International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

Development and Evaluation of Herbal Beads for Nasal Decongestion

Ms.Anjali S Krishna* , Ms.Adithya Prakash , Ms.Durga R
(Department of Pharmaceutical Sciences Cheruvandoor , Ettumanoor)

Date of Submission: 20-07-2025 Date of Acceptance: 30-07-2025

ABSTARCT
The present study focuses on the formulation and evaluation of sodium alginate-based herbal beads intended for nasal decongestion, using the ionic gelation method. With a growing interest in natural therapies and plant-based drug delivery systems, this research aims to provide a safe, effective, and biocompatible alternative to conventional synthetic nasal decongestants. The beads were formulated using a synergistic combination of Coleus amboinicus leaf extract, ginger rhizome extract, lemon juice extract, eucalyptus essential oil, basil oil, and chamomile oil. These ingredients were selected based on their well-documented pharmacological activities relevant to nasal congestion, including mucolytic, anti-inflammatory, antimicrobial, antioxidant, and soothing effects. Sodium alginate served as the primary polymer for encapsulation due to its biodegradability, mucoadhesive properties, and safety profile. Calcium chloride was used as the cross-linking agent to initiate bead formation via ionic gelation, a technique known for its mild processing conditions suitable for preserving the activity of heat-sensitive herbal components. The resulting beads were evaluated for their physical characteristics, including shape, size uniformity, surface texture, and structural integrity, all of which indicated successful formulation. Encapsulation efficiency was measured and found to be satisfactory, confirming the compatibility of the herbal constituents with the alginate matrix. Swelling studies and preliminary in-vitro release observations suggest that the beads are capable of hydrating and gradually releasing the active compounds, which is ideal for sustained contact with the nasal mucosa. The combined action of the incorporated ingredients aims to relieve nasal blockage, reduce inflammation, eliminate microbial pathogens, and soothe irritated mucosal linings. The inclusion of eucalyptus and basil oils enhances the aromatic and penetrating effects, while chamomile oil and lemon juice offer calming and antioxidant benefits. This formulation is particularly targeted for conditions such as allergic rhinitis, sinusitis, and the common cold. Overall, the study demonstrates the potential of this natural, non-invasive dosage form as a novel approach for managing nasal congestion. The use of a biodegradable polymeric carrier along with a blend of traditional medicinal ingredients enhances patient acceptability, reduces adverse effects, and supports sustainable pharmaceutical development. Future investigations will include detailed in-vitro release profiling, antimicrobial testing, and possibly clinical evaluations to validate the efficacy and safety of the developed formulation for therapeutic use.

Key Words: Beads, Calcium chloride, Coleus amboinicus, Eucalyptus oil, Evaluation, Ginger extract, Herbal formulation, Ionic gelation, Lemon juice extract, Nasal congestion, Natural ingredients, Sodium alginate.

I. INTRODUCTION

Nasal congestion is a common and often distressing condition that affects a significant portion of the global population. It is typically characterized by inflammation and blockage of the nasal passages, leading to symptoms such as difficulty breathing through the nose, sinus pressure, headaches, and impaired sense of smell^1. These symptoms are frequently associated with upper respiratory tract infections, allergic rhinitis, sinusitis, and environmental irritants. Although various synthetic medications, such as decongestant sprays and antihistamines, are available to relieve nasal congestion, they often come with side effects including rebound congestion, dryness of the nasal mucosa,

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

drowsiness, and long-term dependency^2. As a result, there is a growing demand for safe, effective, and natural alternatives that provide relief without compromising patient comfort or long-term health^3.

Traditional medicine and phytotherapy offer a valuable repository of bioactive compounds with therapeutic potential, especially for respiratory ailments. Plants such as Coleus amboinicus, Zingiber officinale (ginger), and Citrus limon (lemon) have long been used in folk medicine for managing colds, sinus infections, and related symptoms. Likewise, essential oils like eucalyptus oil, basil oil, and chamomile oil are known for their aromatic, anti-inflammatory, and antimicrobial properties that can contribute to respiratory relief when inhaled or applied topically^4. Incorporating such herbal ingredients into modern drug delivery systems provides a unique opportunity to develop effective formulations that harness the benefits of traditional remedies while adhering to contemporary pharmaceutical standards.

Among various drug delivery platforms, polymer-based beads have gained attention due to their capacity for encapsulating and delivering active compounds in a controlled and targeted manner. Biopolymers such as sodium alginate offer several advantages including biodegradability, non-toxicity, mucoadhesive properties, and ease of formulation^5. Sodium alginate, derived from brown seaweed, forms hydrogels in the presence of divalent cations like calcium, through a process known as ionic gelation. This technique is particularly suitable for encapsulating thermolabile herbal extracts and essential oils, as it does not require high temperatures or organic solvents. The resulting calcium alginate beads offer a protective matrix that enhances the stability of herbal actives and enables sustained or controlled release upon administration^6.

The present study is designed to formulate and evaluate sodium alginate beads loaded with a combination of herbal extracts and essential oils for the purpose of nasal decongestion. The formulation includes Coleus amboinicus leaf extract, which exhibits antimicrobial, anti-inflammatory, and bronchodilatory effects^7; ginger rhizome extract, which provides warming and mucolytic activity that helps break down mucus^8; and lemon juice extract, known for its vitamin C content, astringency, and antioxidant action^9. These are complemented by eucalyptus essential oil, which acts as a natural decongestant and antiseptic through its major component 1,8-cineole^10; basil oil, which offers anti-inflammatory and antimicrobial benefits^11; and chamomile oil, which adds soothing, anti-allergic, and mild sedative effects^12. This synergistic blend was selected to provide multifaceted therapeutic action suitable for treating nasal congestion and associated discomforts.

