International Journal of Pharmaceutical research and Applications
Volume 11, Issue 1, Jan - Feb 2026, pp:130-138 www.ijprajournal.com ISSN: 2456-4494

Formulationandcharacterizationofnonionicsurfactantvesicleconta iningaquilegiafragransextract And Its Anti-Microbial Activity

Ganesh Singh[1], Umesh Kumar Jain[2*], Neeraj Patidar[3]
[1]*Student- Bhopal Institute of Technology and Science -Pharmacy (BITS), Bhopal (M.P)*
[2]*Director & Principal- Bhopal Institute of Technology and Science -Pharmacy (BITS), Bhopal (M.P)*
[3]*Associate Professor - Bhopal Institute of Technology and Science -Pharmacy (BITS), Bhopal (M.P)*
**Corresponding author*

Date of Submission: 04-01-2026 Date of Acceptance: 16-01-2026

ABSTRACT

This study aimed to formulate, develop, and optimize a lipid-based vesicular system (niosomes) containing *Aquilegia fragrans* extract, with emphasis on its antibacterial potential. The plant extract was subjected to percentage yield analysis and phytochemical screening, confirming the presence of alkaloids, flavonoids, and phenolics. Niosomes were prepared by the thin-film hydration method using varying ratios of cholesterol and surfactants, followed by optimization based on key formulation parameters. The optimized formulation exhibited favorable physicochemical properties, including uniform dispersibility, an average particle size of 164.03 nm, a zeta potential of −27.7 mV, and high entrapment efficiency. SEM analysis revealed spherical vesicles with smooth surfaces. Antimicrobial efficacy was assessed against selected Gram-positive and Gram-negative bacterial strains. In vitro antibacterial evaluation using the well diffusion assay demonstrated superior activity of the niosomal extract compared to the plain extract, with inhibition zones of 14 mm against *Staphylococcus aureus* and 9 mm against *Escherichia coli*. Stability studies conducted over 30 days confirmed consistent particle size, morphology, and antibacterial activity under refrigerated conditions. Overall, the findings establish the niosomal system as a promising delivery vehicle for enhancing the stability and antimicrobial efficacy of plant-based bioactives.

Keywords: *Aquilegia fragrans*; niosomes; lipid-based vesicles; antibacterial activity; phytochemicals; stability

I. INTRODUCTION

The ideal drug delivery system delivers drug at rate dictated by the need of the body over the period of treatment and it channels the active entity solely to the site of action. Drug targeting can be defined as the ability to direct a therapeutic agent specifically to desired site of action with little or no interaction with non-target tissue **(Sengar, 2023).**Paul Ehrlich, in 1909, initiated the era of development for targeted delivery when he envisaged a drug delivery mechanism that would target directly to diseased cell. Since then, numbers of carriers were utilized to carry drug at the target organ/tissue, which include immunoglobulins, serum proteins, synthetic polymers, liposomes, microspheres, erythrocytes, niosomes etc.**(Keshav, 2015).**Advantage of niosomes is the development of a simple practical method for the routine and large-scale production without the use of pharmaceutically unacceptable solvents. In recent years, niosomes have been extensively studied for their potential to serve as carriers for delivery of drugs, antigens, hormones and other bioactive agents**(Pirojiya and Dudhat 2025).**

Niosomes or non-ionic surfactant vesicles are microscopic lamellar structures formed on admixture of non-ionic surfactant of the alkyl or dialkylpolyglycerol ether class and cholesterol with subsequent hydration in aqueous media **(More, 2018).** Niosomes are promising vehicle for drug delivery and being non-ionic, it is less toxic and improves the therapeutic index of drug by restricting its action to target cells. The focus of this review is to bring out the various methods of preparation, characterizations, factors affecting, advantages and applications of niosomes. In niosomes, the vesicles forming amphiphile is a non-ionic surfactant such as Span – 60 which is usually stabilized by addition of cholesterol and small amount of anionic surfactant such as dicetyl phosphate **(Patel *et al.*, 2022).**

