Formulation and Evaluation of a *Moringa oleifera*-Enriched Herbal Mouth Spray for the Treatment of Oral Ulcers

Pratiksha Hajare*, Vaishnavi Kate[1], Aditi Kherde[2], Harish Sharma[3]

Department of Pharmacology, P. E. Society's Modern College of Pharmacy, Nigdi, Pune, Maharashtra-411044

Department of Pharmacology, P. E. Society's Modern College of Pharmacy, Nigdi, Pune, Maharashtra-411044

Department of Pharmacology, P. E. Society's Modern College of Pharmacy, Nigdi, Pune, Maharashtra-411044

Abstract: Mouth ulcers (aphthous ulcers) are common oral lesions associated with pain, inflammation, and discomfort, often affecting daily activities such as eating and speaking. Conventional treatments, though effective, may produce adverse effects with prolonged use, highlighting the need for safer alternatives. The present study aimed to formulate and evaluate a herbal mouth ulcer spray containing Moringa oleifera leaf extract, known for its antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties. The ethanolic extract of Moringa oleifera leaves was incorporated into a spray formulation using suitable excipients, and multiple batches were prepared to obtain an optimized formulation. The developed formulation was evaluated for physicochemical parameters including organoleptic properties, pH, viscosity, spray pattern, spray angle, dose uniformity, drug content, stability, and irritation potential. Antimicrobial activity was assessed against Staphylococcus aureus using the agar diffusion method. The optimised formulation exhibited satisfactory characteristics with acceptable pH, low viscosity, uniform spray performance, and high drug content uniformity. It demonstrated significant antimicrobial activity with a notable zone of inhibition, indicating effectiveness against the test organism. Stability studies confirmed that the formulation remained stable under standard conditions. The results suggest that the formulated herbal spray is a promising, safe, and effective alternative for the management of mouth ulcers.

Keywords: Moringa oleifera, mouth ulcer spray, antibacterial activity, Staphylococcus aureus, aphthous ulcer

Introduction:

Aphthous ulcers, another name for mouth ulcers, are sores that develop on the membrane of the oral cavity. The definition states, "A breach within the mucosal surface of the buccal cavity." (1) Uncovered sores of the mucous membrane or surface where inflammatory dead tissue has been removed are called ulcers. Many illnesses have unclear etiopathogenesis despite their high occurrence. (2) It often causes discomfort and is followed by bleeding, swelling, and redness in the afflicted region. A person's eating habits may change as the mouth ulcer heals, and it frequently causes pain and suffering. (3) They may be categorised as acute or chronic based on how they manifest and develop. Topical corticosteroids, antiseptics, and analgesics are examples of conventional therapies that may have negative side effects with extended usage. Hence, there is a growing interest in herbal remedies that are safe, effective, and economical.(4)

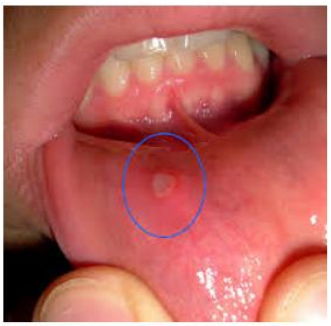


Fig. 1 Minor ulcer

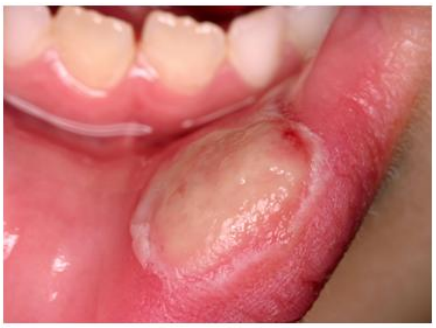


Fig. 2: Major ulcer

Traditional medicine makes extensive use of Moringa oleifera, sometimes referred to as the drumstick tree. It can be utilized as a safe and economical plant antimicrobial agent since it includes active chemicals with antibacterial properties, including as flavonoids, tannins, saponins, alkaloids, phenolics, and triterpenoids. (5) Moringa oleifera leaf extract has a high protein and mineral content. It has the capacity to cure many oral soft tissue conditions like traditional medication. Moringa oleifera may be regarded as a useful natural remineralizing agent as it improved the remineralization process of demineralized enamel and dentin, according to a study by Nawal Aidaros et al. (6)