Several methods can be employed to prepare sodium alginate beads, including^6:

- Ionotropic Gelation: This method involves dropping a sodium alginate solution into a calcium chloride bath, where the alginate molecules cross-link with calcium ions to form a gel-like structure.
- Emulsion-Gelation Method: This technique involves creating an emulsion of sodium alginate droplets in a continuous phase, followed by gelation of the droplets using calcium chloride.
- Spray Drying: This method involves atomizing a sodium alginate solution into a hot gas stream, resulting in the formation of dried beads.
- Extrusion Method: This technique involves forcing a sodium alginate solution through a nozzle or die to form droplets, which are then collected in a calcium chloride bath for gelation

The beads were formulated using the ionic gelation method, where sodium alginate serves as the gelling polymer and calcium chloride as the cross-linking agent. This method ensures gentle processing, preserving the activity of herbal constituents and resulting in spherical beads with adequate mechanical strength^6. The encapsulation of the actives within the polymeric matrix aims to improve mucosal adhesion, increase the residence time of the formulation in the nasal cavity, and provide gradual release of the herbal constituents for prolonged therapeutic effect. Moreover, this delivery form minimizes systemic absorption and thus reduces the risk of side effects commonly associated with conventional nasal therapies.

In light of increasing consumer preference for natural and sustainable healthcare solutions, this research contributes to the field of herbal drug delivery by offering a novel formulation for nasal decongestion. The study not only explores the formulation and physical evaluation of the beads but also emphasizes the potential of integrating traditional herbal wisdom with modern pharmaceutical technology. By delivering plant-based actives in a stable and effective form, the developed beads may provide a safer alternative for

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

managing nasal congestion, supporting respiratory health, and enhancing patient compliance. Further studies are proposed to evaluate in-vitro release kinetics, antimicrobial activity, and clinical performance of the formulation.

II. DRUG AND EXCIPIENTS PROFILE

Coleus amboinicus (Coleus amboinicus Lour.), commonly known as Indian Borage, is a medicinal plant from the Lamiaceae family, widely recognized for its therapeutic effects. The leaves of this plant contain bioactive compounds such as carvacrol, thymol, eugenol, and rosmarinic acid, which contribute to its potent antimicrobial, anti-inflammatory, and mucolytic properties. The primary active constituent, carvacrol, has been shown to exhibit significant antimicrobial effects, making it effective against respiratory pathogens. Thymol and eugenol are responsible for its anti-inflammatory action, which helps reduce swelling and congestion in the nasal passages. Additionally, rosmarinic acid has antioxidant properties that support the overall health of the mucosal lining in the nasal passages. By reducing inflammation, fighting infections, and acting as a mucolytic agent, Coleus amboinicus helps clear blocked nasal airways and provides significant relief from nasal congestion^13.

Fig a.Coleus amboinicus

Zingiber officinale (Zingiber officinale Roscoe), or ginger, is a member of the Zingiberaceae family. Ginger is widely used in traditional medicine for its anti-inflammatory, antioxidant, and antimicrobial properties. The rhizomes of ginger contain bioactive compounds such as gingerols, shogaols, and zingerone. Gingerols and shogaols possess potent anti-inflammatory effects, which help to reduce the inflammation of the nasal tissues and relieve swelling. These compounds also have mucolytic properties, which thin the mucus in the sinuses, making it easier to expel. Zingerone, another bioactive compound in ginger, has antioxidant properties that protect nasal tissues from oxidative damage. The warming and stimulating effects of ginger help increase blood circulation in the nasal passages, promoting faster healing and further reducing the sensation of blockage. Ginger's ability to address both the symptoms and underlying causes of nasal congestion makes it an essential ingredient in this formulation^14.

Fig b.Zingiber officianale

Citrus limon (Citrus limon L.), or lemon, belongs to the Rutaceae family and is a common fruit known for its high vitamin C content. Lemon juice is also rich in flavonoids, citral, and limonene, which contribute to its numerous health benefits. Vitamin C plays a crucial role in boosting the immune system, which helps the body fight off the infections that often lead to nasal congestion. Flavonoids in lemon juice are known for their antioxidant and anti-inflammatory properties, which help protect the mucosal lining of the nasal passages from damage and reduce swelling. Citral, a key compound in lemon, is known for its antimicrobial activity, which helps eliminate bacteria and viruses that may cause nasal congestion. Lemon juice also acts as a natural decongestant by clearing excess mucus from the nasal passages, providing relief from the discomfort associated with blocked airways. The refreshing and soothing effects of lemon juice also promote a sense of relief, helping to calm inflamed nasal tissues^15.

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

Fig c.Citrus limon

Eucalyptus globulus (Eucalyptus globulus Labill.), or eucalyptus, is a member of the Myrtaceae family, renowned for its therapeutic properties, particularly in treating respiratory conditions. The primary active compound in eucalyptus oil is 1,8-cineole (eucalyptol), which has been extensively studied for its decongestant and expectorant properties. Eucalyptol helps to open the airways by reducing the viscosity of mucus, making it easier to expel. This compound also has anti-inflammatory properties, which help to decrease the swelling of the nasal tissues, further relieving congestion. In addition to its decongestant properties, eucalyptus oil possesses antimicrobial activity, which helps combat the bacteria and viruses that contribute to nasal infections and congestion. The cooling and soothing sensation provided by eucalyptus oil can also help ease the discomfort associated with sinus pressure, making it an ideal ingredient in nasal decongestant formulations^16.