The applications of niosomes are wide-ranging, from drug delivery and gene therapy to the release of cosmetic agents and antioxidants. Their ability to encapsulate sensitive compounds, protect them from premature degradation, and efficiently deliver them to the target site makes them essential tools for personalized medicine and the development of advanced therapies **(Mitchell *et al.*, 2021).**However, niosome design must be adjusted

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 1, Jan - Feb 2026, pp:130-138 www.ijprajournal.com ISSN: 2456-4494

according to the characteristics of the molecule to be transported and the specific needs of the application. Niosomes represent an innovative solution to overcome bioavailability limitations and bioactive molecule stability. Their structural and functional versatility, combined with an optimized design, positions them as one of the most promising strategies in the development of controlled release systems, with applications in scientific and technological fields **(Pakulska*et al.*, 2016).**

Medicinal plants have long served as a valuable source of therapeutic agents due to their diverse phytochemical constituents and broad pharmacological potential. Among these, *Aquilegia fragrans*, a member of the Ranunculaceae family, has attracted attention for its traditional applications in managing various ailments. The plant is known to contain a range of bioactive compounds, including flavonoids, alkaloids, and phenolic derivatives, which are associated with antimicrobial, antioxidant, and anti-inflammatory activities **(Nardi, 2015).**Formulating plant extracts into stable dosage forms enhances their bioavailability, stability, and therapeutic potential. In this context, characterization of *Aquilegia fragrans* extract plays a crucial role in understanding its physicochemical properties and biological activity. Evaluating its antimicrobial effect against pathogenic microorganisms further highlights its potential application in developing safe and effective plant-based antimicrobial formulations**(McClements *et al.*, 2021).**

The present study aims to formulate and characterize niosomal vesicles containing *Aquilegia fragrans* extract and to evaluate their antimicrobial activity against pathogenic microorganisms.

II. MATERIAL AND METHODS

2.1 Chemicals

GlacialAceticAcid, Nitroprusside, SodiumHydroxide,and Ammonia were obtained from Merck, a reputable supplier of analytical reagents. Rankem provided the 1%Copper Sulphate Solution, and Clorofiltind provided the Chloroform, Conc. HCl and 95%Alcohol. Himedia provided the Magnesium.Molychem provided theEthanol. Conc. H_2SO_4 were obtained from Fizmerck and Researchlab provided the Petroleumether.

2.2 CollectionofPlant Material

*Aquilegia fragrans*plantleaves were harvested, and they were dried for three days in the shadeat roomtemperature. Dried plant components were kept in sealed glass containers in a dry, cool atmosphere to avoid contamination and deterioration. A plant taxonomist confirmed the identity and purity of the medicinal herb *Aquilegia fragrans.*

2.3 Process of Plant Material Extraction

The extraction of *Aquilegia fragrans*plant leaves using a continuous hot percolation method by Soxhlet apparatus with ethanol and petroleum ether was carried out following a standardized protocol. The plant leaves were first dried in the shade and grind into a fine powder. A weighed amount (300g) of the powdered material was placed inside a porous thimble and loaded into the Soxhlet extractor. Petroleum ether was used first at 60°C for non-polar compound extraction, followed by ethanol for polar compounds. The round-bottom flask was filled with 300–500 mL of the respective solvent and heated using a water bath. As the solvent evaporated, it condensed in the reflux condenser and repeatedly percolated through the plant material, dissolving the bioactivecompounds.

Theextractionprocesswascontinued for 6–8hoursuntilthe solvent inthe siphon tube became colorless. After extraction, the solvent was removed using a rotary evaporator, and the concentrated extract was further dried under at 40°C in a rotary vacuum evaporator (Buchi type). The dried extract was weighed, and extract's % yield was calculated using the following formula:

$$\%\ \text{Yield} = \frac{\text{Weight of extract}}{\text{Weight of Plant Material used}} \times 100$$

Thepreparеddriedextractwasthenstoredatlowtemperaturesforfurtherphytochemicalanalysis and organoleptic characters (percentage yield, colour and odour) **(Khandelwal, 2008).**