Through bioactive phytochemicals including isothiocyanates, tannins, and flavonoids, Moringa oleifera also has potent antibacterial action, especially against Gram-positive bacteria like Staphylococcus aureus and Bacillus cereus as well as some Gram-negative organisms like E. coli. According to studies, leaf and seed extracts can work as natural food preservatives or water purification agents by rupturing bacterial membranes and killing the cells. (7) Because it contains flavonoids, phenolics, vitamins, and minerals, it has anti-inflammatory, antibacterial, antioxidant, and wound-healing qualities. Moringa oleifera was

chosen as the primary herbal component for the creation of a mouth ulcer spray in light of these characteristics. (8)

The objective of the present study was to formulate a herbal mouth ulcer spray containing Moringa oleifera ethanolic extract and to evaluate it for various physicochemical parameters to ensure its suitability for oral use.

Materials and method:

All the materials used in the formulation were of analytical grade. Moringa oleifera leaf extract was used as the main active ingredient due to its antioxidant and anti-inflammatory properties. Glycerine and sorbitol were incorporated as humectant and sweetening agents, respectively, to improve moisture retention and palatability. Propylene glycol was used as a co-solvent and preservative enhancer, while ethanol served as the primary solvent for extraction and formulation. Peppermint oil was added as a flavoring agent to enhance patient acceptability. Tween 80 was included as a surfactant to improve solubility and dispersion of ingredients. Sodium benzoate was used as a preservative and pH-adjusting agent, and purified water was used as the vehicle to make up the final volume.

Fig. 3 Moringa oleifera leaves

Fig. 4 Moringa oleifera leaves powder

Table 1: Composition and Functional Role of Ingredients Used in Herbal Mouth Ulcer Spray Formulation

Ingredients	role
Moringa leaf extract	Anti-inflammatory, antioxidant
Glycerine	Humectant
Propylene glycol	Preservative Cosolvent
Ethanol	Solvent
Peppermint oil	Flavoring agent
Tween 80	surfactant
Sorbitol	Sweetner
Sodium benzoate	pH adjuster
Purified water	vehicle

Table 2: Formulation Design Showing Composition of Different Batches (F1–F3) and Optimized Formulation

Ingredient	F1	F2	F3	Optimized
Moringa leaf extract (g)	5	5	5	5
Glycerine (ml)	5	7	10	7
Propylene glycol (ml)	10	12	15	12
Ethanol (ml)	15	20	25	20
Peppermint oil (ml)	0.10	0.15	0.20	0.15
Tween 80 (ml)	0.3	0.5	0.7	0.5
Sorbitol (ml)	0.5	1	1.5	1
Sodium benzoate (g)	0.1	0.1	0.1	0.1
Purified water	q.s. to 100 ml	q.s. to 100 ml	q.s. to 100 ml	q.s. to 100 ml

Methodology

1. Preparation of Moringa Leaf Extract:

To conserve thermolabile components, fresh Moringa oleifera leaves were authenticated, air-dried for a week at 25 ± 2°C in the shade, and then ground into a fine powder using an electric grinder. To guarantee consistency, the powder was sieved using a 60-mesh screen. 100 g of the powder was cold macerated in 500 mL of 95% ethanol for 72 hours with intermittent stirring in order to extract it. To optimize phytochemical recovery, the mixture was filtered using Whatman No. 1 filter paper, and the residue was extracted twice using new solvent. In order to achieve a solvent-free extract, the mixed filtrates were concentrated using a vacuum rotary evaporator (Büchi Rotavapor R-210) at 40°C under decreased pressure. This was followed by desiccation in a vacuum chamber. The dried extract was kept in sealed containers at 4°C after its yield was determined gravimetrically.[9]