Fig d.Eucalyptus globulus

Ocimum basilicum (Ocimum basilicum L.), or basil, belongs to the Lamiaceae family and is widely known for its culinary and medicinal properties. The essential oil extracted from basil leaves contains active compounds such as linalool, eugenol, and methyl chavicol, which contribute to its antimicrobial, anti-inflammatory, and antioxidant effects. Linalool and eugenol are particularly effective in reducing inflammation in the nasal passages, helping to alleviate the swelling that often leads to congestion. Methyl chavicol, another active compound, possesses antimicrobial properties, which help prevent and treat infections that cause or exacerbate nasal congestion. Basil oil also has immunomodulatory effects, helping to strengthen the body's natural defense mechanisms and promoting quicker healing of inflamed nasal tissues. The soothing and calming effects of basil oil make it a valuable ingredient in easing the discomfort associated with nasal congestion^17.

Fig e.Oscimum basilicum

Matricaria chamomilla (Matricaria chamomilla L.), or chamomile, is a member of the Asteraceae family. Chamomile oil is widely used for its anti-inflammatory, antiallergic, and soothing properties, which are primarily attributed to its active compounds bisabolol, chamazulene, and apigenin. Bisabolol and chamazulene have strong anti-inflammatory effects, which help reduce the swelling of nasal tissues and alleviate the irritation caused by congestion. Apigenin, another key constituent of chamomile, has mild sedative effects that promote relaxation and relieve discomfort. Chamomile oil also has antiallergic properties, making it effective in treating allergic rhinitis, a common cause of nasal congestion. By soothing the inflamed nasal mucosa, reducing allergic reactions, and providing a calming effect, chamomile oil offers relief from both the discomfort and the underlying inflammation associated with nasal congestion^18.

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

Fig f.Matricaria chamomilla

Sodium Alginate is a natural polysaccharide derived from brown seaweed (Laminaria species) and is used as a key excipient in the formulation. Sodium alginate is biocompatible, biodegradable, and non-toxic, making it an ideal choice for drug delivery systems. It functions as a gelling agent, forming a gel matrix in the presence of calcium ions. This gel matrix is essential for encapsulating the herbal actives and ensuring their controlled and sustained release. The mucoadhesive nature of sodium alginate helps the formulation adhere to the mucosal lining of the nasal passages, ensuring that the active ingredients are delivered directly to the site of action over an extended period^19.

Fig g.Sodium alginate

Calcium Chloride serves as a cross-linking agent in the gelation process. When combined with sodium alginate, calcium chloride facilitates the formation of a stable gel matrix by forming ionic bonds with the alginate molecules. This cross-linking enhances the structural integrity of the gel beads and helps maintain their shape during the delivery process. By controlling the gelation process, calcium chloride ensures that the herbal actives are slowly and steadily released from the beads, providing sustained therapeutic effects^20.

Fig h.Calcium chloride

III. METHOD OF PREPARATION

All the herbal extracts (Coleus amboinicus, Zingiber officinale, Citrus limon, Eucalyptus globulus, Ocimum basilicum, and Matricaria chamomilla) were measured and mixed in a beaker to form a homogeneous solution. To this mixture, sodium alginate was added and stirred well to ensure uniformity. The prepared herbal-alginate mixture was then transferred into a syringe. A cross-linking solution of calcium chloride was prepared separately and kept ready. The syringe containing the herbal-alginate solution was used to drop the mixture into the calcium chloride solution, where the ionic gelation process led to the formation of beads. The beads were left in the calcium chloride solution for 20 minutes to complete the gelation. After gelation, the beads were filtered, washed several times with distilled water to remove excess calcium chloride, and then air-dried at room temperature for 24 hours to remove excess moisture and ensure bead stability

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

SL.NO.	INGREDIENTS	F-B1	F-B2	F-B3	F-B4	F-B5
1	Coleus amboinicus leaves extract	20ml	20ml	20ml	20ml	20ml
2	Ginger Rhizome extract	3ml	2ml	1.5ml	2.5ml	2.5ml
3	Lemon juice extract	3ml	2ml	1ml	2.5ml	1ml
4	Eucalyptus oil	2ml	0.5ml	1ml	1ml	1ml
5	Basil oil	2ml	0.5ml	1ml	1ml	1ml
6	Chamomile oil	0.5ml	0.5ml	1ml	1ml	1ml
7	Sodium Alginate	4g	3.5g	3g	2g	2g
8	Calcium Chloride	1g	0.7g	0.4g	0.4g	0.4g

Table 1.Compositions of bead.[F-B5 was selected]

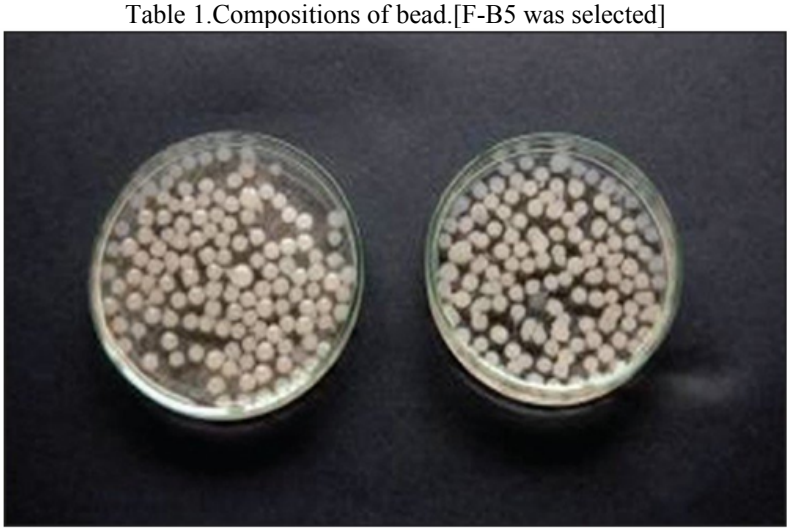

Fig i.Sodium alginate beads with active ingredients.