2.4 Preliminaryphytochemicalinvestigations

Preliminary phytochemical investigations is the systematic study of the chemical substances found in plants called phytochemicals, which are responsible for their medicinal, nutritious, or poisonous qualities. These investigations were carried out to check and identify the effective constituents such as alkaloids, flavonoids, tannins, saponins, and phenolics of leaves extract *Aquilegia fragrans*. Investigated for as per the standard procedure reported practical pharmacognosy books **(Kokate*et al.*, 2001).**

2.5 TheOrganolepticStudiesof *Aquilegiafragrans*

Visual observation was used to assess organoleptic qualities. Organoleptic studies of *Aquilegia fragrans*, such as general appearance, color, odor, and condition, were conducted and observed**(Semuli, 2014).**

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 1, Jan - Feb 2026, pp:130-138 www.ijprajournal.com ISSN: 2456-4494

2.6 Solubilitystudyof*Aquilegiafragrans*

The qualitative solubilityof*Aquilegiafragrans* invarious solvents was investigated using Indian pharmacopoeia. *Aquilegia fragrans* was weighed and placed into a 10 mltest tube, where it was dissolved in the appropriate solvents (1 ml each of ethanol, DCM, distilled water, chloroform, and acetone) **(Jan *etal.*, 2021).**

2.7 PreparationofLipidBasedVesicleSystem(Niosomes)

The film hydration method was developed among various methods for the formulation of niosomes. The following cholesterol and surfactant ratios were chosen: (100 to 500 mg) In chloroform containing 500 mg of extract, selected ratios of cholesterol and surfactants such as Span60 were dissolved individually. Arotaryflashevaporatorwas usedto evaporatethe solvent at a reduced pressure and a maintained temperature between 50°C until a fragile lipid film was formed. At 50°C, the flask was continued rotating at 50°C for 1 hour, while the adhered film insidetheroundbottomflaskwasrehydratedwith30mlofPhosphatebuffersaline(PBS)pH 7.4 for 1 hour. After collecting the hydrated noisome, it was placed into a beaker and sonicated using bath sonicator for 20 mins to get niosomal dispersion. The sonicated dispersion was kept asidewithout disturbingthesystemat roomtemperature(RT)forswellingofvesicles,andtheni t was stored for 12 hours at 2-5°C **(Hegdekar*et al.*, 2023, Rajak*et al.*, 2022).**

Table1: CompositionofNiosomesformulation

Formulations	Cholesterol (mg)	Span 60 (mg)	Chloroform (ml)	Extract (mg)	Phosphate buffer pH 7.4	Temperature (°C)
NSV1	500	100	20ml	300	30	50°C
NSV2	400	200	20ml	300	30	50°C
NSV3	300	300	20ml	300	30	50°C
NSV4	200	400	20ml	300	30	50°C
NSV5	100	500	20ml	300	30	50°C

2.8 CharacterizationofNiosomes:

2.8.1 Particlesize

OneofthemostcrucialparametersforcharacterizingaNiosomesisitssize.TheMalvernZetasizer (MalvernInstruments)wasusedtomeasuretheNiosomes'ssize (**Jain*etal.*,2011)**.

2.8.2 Zetapotential

TofindtheparticlechargeandthevelocityatwhichtheparticlesmovedinanelectricfIeld,thezeta potentialwas measured. ZetasizerMalverninstruments were usedto evaluate the Niosomes (**Balla*etal.*,2020)**.

2.8.3 ScanningElectronMicroscopic(SEM)

TheoptimizedNiosomes'smorphologicalcharacteristicswereobtainedbyemployingtheelectronbeam fromascanningelectronmicroscope.Asputtercoaterinvacuumwasthenusedtocoattheniosomeswithathincoating(2–20nm)ofmetal,suchasplatinum,palladium,orgold.Afterthat ,thepretreatment specimenwasstruck byanelectronbeam, producingsecondaryelectronscalledaugers.

Rutherfordand Kramer's Law was used to select and process just the electrons scattered at a 90° angle from this interactionbetweenthe electronbeamandthe specimen'satomsinorderto produce surfacetopography photographs(**Ahmed *et al.*, 2020)**.