2. Phase A – Dissolution of Semi-solid Extract:

Five grams of the semi-solid ethanolic extract of *Moringa oleifera* was weighed and transferred into a beaker. Twenty milliliters of 96% ethanol was added, and the mixture was gently warmed in a water bath below 40°C with continuous stirring until a uniform solution was obtained. (10)

3. Phase B – Preparation of Solvent–Humectant Base:

Glycerin (7 mL) and propylene glycol (12 mL) were mixed in a beaker and stirred until a clear solution was formed. Sorbitol solution (1–1.5 mL) was then added and mixed thoroughly to improve taste and humectancy. Phase A was slowly added to Phase B with continuous stirring to prevent precipitation. (11)

4. Phase C – Emulsification of Peppermint Oil:

Peppermint oil (0.15–0.25 mL) was mixed with Tween 80 (0.5 mL) until a uniform mixture was obtained. This mixture was slowly incorporated into the main formulation with constant stirring. (12)

5. Preservative Addition and pH Adjustment:

Sodium benzoate (0.10 g) was added as a preservative. The pH was adjusted to a range of 4.5–6.0 using citric acid or sodium citrate solution. (13)

6. Make-up Volume and Filtration:

The final volume was made up to 100 mL using purified water. The formulation was allowed to stand and then filtered through Whatman No. 1 filter paper to remove insoluble particles. (14)

Evaluation:

1. Organoleptic Evaluation

Ten milliliters of the spray were observed in a glass vial under daylight. The color, clarity, and presence of any sediment were noted. The odor was smelled and recorded. (15)

2. pH Determination

The pH meter was calibrated using standard buffer solutions. Ten milliliters of the spray sample were taken at 25 °C. The electrode was immersed in the sample, and the pH was noted. Three readings were recorded, and the average pH was calculated. (16)

3. Viscosity Determination

Ostwald's viscometer was filled with the spray solution. The time taken for the liquid to flow between the two marks was measured. The flow time was compared with that of water at the same temperature. The viscosity was calculated using the following formula. (17)

$$\eta_1 = \eta_2 \times \frac{t_1 \times d_1}{t_2 \times d_2}$$

4. Spray Pattern:

The spray bottle was held vertically at a distance of 10 cm from the paper. One or two sprays were actuated. The spray pattern was observed for uniformity and circular distribution without dripping. (18)

5. Spray angle:

Use solvent-sensitive paper to visualize the spray pattern. Measure the angle formed by the edges of the spray pattern relative to the nozzle position. Spray angle (θ) = tan-1(l/r) where r is the circle's mean radius and l is the distance between the nozzle and the sheet. (18)

6. Spray Volume (Dose per Actuation):

The spray bottle was weighed before spraying (W_1). Ten actuations were sprayed into a graduated cylinder. The bottle was weighed again (W_2). The dose per spray was calculated using the following equation:

$$\text{Dose per spray (mL)} = \frac{(W_1 - W_2)}{\text{Density of spray} \times 10}$$

7. Stability Study:

The spray samples were stored in amber bottles under the 25 ± 2 °C / 60 ± 5% RH (room temperature)

8. Irritation test:

Small amount spray was applied to the forearm skin.

9. Drug Content Uniformity:

One milliliter of the spray was diluted to 100 mL with ethanol. The absorbance was measured at λmax ≈ 340 nm. The concentration of Moringa extract was determined using a previously prepared calibration curve. The percentage of label claim was calculated. (19)

10. Antimicrobial study:

66.1g of the commercially available Vogal Johnson Agar Medium was dissolved in 1000ml of distilled water to create the Vogal Johnson Agar Medium. The dissolved medium was autoclaved for 15 minutes at 121°C under 15 pounds of pressure. After thoroughly mixing the autoclaved media, 20 cc of the molten mixture was added to each Petri plate.