IV. EVALUATION OF BEADS

The beads were evaluated for their size and shape to ensure uniformity and consistency^21. The pH of the beads was measured to ensure compatibility with the nasal mucosa. The beads were also tested for their stability to ensure they maintained their structure and efficacy over time.

A. Physical evaluation

The physical evaluation of the beads involved assessing their size, shape, and uniformity to ensure consistency across the batch. The diameter of the beads was measured using a digital caliper, and their appearance was visually inspected for any irregularities. The beads were also examined for their texture and surface smoothness. Additionally, the weight variation of the beads was determined to assess uniformity in formulation^21.

B. Particle size determination

To determine the size of beads, the Vernier Caliper method was employed, which is most suitable for beads larger than 1 mm. Each bead was carefully placed between the jaws of the Vernier Caliper, ensuring that the jaws were closed gently to avoid compression and maintain accuracy. The diameter of each bead was recorded systematically. This process was repeated for all selected beads, and the obtained values were used to calculate the average bead size along with the standard deviation.

C. Determination of encapsulation efficiency

The powdered beads were extracted into 50 ml of phosphate buffer (pH 7.4) by magnetic stirring for a period of 2 h. The solution was filtered through Whatman filter paper no.5, suitably diluted and estimated for active ingredient spectrophotometrically at 282 nm using UV Visible

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

Spectrophotometer^21. Encapsulation efficiency was calculated by the following formula:
EE (%) = (Theoretical drug content/Practical drug content) ×100

D. Estimation of drug content

Accurately weighed (50 mg) dried beads were taken in a pestle and mortar and powdered. The powdered beads were then separately dissolved in adequate quantity of 0.1 N hydrochloric acid and 7.4 pH phosphate buffer and kept for 24 h. The solution was then filtered, and absorbance was noted at 282 nm using UV Visible spectrophotometer, repeated in triplicate and average was calculated^21.
Drug Content (%) =[(Cs×V×D)/W] ×100
Where:
Cs = Concentration of the sample solution (µg/mL or mg/mL) obtained from the calibration curve
V = Total volume of the sample solution (mL)
D = Dilution factor (if applicable)
W= Weight of the drug or formulation taken for analysis (mg)

E. Determination of swelling index

The extent of swelling was measured in terms of % weight gain by the beads. The swelling behaviours of all the formulations were studied. In this test 50 mg of beads from each formulation was kept in petridish containing distilled water. At the end of 1 hour, the beads were withdrawn, soaked with tissue paper and weighed. Then for every 1 hour, weights of beads were noted, and the process was continued till the end of 8 hours^21. The % weight gain by the beads was calculated by the following formula:
Swelling Index (SI) = [{Wt– W0}/ W0)] x 100
Where, Wt= Weight of swollen beads at time t
W0= Weight of dry beads at t=0
The study was performed in triplicate and average value was used

V. RESULT AND DISCUSSION

Table 2.Physical Evaluation of Beads.

Characteristics	F-B1	F-B 2	F-B 3	F-B4	F-B5
Colour	Creamy Beige	Creamy Beige	Creamy Beige	Creamy Beige	Creamy Beige
Odour	Sharp cooling aroma	Sharp cooling aroma	Sharp cooling aroma	Sharp cooling aroma	Sharp cooling aroma
Shape	Spherical	Spherical	Spherical	Spherical	Spherical
Texture	Uniform	Uniform	Uniform	Uniform	Uniform

The uniformity in colour, odour, shape, and texture across all samples suggests that the formulation process was well-controlled, ensuring reproducibility and stability. The creamy beige colour indicates the proper incorporation of active and excipient components. The sharp cooling

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

aroma suggests the presence of volatile decongestant agents, which contribute to the therapeutic effect by providing a soothing sensation and promoting nasal clearance.

Table 3.Measurements of particle size

B1(cm)	B2(cm)	B3(cm)	Average Size(cm)	Standard Deviation
0.21	0.20	0.22	0.21	±0.01
0.20	0.19	0.20	0.20	±0.01
0.19	0.18	0.20	0.19	±0.02
0.21	0.21	0.22	0.21	±0.01
0.20	0.20	0.21	0.20	±0.01

These findings indicate that the beads are relatively uniform in size, with only minor variations observed across different batches. The standard deviation values suggest a well-controlled formulation process with consistent bead formation. Beads that are too large may cause discomfort or difficulty in application, whereas excessively small beads might not provide sustained drug release. The observed size range of 0.19 cm to 0.21 cm falls within an optimal range for nasal administration, ensuring ease of application while allowing for controlled drug delivery.

UV spectrophotometry of Beads

Table 4.Absorbance of Thymol at 274 nm

Concentration[ug/ml]	Absorbance at 274 nm
2.5	0.1458 ± 0.002
5	0.2743 ± 0.001
10	0.5333 ± 0.003
15	0.7923 ± 0.006
20	1.0513 ± 0.003
25	1.3103 ± 0.007
30	1.5693 ± 0.006