2.9 Anti-microbialactivityofNiosomesbyWelldiffusionassay

- **PreparationofNutrientAgarMedia**

In100millilitersofpurifiedwater,2.8gramsofNutrientMediaweredissolved.Themedia'spHwas measuredpriortosterilization.Themediawasautoclaved for15minutesat121˚Cand15poundsof pressuretosterilizeit.Afternutrientmediapouredintoplates,theplateswereputinalaminarairflow untiltheagarsolidified.

- **WellDiffusionAssay**

Standardizedto108CFU/mlofbacteria,*E.coli*and*S.aureus*bacterialsuspensionwereplacedinthe shaker.Afterthat,100µlofthebroth'sinoculums(108CFU/ml)wereextractedusingamicropipetteand inoculated onto a fresh, sterile, solidifiedAgar Media Plate. Theentiresterileagar surface wascovered withtheinoculumsusingasterilespreaderto inoculatetheagarplate.Using asterilecork-borer,four6-mmwellswerebordeinto the solidifiedAgarMedia Plate.The niosomes andextract(1and1.5mg/ml) solution was then prepared for inoculation into the wells. A sample of 100 µl was loaded (**Mohammadi-Sichani*et al.*, 2012)**.

- **Incubationperiodforobservezoneofinhibitionon agarplates**

Beforebeingincubatedfor18to24hoursat37°C,theinoculatedAgarMediaPlatewaslettodiffusefor roughly30minutesatroomtemperature.Afterincubation

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 1, Jan - Feb 2026, pp:130-138 www.ijprajournal.com ISSN: 2456-4494

,plateswerecheckedtoseeifaclearzone formedaroundthewell,indicatingthatthetestedformulation hadantibacterialactivity.Millimetersof thezoneofinhibition(ZOI)weremeasuredandanalyzed.Using arulerheldonthebackoftheinverted Petriplate,zonesweremeasuredtothenearestmillimeter .Adark,non-reflectivebackgroundwas placedafew inches abovethePetriplate.Thediametersofthewellandthezoneoftotalinhibition(as perceivedbythenakedeye)weremeasured(**Manandhar *etal.*,2019).**

2.10 Stabilitystudy

ThestabilityoftheNiosomesformulationwasexaminedforthreemonthsatacceleratedtemperaturesof $25^0C\pm2^0C$and60±5%RHand$40^0C\pm2^0C$and70±5%RH. Physicalattributesoftheformulation, including color, order, appearance, and particle size, were evaluated at 30, 45, 60, and90days (3 months) (**Khan *et al.*, 2020**).

III. RESULTS

3.1 Plant collection

Table2:Plant collection

Plantname	Plantpart used	Weight
Aquilegiafragrans	Leaves	300gm

3.2 PercentageYield

The percentage yield is particularly important in phytochemical extraction since it helps identify the standard extraction efficiency for a particular plant, different parts of the same plant, or different solvents

Table3:PercentageYieldofcrudeextractsof*Aquilegiafragrans*extract

Plantname	Solvent	Colorof extract	Theoretical weight	Yield(gm)	%yield
Aquilegia fragrans	Petether	Greenish	300	4.51	0.79%
	Ethanol	Green	278	5.43	2.63%

3.3 Preliminary Phytochemical study

Table 4: Phytochemicaltestingofextract

S.No.	Experiment	Presenceorabsenceofphytochemicaltest	
		Pet.Etherextract	Ethanolicextract
1.	**Alkaloids**		
1.1	Dragendroff'stest	Absent	Present
1.2	Mayer'sreagent test	Absent	Present
1.3	Wagner'sreagenttest	Absent	Present
1.3	Hager'sreagenttest	Absent	Present
2.	**Glycoside**		
2.1	Borntragertest	Present	Present
2.2	Killer-Killianitest	Present	Present
Carbohydrates			
3.1	Molish'stest	Present	Present
3.2	Fehling'stest	Present	Present
3.3	Benedict'stest	Present	Present
3.4	Barfoed'stest	Absent	Present
3.5	IodineTest	Absent	Present
Flavonoids			
4.1	ShinodaTest	Absent	Present
TanninandPhenolicCompounds			
5.1	FerricChloridetest	Present	Present
5.2	LeadAcetateTest	Absent	Present
5.3	GelatinTest	Absent	Present
Saponin			
6.1	Foamtest	Present	Present
6.2	FrothTest	Present	Present
TestforTriterpenoidsandSteroids			
7.1	Salkowski'stest	Present	Absent