A 24-hour-cultured strain of Staphylococcus aureus was seeded into Petri-plates with 20 milliliters of Vogal Johnson Agar medium. A 6 mm borer was used to make the wells, and 0.5 µl of our mixture and standard were added. After that, the plates were incubated for a full day at 37°C. The diameter of the inhibition zone that developed around the well was measured in millimeters to determine the antibacterial activity. (20)

Results:

1. **Organoleptic Properties**

The formulation appeared as a clear, greenish solution with a pleasant minty odor. No precipitation was observed, indicating good stability and aesthetic acceptability.

2. **pH**

The pH was found to be 6.52 ± 0.08, which lies within the acceptable range for oral formulations (6.0–7.0), ensuring compatibility with oral mucosa and minimizing irritation.

3. **Viscosity**

The viscosity was recorded as 1.42 ± 0.05 cP, indicating low resistance to flow. This facilitates easy spraying and proper atomization.

4. **Spray Pattern**

The spray pattern was uniform and circular without any dripping, ensuring even distribution of the formulation on the affected area.

5. **Spray Angle**

The spray angle was found to be 42° ± 2°, indicating optimal dispersion characteristics for effective coverage.

6. **Dose per Actuation**

The spray delivered 0.12 ± 0.01 mL per actuation, demonstrating consistent dosing and uniform drug delivery.

7. **Drug Content**

The drug content was found to be 98.6 ± 1.9%, which is within acceptable limits (90–110%), confirming uniform distribution of active constituents.

8. **Stability Study**

The formulation showed no significant changes under storage conditions (25 ± 2 °C / 60 ± 5% RH), indicating good stability.

9. **Irritation Test**

No irritation was observed on application, confirming the safety of the formulation for oral use.

10. Antimicrobial Activity

The formulation showed a zone of inhibition of 12 mm (undiluted) and 7 mm (diluted), confirming concentration-dependent antimicrobial activity against Staphylococcus aureus.

Table 3: Evaluation Parameters and Observed Results of Optimized Herbal Mouth Ulcer Spray

Parameter	Result	Acceptance Criteria
Appearance	Clear solution	Clear, no precipitation
Color	Greenish	Characteristic
Odor	Pleasant, minty	Pleasant
pH	6.52 ± 0.08	6.0 – 7.0
Viscosity (cP)	1.42 ± 0.05	Suitable for spraying
Spray pattern	Uniform, circular	Uniform, no dripping
Spray angle	42° ± 2°	Consistent spray
Spray volume per actuation (mL)	0.12 ± 0.01	Consistent dose
Drug content (% label claim)	98.6 ± 1.9	90 – 110%
Stability at 25 ± 2 °C / 60 ± 5% RH	No significant change	Stable
Irritation test	No irritation	Non irritant

Table 4:Calibration Data for Quantitative Estimation of Moringa oleifera Extract (Absorbance vs Concentration)