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

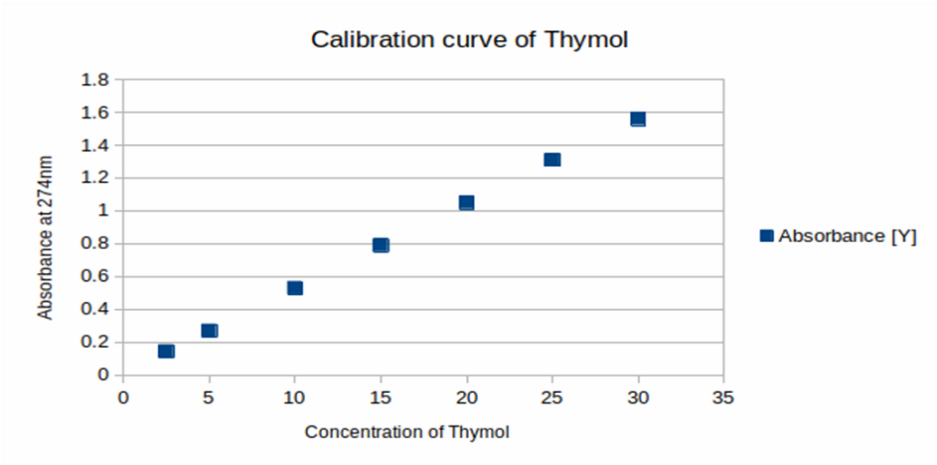

Table 5.Absorbance of Gingerol at 282 nm

Concentration(ug/mL)	Absorbance at 282nm
20	0.18 ± 0.004
40	0.36 ± 0.001
60	0.54 ± 0.007
80	0.72 ± 0.003
100	0.90 ± 0.002

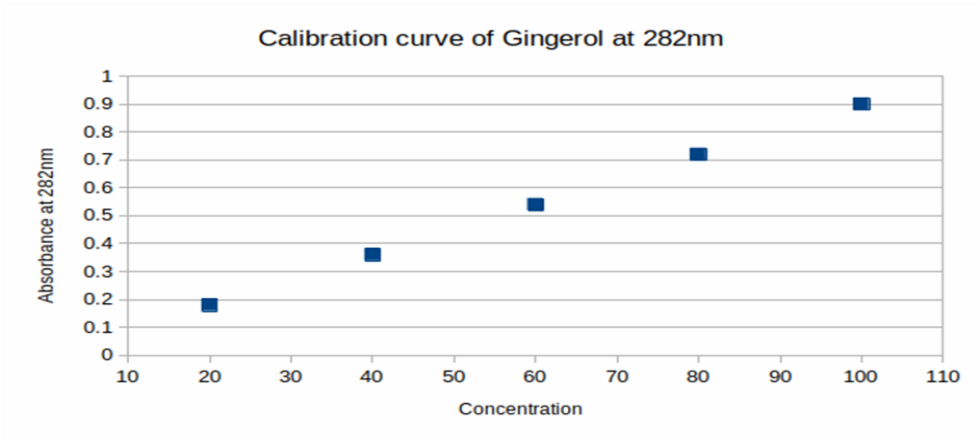

Table 6.Absorbance of Ascorbic Acid at 258 nm

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

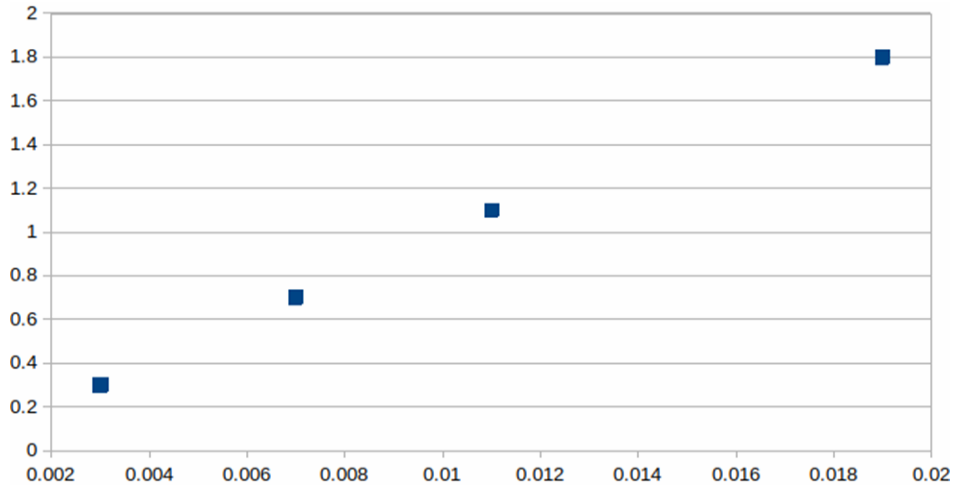

Table 7.Absorbance of Eucalyptol at 285nm

Concentration (ug/ml)	Absorbance at 285nm
0.003	0.3 ± 0.007
0.007	0.7 ± 0.002
0.011	1.1 ± 0.001
0.019	1.8 ± 0.008

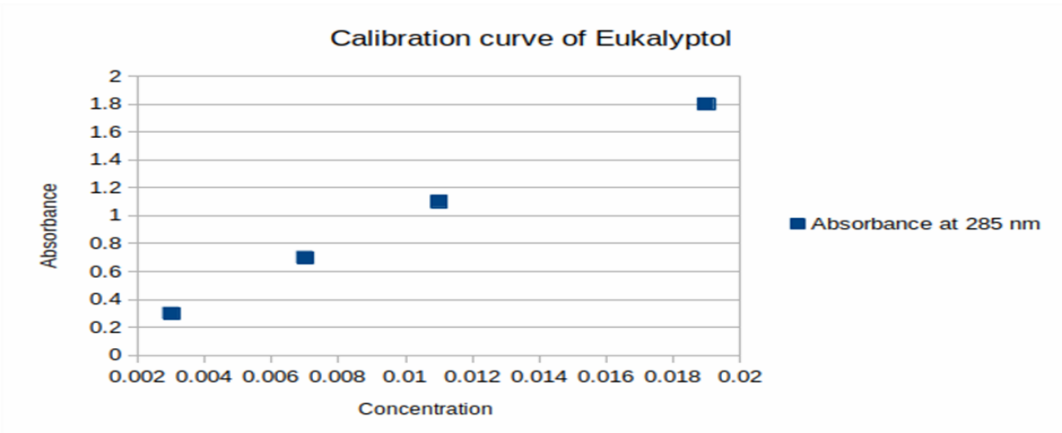

Table 8.Absorbance of Eugenol

Concentration(ug/ml)	Absorbance at 282nm
0.5	0.1967 ± 0.008
1	0.3950 ± 0.009
1.5	0.5933 ± 0.004
2	0.7916 ± 0.002
2.5	0.9899 ± 0.001

