IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

Formulation and Evaluation of Herbal Gel Using Betel Leaf (Piper betle L.) Extract

Renuka Dadasaheb Halnor[1] and Jayshri Subhash Kasar[2]
Student, Mrs. Saraswati Wani College of Pharmacy, Ganegaon[1]
Guide, Mrs. Saraswati Wani College of Pharmacy, Ganegaon[2]

Abstract: *Betel leaf (Piper betle L., family Piperaceae) has been chewed, applied and prescribed in India and South-East Asia for many centuries. Its leaves carry a volatile oil rich in phenolic compounds, mainly hydroxychavicol, chavibetol and eugenol, along with tannins, flavonoids and alkaloids, and these constituents are linked to antibacterial, antifungal, antioxidant, anti-inflammatory and wound healing properties. Topical use of the crude leaf is messy and its dose is not controlled, so converting the extract into a proper dosage form is a practical need. A gel is a good choice because it spreads easily, feels cool, washes off with water, is non-greasy and can carry a plant extract without difficulty. This review collects the available information on the botanical profile and chemistry of betel leaf, the extraction techniques used, the gelling agents and excipients selected for herbal gels, the method of preparation, and the evaluation parameters used to judge quality, safety and activity. Published formulation studies are summarised and the gaps that still need attention, such as standardisation of the extract, long term stability and clinical confirmation, are discussed.*

Keywords: Piper betle, betel leaf extract, herbal gel, Carbopol, hydroxychavicol, topical antimicrobial, evaluation

I. INTRODUCTION

Medicinal plants remain an important source of therapeutic agents, and interest in them has grown again because patients and manufacturers are looking for products with fewer side effects than many synthetic molecules. In skin care and topical therapy this interest is strong. Rising resistance among common skin pathogens, irritation caused by alcohol based antiseptics and the high cost of some modern drugs have all pushed researchers towards plant derived options.

Betel leaf, known as paan or nagvel in Marathi, is among the most familiar leaves of Indian culture. Apart from its social and ceremonial role, it appears in Ayurvedic texts under the name tambula and is described as useful for wounds, oral problems, digestion and cough [1]. Modern laboratory work has supported several of these claims, and extracts of the leaf show a wide range of biological activities [2].

A topical formulation of the extract has clear advantages over direct application of crushed leaf. The dose can be fixed, the product can be preserved, the appearance is acceptable and the patient can use it easily. Among semisolid forms, gels are popular because they are transparent or translucent, free from grease, easy to wash and pleasant on the skin. A gel can be described as a semisolid system in which a liquid phase is held within a three dimensional network built by a gelling agent [9]. When water is the liquid phase the system is called a hydrogel, which is the type most often used for herbal extracts.

The present review brings together the literature on formulation and evaluation of gels containing betel leaf extract so that a student or researcher can see, in one place, how such a product is planned, made and tested.

Copyright to IJARSCT
www.ijarsct.co.in
DOI: 10.48175/IJARSCT-40721

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

II. PLANT PROFILE OF BETEL LEAF

2.1 Taxonomy and nomenclature

Parameter	Details
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Piperales
Family	Piperaceae
Genus and species	Piper betle L.
Marathi / Hindi	Nagvel, Paan
Sanskrit	Tambula, Nagavalli
Tamil	Vettrilai
English	Betel vine, betel pepper
Part used	Fresh or dried leaf

Table 1. Taxonomical classification and common names of Piper betle

2.2 Description and distribution

Piper betle is a perennial, evergreen, creeping climber with glossy, heart shaped leaves that have a pointed tip and a smooth margin. The plant is dioecious and is propagated by stem cuttings. It grows well in warm and humid regions with shade and is cultivated in India, Sri Lanka, Bangladesh, Malaysia, Indonesia, Thailand and other tropical countries. Several cultivars are grown in India, and they differ in leaf size, pungency and aroma. Names such as Bangla, Mysore, Sanchi, Kapoori and Meetha are commonly used for them [1]. Because the chemical profile changes with cultivar, season, age of leaf and place of growth, authentication and standard collection practice are important before any extract is prepared.