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 1, Jan - Feb 2026, pp:130-138 www.ijprajournal.com ISSN: 2456-4494

7.2	Libbermann-Burchard'stest	Present	Absent

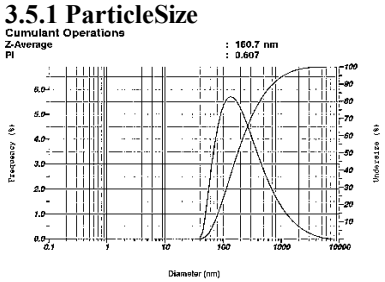
3.4 Organolepticproperties

Table5: TheOrganolepticStudiesof *Aquilegiafragrans*leaves extract

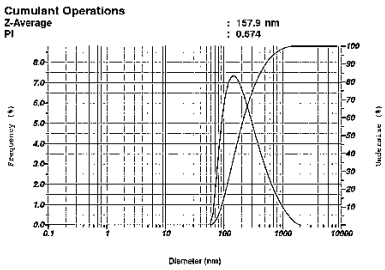
Aquilegiafragrans	**Study**
Colour	Greenish
Odour	Musky
Appearance	Greenish brown

3.5 Evaluationparameterofnonionicsurfactantvesicle formulation

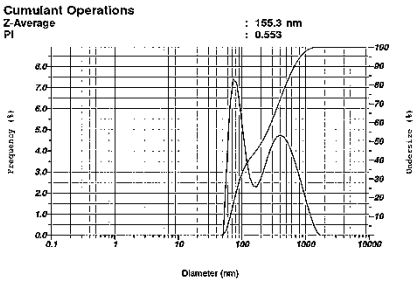
3.5.1 ParticleSize



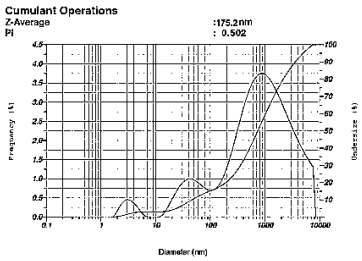
Graph 1:Particlesize(NSV 1)



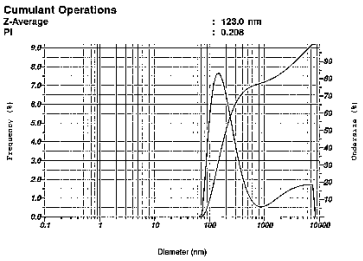
Graph 2:Particlesize(NSV 2)



Graph 3:Particle size(NSV 3)



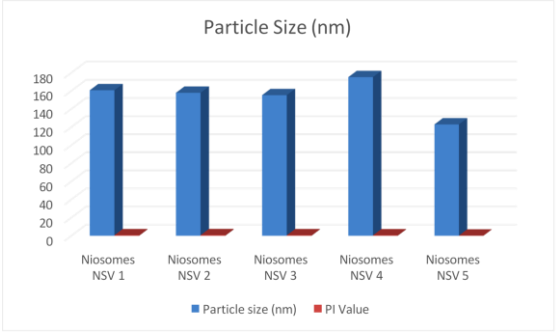
Graph 4:Particlesize(NSV 4)



Graph 5:Particlesize(NSV 5)

Table6:Particlesize

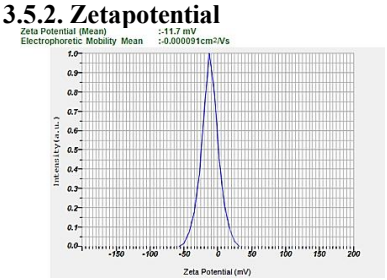
Formulationcode	**Particlesize(nm)**	**PIValue**
NiosomesNSV1	160.7nm	0.607
NiosomesNSV2	157.9nm	0.674
NiosomesNSV3	155.3nm	0.553
NiosomesNSV4	175.2nm	0.502
NiosomesNSV 5	**123.0nm**	**0.208**