Concentration	Absorbance
2	0.19
4	0.357
6	0.536
8	0.702
10	0.881

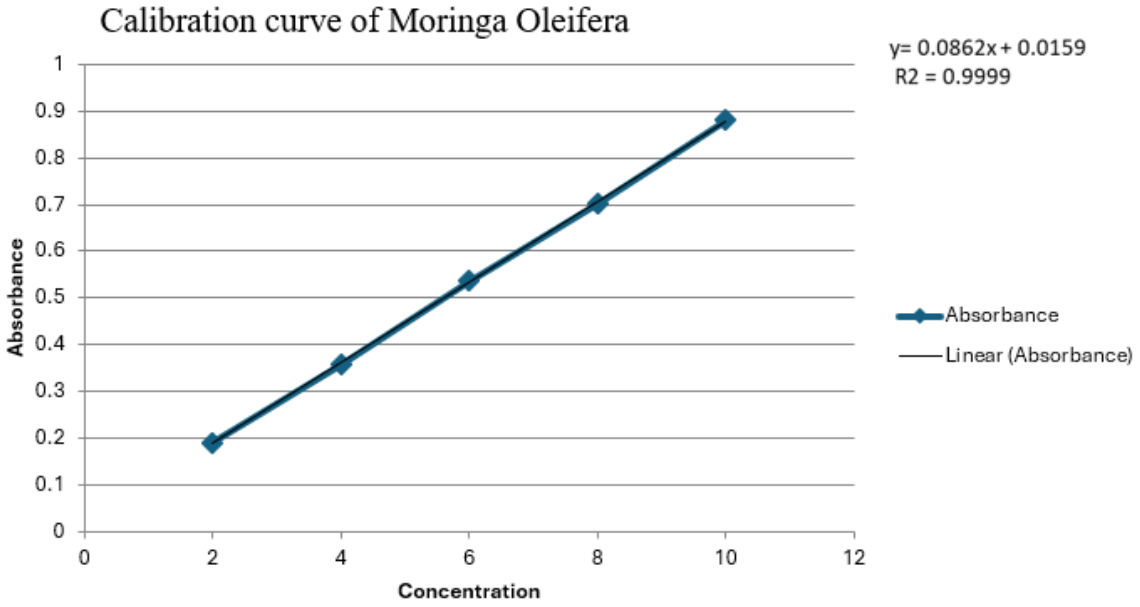
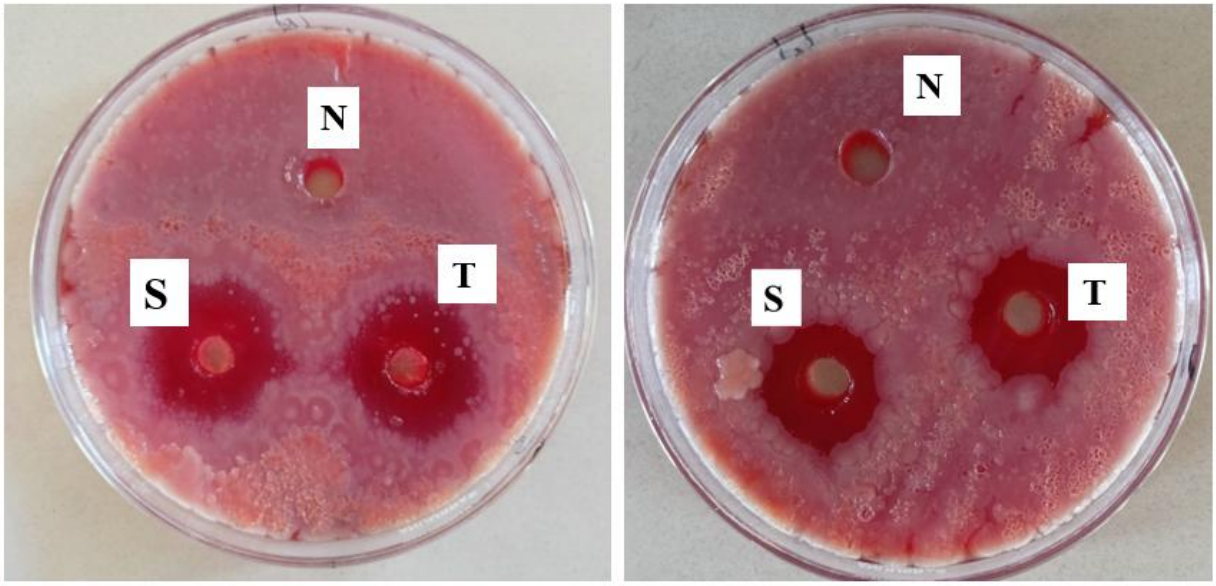


Fig.5 : Calibration curve of Moringa Oleifera



(a) (b)

Fig 6: Antibacterial activity comparison between Formulation and standard
N= Neutral, S= Standard, T= Test
(a) Undiluted Test(100%)
(b) Diluted Test(1:1, Test: water, 50%)

Discussion:

The obtained results as shown in Table 3 indicate that the formulated herbal mouth ulcer spray possesses satisfactory physicochemical and performance characteristics. Each evaluation parameter was specifically selected to ensure the formulation's safety, efficacy, stability, and patient acceptability.