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

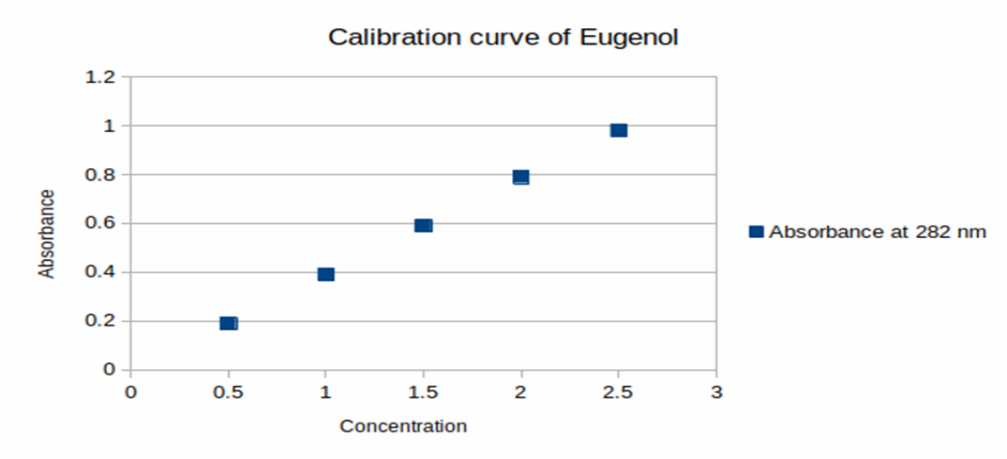

Table 9.Absorbance of Apigenin at 268nm

Concentration(ug/ml)	Absorbance at 268nm
0.5	0.03 ± 0.003
1	0.11 ± 0.005
1.5	0.18 ± 0.001
2	0.26 ± 0.002
2.5	0.34 ± 0.009
3	0.42 ± 0.006

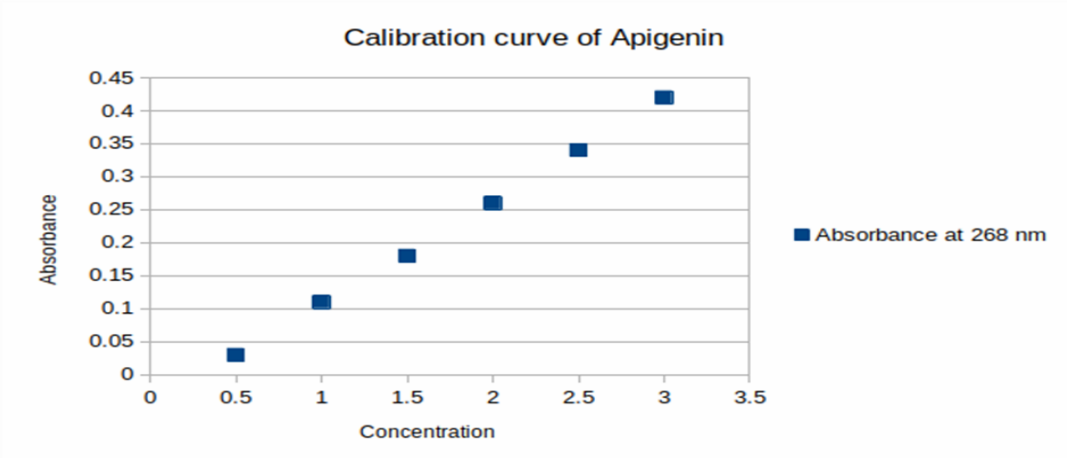

Table 10.Absorbance of Bead Sample

Active Constituent	Absorbance of B1 (nm)	Absorbance of B2 (nm)	Absorbance of B3 (nm)
Thymol (Coleus amboinicus)	0.724 ± 0.009	0.697 ± 0.001	0.712 ± 0.009
Gingerol (Ginger rhizome extract)	0.688 ± 0.003	0.691 ± 0.008	0.673 ± 0.008
Ascorbic acid (Lemon juice extract)	0.614 ± 0.001	0.611 ± 0.004	0.623 ± 0.007
Eucalyptol (Eucalyptus Oil)	0.603 ± 0.002	0.610 ± 0.002	0.606 ± 0.001
Eugenol (Basil Oil)	0.670 ± 0.004	0.681 ± 0.005	0.674 ± 0.004
Apigenin (Chamomile Oil)	0.155 ± 0.008	0.151 ± 0.009	0.148 ± 0.006

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

Table 11.Drug Content and Encapsulation Efficiency of Beads

Active Constituent	Drug Content (%)	Encapsulation Efficiency (%)
Thymol (Coleus amboinicus)	87.54%	82.71%
Gingerol (Ginger rhizome extract)	61.23%	62.28%
Ascorbic acid (Lemon juice extract)	40.89%	51.89%
Eucalyptol	28.47%	16.90%
Eugenol	53.68%	47.66%
Apigenin	12.41%	23.27%

The UV-visible spectroscopy analysis of the nasal decongestant beads showed variations in the absorbance of different active constituents. The highest absorbance values were observed for Thymol, followed by Gingerol, while Apigenin had the lowest absorbance. The absorbance values obtained indicate the successful incorporation of bioactive compounds into the beads. Thymol, Gingerol, and Eugenol exhibited higher absorbance values, suggesting their strong presence and stability within the formulation. The relatively lower absorbance of Apigenin and Eucalyptol might be due to differences in their solubility, interaction with other excipients, or lower concentrations in the formulation

The drug content and encapsulation efficiency of the active constituents varied across different compounds. Thymol exhibited the highest drug content (87.54%) and encapsulation efficiency (82.71%), followed by Gingerol (61.23% and 62.28%) and Eugenol (53.68% and 47.66%). The lowest values were observed for Apigenin (12.41% and 23.27%) and Eucalyptol (28.47% and 16.90%).