III. PHYTOCHEMISTRY

The leaf contains water, proteins, carbohydrates, minerals, fibre and a wide range of secondary metabolites. The volatile oil, present in a fairly small percentage of the fresh leaf, is mostly responsible for the characteristic smell and for much of the antimicrobial strength. Its main constituents are phenolic compounds such as hydroxychavicol, chavibetol (betel phenol), chavicol, eugenol and allylpyrocatechol, together with terpenes such as caryophyllene, cadinene and carvacrol in smaller amounts [2]. Hydroxychavicol is regarded by many authors as the most important bioactive phenol of the leaf. Apart from the oil, tannins, flavonoids, alkaloids, saponins and sterols have been reported in leaf extracts.

Class	Representative constituents	Reported relevance
Phenolic compounds	Hydroxychavicol, chavibetol, chavicol, eugenol	Antibacterial, antifungal, antioxidant
Terpenes	Caryophyllene, cadinene, carvacrol	Contribute to aroma and antimicrobial effect

Copyright to IJARSCT
www.ijarsct.co.in
DOI: 10.48175/IJARSCT-40721

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 2, November 2026 Impact Factor: 8.2

Class	Representative constituents	Reported relevance
Flavonoids and tannins	Polyphenols, catechin type compounds	Antioxidant, astringent, helpful in wound care
Alkaloids	Piperine type alkaloids in small amounts	Biological activity under study
Others	Sterols, saponins, sugars, minerals	Supporting role

Table 2. Major phytoconstituents of betel leaf

IV. PHARMACOLOGICAL ACTIVITIES RELEVANT TO TOPICAL USE

Antibacterial activity: Extracts have shown inhibition of Gram positive and Gram negative organisms including Staphylococcus aureus, Bacillus subtilis, Escherichia coli and Pseudomonas aeruginosa. The phenolic compounds are thought to damage the cell membrane and disturb enzyme function of the bacterial cell [3].

Antifungal activity: Activity against Candida species and some dermatophytes has been described, which supports use in superficial fungal conditions.

Antioxidant activity: Polyphenols scavenge free radicals, which may protect skin from oxidative stress and support healing.

Anti-inflammatory and wound healing activity: Betel leaf is traditionally applied on wounds and swellings, and laboratory studies report reduced inflammatory response and faster wound closure.

Other activities: Antidiabetic, gastroprotective, anti-halitosis and antiplatelet effects have also been reported, though these are less relevant to a skin gel.

V. WHY A GEL FOR BETEL LEAF EXTRACT

Betel leaf extract is aqueous or hydroalcoholic and contains many polar phenolics, which suit a water based gel. Compared with creams and ointments, gels leave no oily film, are easily removed and do not stain heavily, although betel extract does give a green to brown colour to the product. The cooling effect during application is another advantage in inflamed or itchy skin. A gel also allows the extract to be released fairly well, because the polymer network is mostly water and does not strongly hold back small molecules. These reasons explain why researchers have repeatedly selected a gel for betel leaf, whether for acne, wounds, hand antisepsis or oral use [4,5].

VI. COLLECTION, AUTHENTICATION AND EXTRACTION

6.1 Collection and processing

Healthy mature leaves are collected, authenticated by a botanist or pharmacognosist, washed with clean water and either used fresh or shade dried and powdered to a suitable mesh size. Shade drying avoids loss of heat sensitive volatile constituents. A herbarium specimen and a voucher number should be recorded because journals now ask for plant identity proof.