The formulation appeared as a clear, greenish solution with a pleasant minty odour. Organoleptic evaluation was performed to assess visual appearance, colour, and odour because these attributes play a crucial role in patient compliance and acceptability, especially for oral formulations. (21) The absence of turbidity or precipitation also indicates physical stability and proper solubilization of ingredients. (22)

The pH (6.52 ± 0.08) was within the suitable range for oral use. pH determination is essential to ensure compatibility with the oral cavity, as extreme pH values can lead to mucosal irritation, discomfort, or damage to oral tissues. (23) A near-neutral pH helps maintain oral homeostasis and was further supported by the absence of irritation in irritation tests, which were conducted to confirm the formulation's safety upon direct contact with sensitive oral mucosa. (24)

The low viscosity (1.42 ± 0.06 cP) facilitated easy spraying. Viscosity measurement was performed to evaluate the flow properties of the formulation, as it directly influences sprayability, droplet formation, and uniform distribution over the affected area. A low viscosity ensures that the formulation can be easily atomized without clogging the spray nozzle. (25)

The spray pattern and spray angle (~42°) were evaluated to determine the performance of the spray system. These tests ensure that the formulation is delivered as a fine, uniform mist covering an adequate surface area, which is essential for effective treatment of mouth ulcers. (26) The dose per actuation (0.12 ± 0.01 mL) was measured to ensure dose uniformity, which is critical for delivering a consistent amount of active constituents with each use, thereby maintaining therapeutic efficacy. (27)

The drug content (98.6 ± 1.9%) was within acceptable limits. Drug content analysis was performed to confirm the uniform distribution and accuracy of the active constituents in the formulation. This ensures that each administered dose contains the intended amount of active ingredients, which is vital for consistent therapeutic outcomes. (28)

Stability studies were carried out under standard storage conditions to evaluate the formulation's ability to maintain its physical, chemical, and functional properties over time. (30) The absence of significant changes indicates good stability, suggesting that the formulation can retain its efficacy and safety during storage. (30)

The antimicrobial activity of the formulated herbal mouth ulcer spray was evaluated using the agar diffusion method, which was chosen to assess the formulation's ability to inhibit microbial growth, a key factor in the treatment of mouth ulcers that are often associated with microbial infection. The formulation showed a zone of inhibition of 12 mm for the undiluted sample and 7 mm for the diluted sample. The larger zone in the undiluted sample indicates stronger antimicrobial efficacy due to the higher concentration of active constituents. This test was performed to validate the therapeutic potential of the formulation in controlling oral pathogens. (31)

The reduced zone of inhibition in the diluted sample confirms a concentration-dependent antimicrobial effect, as shown in Fig. 5. This observation is important because it demonstrates that the activity of the formulation is directly related to the amount of active phytoconstituents present, supporting its mechanism of action. (32)

Overall, these results demonstrate that the formulation possesses acceptable physicochemical properties, efficient spray performance, stability, safety, and significant antimicrobial activity. The systematic evaluation of each parameter confirms that the herbal mouth ulcer spray is suitable for oral application and has potential effectiveness in controlling infection and promoting healing in mouth ulcers.

Conclusion:

The present study successfully formulated and evaluated herbal mouth ulcer spray containing Moringa oleifera leaf extract. The optimized formulation demonstrated desirable physicochemical properties, including suitable pH, low viscosity, uniform spray characteristics, and good stability. The absence of irritation confirms its safety for oral application. Furthermore, the formulation exhibited significant antimicrobial activity against Staphylococcus aureus, supporting its potential role in preventing infection and promoting healing of mouth ulcers. Overall, the developed herbal spray offers a natural, safe, and cost-effective alternative to conventional therapies. Future studies involving clinical evaluation and long-term stability assessment are recommended to further validate its therapeutic efficacy and commercial applicability.