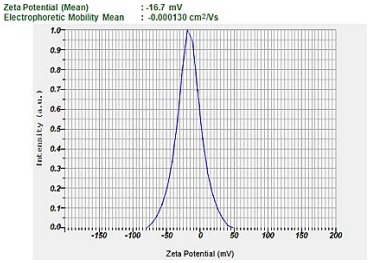
Graph 6:Graphicalparticlesize

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 1, Jan - Feb 2026, pp:130-138 www.ijprajournal.com ISSN: 2456-4494

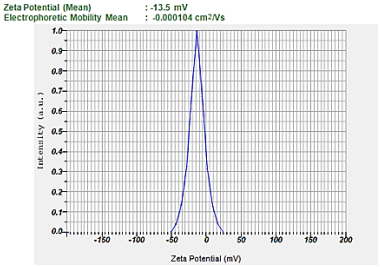
3.5.2. Zetapotential



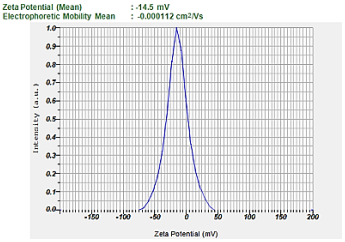
Graph 7:Zeta potential(NSV1)



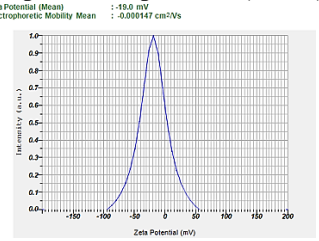
Graph 8:Zeta potential(NSV2)



Graph 9:Zetapotential(NSV3)



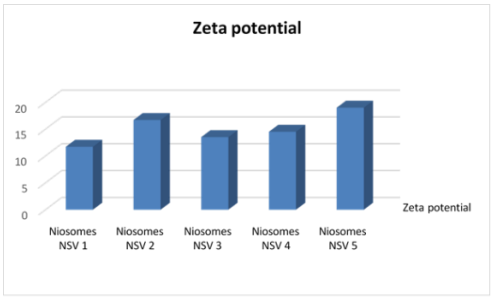
Graph 10:Zeta potential(NSV4)



Graph 11:Zeta potential(NSV5)

Table7:Zeta potential

FormulationCode	Zeta potential
NiosomesNSV1	-11.7mV
NiosomesNSV2	-16.7mV
NiosomesNSV3	**-13.5mV**
NiosomesNSV4	-14.5mV
Niosomes**NSV5**	-19.0mV



Graph 12: Graphicalrepresentation ofZetapotentialofallformulation

3.5.2.1 ScanningElectronMicroscopic(SEM)

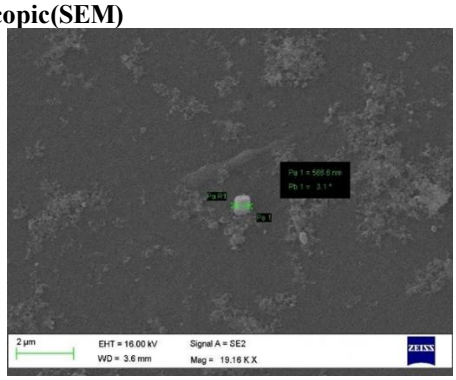


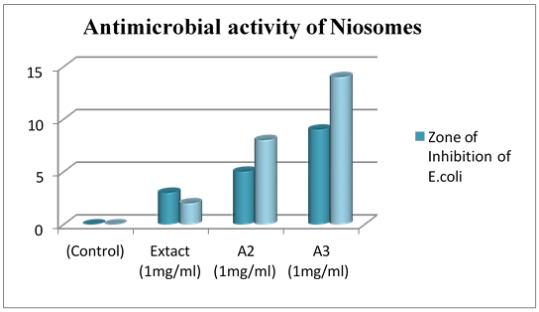
Figure2:SEM (F5)