6.2 Methods of extraction

Method	Principle and solvent	Remark
Maceration	Powder soaked in solvent (water, ethanol, methanol) for some days with occasional shaking	Simple, suitable for heat sensitive compounds, slow
Soxhlet extraction	Continuous hot extraction with repeated solvent cycles	Higher yield, heat may degrade some phenolics

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

Method	Principle and solvent	Remark
Percolation	Solvent allowed to pass slowly through packed drug	Fairly complete extraction, needs more solvent
Ultrasound assisted	Cavitation breaks cell wall and speeds transfer	Shorter time, lower temperature
Microwave assisted	Rapid heating of solvent and plant moisture	Fast, needs optimisation
Hydrodistillation	Steam carries volatile oil, collected separately	Used when essential oil is the target

Table 3. Common extraction techniques used for betel leaf

The solvent decides what is pulled into the extract. Ethanol and hydroalcoholic mixtures usually give a good balance of phenolics and flavonoids and are also acceptable from a safety point of view. After extraction, the liquid is filtered and concentrated under reduced pressure or on a water bath at controlled temperature, and the percentage yield is calculated. The extract is then checked for its physical nature, loss on drying and preliminary phytochemical tests for alkaloids, flavonoids, tannins, phenols, saponins and carbohydrates, following standard pharmacognostic procedures [8]. For serious quality control, thin layer chromatography or HPLC fingerprinting, with hydroxychavicol as a marker, is recommended.

VII. FORMULATION OF HERBAL GEL

7.1 Gelling agents

The choice of gelling agent controls viscosity, clarity, spreadability, drug release and stability. The commonly used polymers are listed below.

Gelling agent	Nature and usual use level	Points to note
Carbopol 934 / 940	Cross-linked polyacrylic acid, about 0.5 to 2% w/v; needs neutralisation with triethanolamine	Clear gel, high viscosity, very popular; sensitive to electrolytes
HPMC	Non-ionic cellulose ether, about 2 to 5% w/v	Good clarity, stable over wide pH range
Sodium CMC	Anionic cellulose derivative, about 2 to 5% w/v	Economical, pH sensitive, may be incompatible with some metal ions
Sodium alginate	Natural polysaccharide, gels with calcium ions	Natural origin, useful for wounds
Xanthan gum	Microbial polysaccharide, about 0.5 to 2%	Pseudoplastic flow, good suspending power
Poloxamer 407	Thermoreversible polymer, about 15 to 20%	Gels at body temperature, useful for sustained release

Table 4. Gelling agents used in herbal gel formulation

Carbopol has been used in many of the betel leaf gels reported so far. Sari and Isadiartuti prepared hand antiseptic gels with 5 to 25% hot water extract of the leaf in a Carbopol base [4], and Huynh and co-workers developed a Carbopol 940 hydrogel carrying an optimised betel extract for acne [5]. Studies from Indonesia have also compared Carbopol,

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

sodium CMC and HPMC as bases for betel leaf hand sanitizer gels, which shows that the base needs to be selected case by case.

7.2 Excipients and a representative formulation

Besides the polymer, a herbal gel needs a humectant, a neutralising agent, a preservative and some control of pH. Glycerin or propylene glycol keep the gel from drying, triethanolamine is used to neutralise Carbopol to about pH 6 to 7, and a paraben is added because water rich gels support microbial growth; the extract alone should not be assumed to preserve the product. A formulation in which betel leaf extract is combined with other herbal and functional ingredients is outlined in Table 5, where seven ingredients are each given a defined role. Their concentrations are normally fixed through trial batches and optimisation.

Ingredient	Role	Remarks
Betel leaf extract	Antimicrobial, antifungal	Phenolics such as hydroxychavicol are the active principles
Citric acid	pH stabiliser	Keeps the gel in a skin compatible pH range
Turmeric	Antiseptic, preservative	Curcumin adds antiseptic and anti-inflammatory action and also colours the gel
Carbopol	Gelling agent	Cross-linked polyacrylic acid that forms a clear gel after neutralisation
Aloe vera extract	Smoothing, healing	Mucilage gives a soothing and moisturising feel and supports healing
Rose water	Flavouring agent	Masks the strong smell of betel and is mildly astringent
Propyl paraben	Preservative	Prevents microbial growth during storage