Reference:

1. Noor, S., Menzel, A., & Gasmi, A. (2021). Oral aphthous: pathophysiology, clinical aspects and medical treatment. *Archives of Razi Institute*, *76*(5), 1155.
2. Srikanth, H. J. (2019). *Clinico-Pathological Study of Ulcero-Membranous Lesions in Oral Cavity and Oropharynx in the Tertiary Care Hospital of Mandya Institute of Medical Sciences, Mandya* (Master's thesis, Rajiv Gandhi University of Health Sciences (India)).
3. Das, A. K., & Chen, C. Y. J. Causes of Mouth Ulcers.
4. Hengge, U. R., Ruzicka, T., Schwartz, R. A., & Cork, M. J. (2006). Adverse effects of topical glucocorticosteroids. *Journal of the American Academy of Dermatology*, *54*(1), 1-15.
5. Klimek-Szczykutowicz, M., Gaweł-Bęben, K., Rutka, A., Blicharska, E., Tatarczak-Michalewska, M., Kulik-Siarek, K., ... & Szopa, A. (2024). Moringa oleifera (drumstick tree)—nutraceutical, cosmetological and medicinal importance: a review. *Frontiers in Pharmacology*, *15*, 1288382.
6. Farouk, H., Mosallam, R., & Aidaros, N. H. (2021). Effect of Green Tea, Black Tea and Moringa Oleifera on Remineralization of Artificially Demineralized Enamel and Dentin: An In-vitro Microhardness Analysis. *Advanced Dental Journal*, *3*(1), 24-34.
7. El-Sherbiny, G. M., Alluqmani, A. J., Elsehemy, I. A., & Kalaba, M. H. (2024). Antibacterial, antioxidant, cytotoxicity, and phytochemical screening of Moringa oleifera leaves. *Scientific Reports*, *14*(1), 30485.
8. Shady, N. H., Mostafa, N. M., Fayez, S., Abdel-Rahman, I. M., Maher, S. A., Zayed, A., ... & Abdelmohsen, U. R. (2022). Mechanistic wound healing and antioxidant potential of Moringa oleifera seeds extract supported by metabolic profiling, in silico network design, molecular docking, and in vivo studies. *Antioxidants*, *11*(9), 1743.
9. Hajare PK, Reddy MR, Somvanshi YD, Dhumekar VA. Formulation and evaluation of Niosomal cream from moringa leaf extract for enhanced Antifungal Activity. J. Drug Delivery Ther. [Internet]. 2025 Apr.
10. Co-Convener, C. P. C. O. BHASKAR PHARMACY COLLEGE.
11. Rao, P. D., Husile, N., Strasser, A. A., & Wise, P. M. (2018). Pilot experiment: the effect of added flavorants on the taste and pleasantness of mixtures of glycerol and propylene glycol. *Chemosensory perception*, *11*(1), 1-9.
12. Gorjian, H., Mihankhah, P., & Khaligh, N. G. (2022). Influence of tween nature and type on physicochemical properties and stability of spearmint essential oil (Mentha spicata L.) stabilized with basil seed mucilage nanoemulsion. *Journal of Molecular Liquids*, *359*, 119379.