The high drug content and encapsulation efficiency of Thymol indicate its strong interaction with the polymer matrix, suggesting that the formulation effectively retains and protects this active ingredient. In contrast, Eucalyptol and Apigenin showed lower encapsulation efficiencies, which may be due to their higher volatility**,** weaker polymer interaction, or potential diffusion losses during the formulation process. Encapsulation efficiency plays a crucial role in drug delivery, as it determines the amount of active ingredient available for sustained release. To improve the encapsulation of Eucalyptol and Apigenin, formulation modifications such as using different polymers, optimizing crosslinking density, or altering the solvent system can be explored.

VI. SUMMARY AND CONCLUSION

Nasal decongestant beads represent an innovative approach for prolonged and controlled release of herbal decongestants. These beads are designed to gradually release active ingredients, offering sustained relief from nasal congestion. The preparation process involves encapsulating herbal extracts and essential oils in a polymer matrix. The beads were assessed for colour, odour, shape, texture, and particle size uniformity. They exhibited a uniform creamy beige colour, a strong cooling aroma, and a consistent spherical shape, ensuring batch-to-batch reproducibility. Particle size analysis confirmed minimal standard deviation (±0.01 to ±0.02 cm), indicating precise manufacturing control. This level of consistency is essential for controlled drug release and ease of nasal application.The beads formulation appeared stable, making them a promising candidate for further development as a herbal alternative to synthetic nasal decongestants.

The findings of this study demonstrate the potential benefits of herbal nasal decongestant bead, with unique advantages and areas for improvement. The nasal beads demonstrate excellent uniformity and controlled release, making them a promising long-lasting solution. While these formulations show promise, further research and development are necessary to enhance their efficacy, stability, and commercial viability.

Future prospects for herbal nasal decongestant are exciting and varied. One potential approach is the development of pouches or pockets for nasal beads, which can be inserted into face masks or attached to clothing, allowing for easy and convenient use. Other potential areas of research and development include techniques to enhance the formulations' effectiveness and user experience. Additionally, user acceptability studies could help gather feedback to refine the design and functionality of product, making them more appealing to consumers. With further research and development, the product could offer a safer, more

holistic, and more effective alternative to synthetic nasal decongestants, ultimately benefiting consumers seeking natural remedies for nasal congestion.

VII. ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to our research guides and faculty members for their constant encouragement, invaluable guidance, and continuous support throughout the course of this project. We are sincerely thankful to the laboratory staff for providing the necessary technical assistance and for maintaining a conducive environment that enabled us to complete our work effectively. We also extend our appreciation to our institution for offering the infrastructure, facilities, and academic support that were crucial to the success of our research. Our sincere thanks to our friends and colleagues for their constant motivation and assistance during the different stages of this study. We are deeply grateful to our families for their unconditional love, patience, and encouragement, which gave us the strength to complete this project. Finally, we would like to extend our special thanks to Aloha Cosmetics for their generous support in providing essential oils free of cost for our experimental trials, contributing significantly to the success of our work.

REFERENCE

[1]. Corey JP, Houser SM, Ng BA. Nasal congestion: a review of its etiology, evaluation, and treatment. Ear Nose Throat J. 2000 Sep;79(9):690-3, 696, 698 passim. PMID: 11011488.

[2]. Krouse J, Lund V, Fokkens W, Meltzer EO. Diagnostic strategies in nasal congestion. Int J Gen Med. 2010 Apr 8;3:59-67. doi: 10.2147/ijgm.s8084. PMID: 20463824; PMCID: PMC2866556.

[3]. Wang, J., Mao, Z. F., & Cheng, L. (2024). Rise and fall of decongestants in treating nasal congestion related diseases. Expert Opinion on Pharmacotherapy, 25(14), 1943–1951. https://doi.org/10.1080/14656566.2024.2411009

[4]. Lee B, Kwon CY, Park MY. Herbal medicine for the treatment of chronic rhinosinusitis: A systematic review and meta-analysis. Front Pharmacol. 2022 Jul 18;13:908941. doi: 10.3389/fphar.2022.908941. PMID: 35924061; PMCID: PMC9341451.

[5]. Vikulina, A. S., & Campbell, J. (2021). Biopolymer-Based Multilayer Capsules and Beads Made via Templating: Advantages, Hurdles and Perspectives. Nanomaterials, 11(10), 2502. https://doi.org/10.3390/nano11102502

[6]. Sipos B, Benei M, Katona G, Csóka I. Optimization and Characterization of Sodium Alginate Beads Providing Extended Release for Antidiabetic Drugs. Molecules. 2023 Oct 8;28(19):6980. doi: 10.3390/molecules28196980. PMID: 37836823; PMCID: PMC10574423.