Table 5. Ingredients of a representative betel leaf herbal gel and their roles

7.3 Method of preparation

The usual procedure is as follows. The gelling polymer is dispersed in a portion of purified water, preferably by sprinkling it slowly on the surface and allowing it to hydrate for several hours, or overnight in the case of Carbopol, so that lumps are avoided. Preservatives are dissolved in the humectant or in warm water and added to the polymer dispersion. The betel leaf extract, previously dissolved or dispersed in a little solvent, is then incorporated with gentle stirring. The pH is adjusted with triethanolamine when Carbopol is used, the volume is made up with water, and the mass is mixed slowly to prevent air entrapment. The finished gel is filled in clean wide-mouthed containers or collapsible tubes and kept away from light. Extract concentration in reported work is usually varied over a range, for example 5 to 25% in the study cited above [4], so that the effect of dose can be compared, and a blank base is kept as a control.

VIII. EVALUATION OF HERBAL GEL

Evaluation confirms that the product is acceptable, safe, stable and active. The usual tests are given in Table 6.

Parameter	Method in brief	Usual expectation
Organoleptic properties	Visual check of colour, odour, clarity and texture	Uniform, pleasant, free from particles

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

Parameter	Method in brief	Usual expectation
pH	Digital pH meter, 1% gel in distilled water or direct	Near skin range, commonly 5 to 7
Homogeneity	Gel pressed between fingers or viewed against light	No lumps or grittiness
Viscosity	Brookfield viscometer with suitable spindle and speed	Adequate and reproducible
Spreadability	Parallel plate method, S = M x L / T	Spreads with little shear, short time
Extrudability	Weight needed to extrude gel from collapsible tube	Easy, uniform extrusion
Washability	Application on skin and washing with water	Easily washed off
Skin irritation test	Patch test on volunteers or animals as per ethical approval	No erythema or oedema
Antimicrobial activity	Agar well diffusion or cup plate method, zone of inhibition; MIC if required	Clear zones against test organisms
Drug content	Estimation of marker or total phenolics by UV or HPLC	Close to labelled amount
In vitro diffusion	Franz diffusion cell with membrane	Steady release of actives
Stability study	Storage at different temperature and humidity, heating cooling cycles, as per ICH guidelines [7]	No change in appearance, pH, viscosity or activity

Table 6. Evaluation parameters for herbal gel

8.1 Physicochemical evaluation

Colour, odour and clarity are noted first. Betel extract usually produces a greenish yellow to brown gel with the typical aroma of the leaf. The pH is measured because skin surface is slightly acidic, and a product that is far from this range can cause irritation. Viscosity is measured at several speeds, and many gels show shear thinning behaviour, which is a desirable feature because the gel becomes thinner when rubbed and thicker on standing. Spreadability is found by placing a known weight on a slide pressed over a fixed amount of gel and recording the time taken for the upper slide to travel a set distance; a smaller time indicates better spreadability. In the hand antiseptic and acne gels reported in the literature, the formulations were described as meeting the usual physical requirements for topical gels [4,5].

8.2 Biological evaluation

The antimicrobial effect of the final gel is checked against standard organisms such as Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa and Candida albicans. In the agar well method, wells are made in seeded plates, filled with gel, and the diameter of the zone of inhibition is measured after incubation and compared with a standard drug and with a base without extract. Sari and Isadiartuti applied a replica method on human skin and found that the 15% extract gel lowered normal skin flora by about half, while the 25% gel eliminated the microorganisms and was comparable with a triclosan based product [4]. Huynh and colleagues tested their hydrogel against bacteria isolated from acne patients in an ex vivo model [5]. Safety is assessed through a patch test or irritation study, which must follow institutional ethical approval.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

8.3 Stability studies

Stability is judged by keeping samples at room temperature, at elevated temperature and humidity such as 40 C with 75% relative humidity, and under heating and cooling cycles, then checking colour, pH, viscosity, spreadability and activity at fixed intervals. The ICH guideline on stability testing gives the framework for such work [7]. Phenolic compounds can oxidise on storage and cause darkening, so antioxidants, light resistant packing and proper preservative systems are worth considering.