13. IFECHUKWU, A. J. EFFECT OF ADDITION OF CITRIC ACID AND SODIUM BENZOATE ON THE KEEPING QUALITY OF SOYMILK.
14. Laxen, D. P., & Chandler, I. M. (1982). Comparison of filtration techniques for size distribution in freshwaters. *Analytical Chemistry*, *54*(8), 1350-1355.
15. Tiara, T., Ervianingsih, E., & Amri, S. R. (2024, October). Formulation And Antibactery Activity Test Of Deodoran Spray Etanol Extract Of Mangrove Leaves (Rhizophora Mucronata) Against The Bacteri Staphylococcus Aureus. In *International Conference of Business, Education, Health, and Scien-Tech* (Vol. 1, No. 1, pp. 2245-2254).
16. Pandey, G., Choudhary, S., Chaudhari, R., & Joshi, A. (2020). Ultrasonic atomizer based development of pH sensor for real time analysis. *Scientific Reports*, *10*(1), 10910.
17. Chideme, N., & De Vaal, P. L. (2024). Effect of liquid viscosity and surface tension on the spray droplet size and the measurement thereof.
18. Sayinci, B., & Bastaban, S. (2011). Spray distribution uniformity of different types of nozzles and its spray deposition in potato plant. *African Journal of Agricultural Research*, *6*(2), 352-362.
19. George, T. T. (2021). *Characterisation and encapsulation of Moringa oleifera extracts* (Doctoral dissertation, Cape Peninsula University of Technology).
20. Raghupathi, K. R., Koodali, R. T., & Manna, A. C. (2011). Size-dependent bacterial growth inhibition and mechanism of antibacterial activity of zinc oxide nanoparticles. *Langmuir*, *27*(7), 4020-4028.
21. Clapham, D. (2022). Presentational and Organoleptic Aspects of Formulation.
22. Zheng, B., & McClements, D. J. (2020). Formulation of more efficacious curcumin delivery systems using colloid science: enhanced solubility, stability, and bioavailability. *Molecules*, *25*(12), 2791.
23. Loke, C., Lee, J., Sander, S., Mei, L., & Farella, M. (2016). Factors affecting intra-oral pH–a review. *Journal of oral rehabilitation*, *43*(10), 778-785.
24. Oberholzer, I. D. (2009). Peroral and Nasal Delivery.
25. Carvalho, F. K., Antuniassi, U. R., Chechetto, R. G., Mota, A. A. B., de Jesus, M. G., & de Carvalho, L. R. (2017). Viscosity, surface tension and droplet size of sprays of different formulations of insecticides and fungicides. *Crop Protection*, *101*, 19-23.
26. Khunt, Y., Morad, M., Vasoya, Y., Rathod, A., Khakhi, D., Vekariya, V., & Vora, V. Formulation and Characterization of a Mouth Ulcer Spray: Stability, Safety, and Therapeutic Potential.
27. Kang, C., Wang, J., Li, R., Gong, J., Wang, K., Wang, Y., ... & Li, F. (2023). Smart targeted delivery systems for enhancing antitumor therapy of active ingredients in traditional Chinese medicine. *Molecules*, *28*(16), 5955.

28. Choudhary, N., & Sekhon, B. S. (2011). An overview of advances in the standardization of herbal drugs. *Journal of Pharmaceutical Education and Research*, *2*(2), 55.
29. Marquele-Oliveira, F., Fonseca, Y. M., De Freitas, O., & Fonseca, M. J. V. (2007). Development of topical functionalized formulations added with propolis extract: stability, cutaneous absorption and in vivo studies. *International journal of pharmaceutics*, *342*(1-2), 40-48.
30. Thakur, L., Ghodasra, U., Patel, N., & Dabhi, M. (2011). Novel approaches for stability improvement in natural medicines. *Pharmacognosy reviews*, *5*(9), 48.
31. Panpaliya, N. P., Dahake, P. T., Kale, Y. J., Dadpe, M. V., Kendre, S. B., Siddiqi, A. G., & Maggavi, U. R. (2019). In vitro evaluation of antimicrobial property of silver nanoparticles and chlorhexidine against five different oral pathogenic bacteria. *The Saudi dental journal*, *31*(1), 76-83.
32. Bharti, S. K., Krishnan, S., Kumar, A., & Kumar, A. (2018). Antidiabetic phytoconstituents and their mode of action on metabolic pathways. *Therapeutic Advances in Endocrinology and metabolism*, *9*(3), 81-100.