[7]. Astuti P, Sudarsono S, Nisak K, Nugroho GW. Endophytic Fungi Isolated from Coleus amboinicus Lour Exhibited Antimicrobial Activity. Adv Pharm Bull. 2014 Dec;4(Suppl 2):599-605. doi: 10.5681/apb.2014.088. Epub 2014 Dec 31. PMID: 25671195; PMCID: PMC4312411.

[8]. Townsend EA, Siviski ME, Zhang Y, Xu C, Hoonjan B, Emala CW. Effects of ginger and its constituents on airway smooth muscle relaxation and calcium regulation. Am J Respir Cell Mol Biol. 2013 Feb;48(2):157-63. doi: 10.1165/rcmb.2012-0231OC. Epub 2012 Oct 11. PMID: 23065130; PMCID: PMC3604064.

[9]. Ferrara L, Naviglio D, Armone Caruso A. Cytological aspects on the effects of a nasal spray consisting of standardized extract of citrus lemon and essential oils in allergic rhinopathy. ISRN Pharm. 2012;2012:404606. doi: 10.5402/2012/404606. Epub 2012 Dec 9. PMID: 23304560; PMCID: PMC3523552.

[10]. Burrow A, Eccles R, Jones AS. The effects of camphor, eucalyptus and menthol vapour on nasal resistance to airflow and nasal sensation. Acta Otolaryngol. 1983 Jul-Aug;96(1-2):157-61. doi: 10.3109/00016488309132886. PMID: 6613544.

[11]. Kim DS, Hong SJ, Yoon S, Jo SM, Jeong H, Youn MY, Kim YJ, Kim JK, Shin EC. Olfactory Stimulation with Volatile Aroma Compounds of Basil (Ocimum basilicum L.) Essential Oil and Linalool Ameliorates White Fat

International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 500-512 www.ijprajournal.com
ISSN: 2456-4494

Accumulation and Dyslipidemia in Chronically Stressed Rats. Nutrients. 2022 Apr 27;14(9):1822. doi: 10.3390/nu14091822. PMID: 35565791; PMCID: PMC9105046.

[12]. Sah A, Naseef PP, Kuruniyan MS, Jain GK, Zakir F, Aggarwal G. A Comprehensive Study of Therapeutic Applications of Chamomile. Pharmaceuticals (Basel). 2022 Oct 19;15(10):1284. doi: 10.3390/ph15101284. PMID: 36297396; PMCID: PMC9611340.

[13]. Leesombun, A., Thanapakdeechaikul, K., Suwannawiang, J., Mukto, P., Sungpradit, S., Bangphoomi, N., Changbunjong, T., Thongjuy, O., Weluwanarak, T., & Boonmasawai, S. (2022). Effects of Coleus amboinicus L. Essential Oil and Ethanolic Extracts on Planktonic Cells and Biofilm Formation of Microsporum canis Isolated from Feline Dermatophytosis. Antibiotics, 11(12), 1734. https://doi.org/10.3390/antibiotics11121734

[14]. Yamprasert R, Chanvimalueng W, Mukkasombut N, Itharat A. Ginger extract versus Loratadine in the treatment of allergic rhinitis: a randomized controlled trial. BMC Complement Med Ther. 2020 Apr 20;20(1):119. doi: 10.1186/s12906-020-2875-z. PMID: 32312261; PMCID: PMC7171779.

[15]. Klimek-Szczykutowicz M, Szopa A, Ekiert H. Citrus limon (Lemon) Phenomenon-A Review of the Chemistry, Pharmacological Properties, Applications in the Modern Pharmaceutical, Food, and Cosmetics Industries, and Biotechnological Studies. Plants (Basel). 2020 Jan 17;9(1):119. doi: 10.3390/plants9010119. PMID: 31963590; PMCID: PMC7020168.

[16]. Sharma, S., Sushma, . and Nishtha, . (2021) "A Review on Eucalyptus Globulus – An Authentic Herb", Journal of Pharmaceutical Research International, 33(53B), pp. 107–114. doi: 10.9734/jpri/2021/v33i53B33686.

[17]. Shahrajabian, M. H., Sun, W., & Cheng, Q. (2020). Chemical components and pharmacological benefits of Basil (Ocimum basilicum): a review. International Journal of Food Properties, 23(1), 1961–1970. https://doi.org/10.1080/10942912.2020.1828456

[18]. Alvarado-García PA, Soto-Vásquez MR, Rodrigo-Villanueva EM, Gavidia-Valencia JG, Rodríguez NM, Rengifo-Penadillos RA, et al. Chamomile (Matricaria chamomilla L.) Essential Oil and its Potential Against Stress, Anxiety, and Sleep Quality. Pharmacognosy Journal. 2024;16(1):100-107.

[19]. Frent OD, Vicas LG, Duteanu N, Morgovan CM, Jurca T, Pallag A, Muresan ME, Filip SM, Lucaciu RL, Marian E. Sodium Alginate-Natural Microencapsulation Material of Polymeric Microparticles. Int J Mol Sci. 2022 Oct 11;23(20):12108. doi: 10.3390/ijms232012108. PMID: 36292962; PMCID: PMC9603258.

[20]. Olano, Agustín & NICKERSON, T. & BERNHARD, R.. (2006). Recovery of lactose from aqueous solutions: Precipitation with calcium chloride and sodium hydroxide. J. Food Sci.,42, 1484-6. Journal of Food Science. 42. 1484 - 1486. 10.1111/j.1365-2621.1977.tb08405.x.

[21]. Shivhare UD, Mathur VB, Shrivastava CG, Ramteke VI. Preparation of microbeads by different techniques and study of their influence on evaluation parameters. J Adv Pharm Educ Res. 2013;3(3):279-288. Available from: https://japer.in/article/preparation-of-microbeads-by-different-techniques-and-study-of-their-influence-on-evaluation-parameters.