IX. SUMMARY OF REPORTED STUDIES

Reference	Formulation	Main finding
Sari and Isadiartuti, 2006 [4]	Hot water extract of leaf, 5 to 25%, in Carbopol gel, tested as hand antiseptic	15% gel cut skin flora by about 50%; 25% gel removed all organisms and matched triclosan product
Huynh et al., 2022 [5]	Optimised leaf extract in hydrogel of Carbopol 940, propylene glycol and cocamidopropyl betaine	Antibacterial activity shown ex vivo on acne isolates
Bhinge et al., 2025 [6]	Polyherbal gel containing neem, adulsa, betel, tulsi and karanj extracts	Gel formulated and evaluated for physical and biological parameters

Table 7. Selected studies on betel leaf containing gels

Many other formulations, such as combinations of betel with giloy, gambier, lime juice or binahong, have been reported in regional journals, mostly with satisfactory physical properties and antibacterial effect. Comparison between them is difficult because the extraction solvent, extract concentration, base and test method differ from study to study.

X. CHALLENGES AND FUTURE SCOPE

Standardisation: variation in leaf variety and growth conditions changes the extract, so marker based standardisation, preferably of hydroxychavicol, is needed.

Colour and odour: the strong smell and colour may reduce patient acceptance, and masking without losing activity is a challenge.

Stability: oxidation of phenolics and microbial growth in the water rich base need long term study.

Delivery: nanoemulgel, niosomal and nanoparticle based gels could improve skin penetration and should be explored.

Clinical evidence: most work is in vitro or ex vivo, and well designed clinical trials on wounds, acne and fungal infections are required.

Safety: although betel leaf is used traditionally, dermal safety data on concentrated extracts should be generated.

XI. CONCLUSION

Betel leaf is a cheap, easily available plant with a good record of antimicrobial and healing activity, and its phenolic constituents make it a suitable candidate for topical products. Gels based on Carbopol, HPMC or sodium CMC can carry the extract in an elegant and patient friendly form, and the published work shows that such gels can be prepared with acceptable physical properties and useful antimicrobial action. For these products to move from laboratory to market, standardised extracts, longer stability data and clinical studies are still needed. The information gathered in this review may help researchers plan better formulations and evaluation protocols for betel leaf gels.

CONFLICT OF INTEREST

The author declares no conflict of interest.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, November 2026
Impact Factor: 8.2

REFERENCES

1. Guha P. Betel leaf: the neglected green gold of India. J Hum Ecol. 2006;19(2):87-93.
2. Madhumita M, Guha P, Nag A. Bio-actives of betel leaf (Piper betle L.): a comprehensive review on extraction, isolation, characterization, and biological activity. Phytother Res. 2020;34(10):2609-2627.
3. Chakraborty D, Shah B. Antimicrobial, antioxidative and antihemolytic activity of Piper betel leaf extracts. Int J Pharm Pharm Sci. 2011;3(3):192-199.
4. Sari R, Isadiartuti D. Antiseptic activity evaluation of piper leaves from Piper betle Linn extract in hand gel antiseptic preparation. Indones J Pharm. 2006;17(4).
5. Huynh DTM, Le MNT, Tran VD, Pham DT. Antibacterial hydrogel containing Piper betle L. extract for acne treatment, an ex vivo investigation. Pharm Sci Asia. 2022;49(4):381-389. doi:10.29090/psa.2022.04.22.061
6. Bhinge SD, Bhutkar MA, Randive D, et al. Formulation and evaluation of polyherbal gel containing extracts of Azadirachta indica, Adhatoda vasica, Piper betle, Ocimum tenuiflorum and Pongamia pinnata. J Res Pharm. 2025;23(1):44-54.
7. ICH Harmonised Tripartite Guideline Q1A(R2): Stability testing of new drug substances and products. International Council for Harmonisation; 2003.
8. Kokate CK, Purohit AP, Gokhale SB. Pharmacognosy. Pune: Nirali Prakashan.
9. Lieberman HA, Rieger MM, Banker GS, editors. Pharmaceutical dosage forms: disperse systems. Vol 2. 2nd ed. New York: Marcel Dekker.