Testing (28th ed.). CLSI document M100. Clinical and Laboratory Standards Institute.

5. European Pharmacopoeia VCommission. (2019). European Pharmacopoeia (10th ed.). European Directorate for the Quality of Medicines & HealthCare.
6. Gupta, V. K., Sharma, S. K., & Sharma, N. (2015). Biodiesel production from microalgae Chlorella pyrenoidosa using two-step transesterification: optimization and kinetics. Journal of Bioprocessing & Biotechniques, 5(2), 1000232.

7. Hossain, M. A., & Shah, M. D. (2011). Extraction and isolation of flavonoids: A review. American Journal of Food Technology, 6(2), 149–165.

8. Indian Pharmacopoeia Commission. (2018). Indian Pharmacopoeia (8th ed.). Indian Pharmacopoeia Commission.

9. Li, S., Zhang, B., & Jiang, D. (2017). Advances in the development of novel antimicrobial agents targeting methicillin-resistant Staphylococcus aureus. Medicinal Research Reviews, 37(6), 1375–1426.

10. World Health Organization. (2019). WHO Model List of Essential Medicines (21st List). World Health Organization.

11. Alves-Silva, J. M., Romane, A., &Efferth, T. (2017). Salvia officinalis L. And Thymus vulgaris L. Essential Oils and Their Components as a New Alternative Source of Antimicrobial Drugs. Microbial Drug Resistance, 23(2), 166–174.

12. Balouiri, M., Sadiki, M., &Ibnsouda, S. K. (2016). Methods for in vitro evaluating antimicrobial activity: A review. Journal of Pharmaceutical Analysis, 6(2), 71–79.

13. British Pharmacopoeia Commission. (2019). British Pharmacopoeia (BP 2019). TSO (The Stationery Office).

14. Burdock, G. A. (Ed.). (2010). Fenaroli's Handbook of Flavor Ingredients (6th ed.). CRC Press.

15. Committee on Herbal Medicinal Products (HMPC). (2015). Community herbal monograph on Zingiber officinale Roscoe, rhizoma. European Medicines Agency.

16. Council of Europe. (2020). European Pharmacopoeia (10th ed.). Directorate for the Quality of Medicines & HealthCare.

17. European Medicines Agency. (2011). Assessment report on Zingiber officinale Roscoe, rhizoma. European Medicines Agency.

18. Goyal, R. K., & Goyal, M. R. (2011). Biological and medicinal properties of garlic (Allium sativum L.). Nutrition & Food Science, 41(5), 266–274.

**19.** Herbal Medicine Research Centre, Institute of Medical Sciences. (2011). Compendium of Medicinal Plants Used in Malaysia. Herbal Medicine Research Centre, Institute for Medical Research.

**20.** Indian Pharmacopoeia Commission. (2018). Indian Pharmacopoeia (8th ed.). Indian Pharmacopoeia Commission.

**21.** Kaur, D., & Bhardwaj, A. (2011). Pharmacognostic Evaluation of Allium sativum Linn. Bulbs. Pharmacognosy Journal, 3(20), 26–31.

**22.** Khoza, B. S., & Naidoo, P. (2019). Use of Herbal Remedies by Patients in a Dental Clinic in South Africa. Complementary Medicine Research, 26(3), 174–179.

**23.** Lanzotti, V. (2006). The analysis of onion and garlic. Journal of Chromatography A, 1112(1–2), 3–22.

**24.** Lis-Balchin, M. (2006). Aromatherapy Science: A Guide for Healthcare Professionals. Pharmaceutical Press.

**25.** Marrelli, M., Conforti, F., Araniti, F., Statti, G., & Menichini, F. (2016). Effects of Satureja species extracts on antioxidant defenses in CHO-K1 cells. Industrial Crops and Products, 87, 133–141.