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 1, Jan - Feb 2026, pp:130-138 www.ijprajournal.com ISSN: 2456-4494

3.6 Resultsofantimicrobialactivity ofNiosomesF5formulation

Table8: Antimicrobialactivity ofNiosomes*againstE.coliandS.aureus*

SampleName(mg/ml)	ZoneofInhibition(mm) of*E.coli*	ZoneofInhibition(mm) of*S.aureus*
D(Control)	0mm	0mm
CExtract(1mg/ml)	6mm	5mm
B (1mg/ml)	8mm	7mm
A(1.5mg/ml)	12mm	11mm



Graph 13:GraphicalrepresentationofAntimicrobialactivityofNiosomes*againstE.coli and S. aureus*

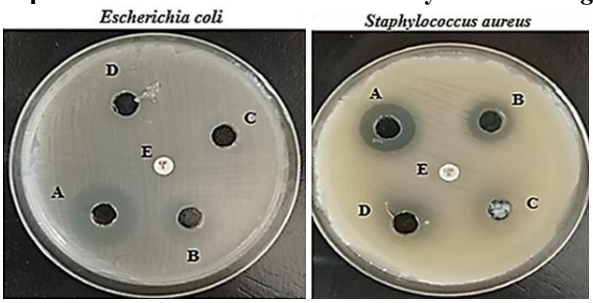


Figure3: Antimicrobialactivity against*E.coli*

3.7 Stabilitystudy

Table9:Stability StudyofNiosomes(F5)formulation

Time (Days)	25^{0}C±2^{0}Cand60±5%RH				40^{0}C±2^{0}C and70±5%RH			
	Colour	Odour	Appeanance	Particle sizenm	Colour	Odour	Appearance	Particlesizenm
0	Yellowish milky	Musky	Liquid	164.03nm	Greenish	Musky	Liquid	164.03nm
30	Yellowish milky	Musky	Liquid	164.11nm	Greenish	Musky	Liquid	164.17nm
45	Yellowish milky	Musky	Liquid	164.10nm	Greenish	Musky	Liquid	164.23nm
60	Yellowish milky	Musky	Liquid	164.28nm	Greenish	Musky	Liquid	164.55nm
90	Yellowish milky	Musky	Liquid	165.01nm	Greenish	Musky	Liquid	164.53nm

IV. CONCLUSION

In conclusion, the niosomal formulation of *Aquilegia fragrans* extract was successfully developedandoptimized based onkeyformulationandevaluationparameters. Thedigitalresults supported that the formulation achieved high percentage yield, confirmed phytochemical presence, and exhibited desirable physical properties, including optimal particle size, stable zeta potential, and consistent morphology. The antibacterial study highlighted a significant improvement inantimicrobialactivitywhenthe extract was encapsulated inniosomes, validating the potential of the vesicle system in enhancing the

bioactivity of herbal extracts. Furthermore, the stability study confirmed the robustness of the formulation over time, establishing the niosomal system as an effective and stable delivery vehicle for plant-based antibacterial agents.

REFERENCES

[1]. Sengar, A. (2023). Targeting methods: A short review including rationale, goal, causes, strategies for targeting. *Journal homepage: www. ijrpr. com ISSN*, *2582*, 7421.

[2]. Keshav, J. (2015). Niosomes as apotential carrier system: a review. *International Journal of Pharmaceutical, Chemical & Biological Sciences*, *5*(4).

[3]. Pirojiya, H., &Dudhat, K. (2025). Niosomes: a revolution in sustainable and targeted drug delivery-green synthesis, precision medicine, and beyond. *Regenerative Engineering and Translational Medicine*, *11*(2), 379-415.

[4]. More, V. V. (2018). Niosomal drug delivery-a comprehensive review. *Asian Journal of Pharmaceutics (AJP)*, *12*(04).

[5]. Patel, P., Parashar, A. K., Kaurav, M., Yadav, K., Singh, D., Gupta, G. D., &Kurmi, B. D. (2022). Niosome: a vesicular drug delivery tool. In *Nanoparticles and Nanocarriers Based Pharmaceutical Preparations* (pp. 333-364). Bentham Science Publishers.

[6]. Mitchell, M. J., Billingsley, M. M., Haley, R. M., Wechsler, M. E., Peppas, N. A., & Langer, R. (2021). Engineering precision nanoparticles for drug delivery. *Nature reviews drug discovery*, *20*(2), 101-124.

[7]. Pakulska, M. M., Miersch, S., & Shoichet, M. S. (2016). Designer protein delivery: From natural to engineered affinity-controlled release systems. *Science*, *351*(6279), aac4750.

[8]. Nardi, E. (2015). Il genere Aquilegia L.(Ranunculaceae) in Italia= The genus Aquilegia L.(Ranunculaceae) in Italy: aquilegiarumitalicarum in europaearumconspectudescriptio.

[9]. McClements, D. J., Das, A. K., Dhar, P., Nanda, P. K., & Chatterjee, N. (2021). Nanoemulsion-based technologies for delivering natural plant-based antimicrobials in foods. *Frontiers in Sustainable Food Systems*, *5*, 643208.

[10]. Khandelwal,K. (2008). Practicalpharmacognosy.PragatiBooksPvt.Ltd ..

[11]. Kokate, C. K., Purohit, A. P. G. S., & Gokhale, S. B. (2001). Pharmacognosy by CK kokateNiraliPrakashan.

[12]. Semuli, M. (2014). Nutritional composition, descriptive sensory analysis and consumer acceptability of products developed from Agave americana flowers.

[13]. Jan, H., Usman, H., Shah, M., Zaman, G., Mushtaq, S., Drouet, S., ... & Abbasi, B. H. (2021). Phytochemical analysis and versatile in vitro evaluation of antimicrobial, cytotoxic and enzyme inhibition potential of different extracts of traditionally used Aquilegia pubiflora Wall. Ex Royle. *BMC Complementary Medicine and Therapies*, *21*(1), 165.

[14]. Hegdekar, N. Y., Priya, S., Shetty, S. S., & Jyothi, D. (2023). Formulation and evaluation of niosomal gel loaded with asparagus racemosus extract for anti-inflammatory activity. Ind J Pharm Edu Res, 57, 63-74.

[15]. Jain, N., Bhargava, A., Majumdar, S., Tarafdar, J. C., & Panwar, J. (2011). Extracellular biosynthesis and characterization of Niosomess using Aspergillusflavus NJP08: a mechanism perspective. Nanoscale, 3(2), 635-641.

[16]. Balla, A., &Goli, D. (2020). Formulation & Evaluation of PLGA Niosomes of RopiniroleHCl for Targeting Brain. *Indian Journal of Pharmaceutical Sciences*, *82*(4).

[17]. Ahmed, M. M., Fatima, F., Kalam, M. A., Alshamsan, A., Soliman, G. A., Shaikh, A. A., &Anwer, M. K. (2020). Development of spray-dried amorphous solid dispersions of tadalafil using glycyrrhizin for enhanced dissolution and aphrodisiac activity in male rats. *Saudi Pharmaceutical Journal*, *28*(12), 1817-1826.

[18]. Mohammadi-Sichani, M., Karbasizadeh, V., Aghai, F., &Mofid, M. R. (2012). Effect of different extractsofStevia rebaudiana leaves

on Streptococcus mutans growth. *J Med Plants Res*, *6*(32), 4731-4734.

[19]. Manandhar, S., Luitel, S., &Dahal, R. K. (2019). In vitro antimicrobial activity of some medicinal plants against human pathogenic bacteria. *Journal of tropical medicine*,*2019*(1), 1895340.

[20]. Khan, F., Iqbal, S., Khalid, N., Hussain, I., Hussain, Z., Szmigielski, R., & Janjua, H. A. (2020). Screening and stability testing of commercially applicable Heliotropiumcrispum Niosomes formulation with control over aging and biostability. *Applied Nanoscience*, *10*, 1941-1956.