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Chemical Evaluation of Classical Pāka Kāla and Stability of Taila Kalpana with Special Reference to Nirgundi Taila: A Review

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Abstract: *Taila Kalpana is an important pharmaceutical dosage form of Ayurveda included under Sneha Kalpana. It involves processing of an oleaginous substance with Kalka and Drava Dravya under controlled heating until the desired stage of Sneha Siddhi is achieved. The duration and intensity of heating influence moisture removal, extraction, concentration, transformation and ultimately the quality and stability of the finished product. Nirgundi Taila is a classical medicated oil prepared using Nirgundi and an oleaginous medium and has an established place in Ayurvedic therapeutics. Modern analytical evaluation provides an opportunity to correlate classical Pāka Lakṣaṇa with measurable physicochemical and chromatographic characteristics. A published analytical study of Nirgundi Taila has reported parameters including refractive index, weight per millilitre, viscosity, saponification value, iodine value, acid value, unsaponifiable matter and TLC/HPTLC fingerprints. The present review examines the classical concept of Pāka Kāla, its pharmaceutical significance, possible chemical changes during Taila Pāka, physicochemical and chromatographic evaluation, stability considerations and the scope for establishing a scientific relationship between processing duration and stability of Nirgundi Taila. A proposed experimental model involving different Pāka durations, controlled temperature monitoring, physicochemical analysis, HPTLC fingerprinting and stability assessment is also presented..*

Keywords: Taila Kalpana, Sneha Kalpana, Pāka Kāla, Nirgundi Taila, Vitex negundo, stability, HPTLC, acid value, peroxide value, pharmaceutical standardization.

I. INTRODUCTION

Ayurveda has developed several pharmaceutical dosage forms for transforming crude medicinal substances into therapeutically useful preparations. Among these, Sneha Kalpana occupies an important position because medicated oils and ghee provide a lipid-based medium for processing medicinal substances and permit their administration through different therapeutic routes.[1,2] Taila Kalpana is therefore not merely a process of mixing medicinal drugs with oil; it is a controlled pharmaceutical process involving heating, extraction, moisture removal and transformation of the formulation.[1–4]

The quality of a medicated oil is influenced by several factors, including authentication and quality of raw materials, proportion of Sneha, Kalka and Drava Dravya, particle size, temperature, duration of heating, stirring, endpoint of processing, filtration and storage conditions.[2–5] Among these variables, the duration and thermal exposure during Sneha Pāka are particularly important because inadequate processing may result in incomplete moisture removal and extraction, whereas excessive heating may promote undesirable chemical changes.[4–6]

Classical Ayurvedic texts describe different stages of Sneha Pāka, principally Mṛdu, Madhyama and Khara Pāka. These stages are identified through characteristic pharmaceutical observations rather than merely through a fixed number of hours.[2,3] This indicates that the classical concept of Pāka Kāla is closely associated with the attainment of Sneha Siddhi rather than chronological duration alone.

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Nirgundi Taila is an appropriate formulation for studying this concept because its preparation and analytical characteristics have been previously documented. Padmakiran et al. reported an analytical study of Nirgundi Taila prepared from Nirgundi leaf and root with Tila Taila and evaluated its physicochemical parameters, TLC and HPTLC fingerprints.[7] The reported study provides a useful analytical baseline for further research. The original study also specifically notes that the formulation was prepared according to classical references and evaluated through standard analytical procedure

The recent emphasis on analytical standardization of Sneha Kalpana further supports the need to evaluate parameters capable of demonstrating identity, quality, purity, reproducibility and stability.[8] A 2026 review specifically examined analytical parameters used for standardization of Sneha Kalpana, highlighting the relevance of physicochemical and chromatographic approaches.[8]

II. CLASSICAL CONCEPT OF SNEHA KALPANA

Sneha Kalpana is a pharmaceutical procedure in which Sneha Dravya is processed with Kalka Dravya and Drava Dravya.[1–3] Sharṅgadhara Saṃhitā gives detailed descriptions regarding the preparation and processing of Sneha formulations.[3]

The principal components are:

Component	Classical term	Pharmaceutical role
Oleaginous medium	Sneha Dravya	Lipid vehicle and extraction medium
Herbal paste	Kalka Dravya	Concentrated medicinal material
Liquid medium	Drava Dravya	Aqueous/extractive medium
Heating	Pāka	Facilitates extraction and moisture removal
Endpoint	Sneha Siddhi	Indicates completion of processing

The interaction between these components under controlled heating is responsible for formation of the finished medicated oil. Modern reviews similarly describe Sneha Kalpana as a process capable of incorporating constituents from both liquid and paste forms into the lipid medium.[4,8]

III. CLASSICAL CONCEPT OF PĀKA KĀLA

Pāka Kāla can be understood as the duration and progression of the heating process required to achieve proper Sneha Siddhi.

Importantly, classical texts do not prescribe one universally applicable chronological duration for every Taila formulation. Instead, the completion of Pāka is determined through characteristic Siddhi Lakṣaṇa.[2,3]

Thus:

Pāka Kāla = thermal exposure required to achieve appropriate Pāka Siddhi

rather than:

Pāka Kāla = fixed number of hours

This distinction is particularly important for scientific research because two batches processed for the same chronological duration may experience different thermal exposure depending on vessel type, heat source, quantity, stirring and evaporation rate.

IV. CLASSICAL PĀKA LAKṢAṆA

Classical descriptions provide several practical observations for identifying Sneha Siddhi.

A classical reference describes the attainment of appropriate smell, colour and taste along with cessation of characteristic sound and changes in foam as indicators of Siddhi.[9]

शब्दस्योपरमे प्राप्ते फेनस्योपशमे तथा ।
गन्धवर्णरसादीनां संपत्तौ सिद्धिमादिशेत् ॥ सु. चि. 31/12

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These observations can be interpreted as a traditional in-process quality-control system. However, modern equivalents should be regarded as hypotheses requiring experimental validation rather than assuming a direct one-to-one relationship.

Table 1. Classical observations and possible analytical correlates

Classical observation	Possible modern correlate
Reduction of sound	Reduction in residual moisture
Change/disappearance of foam	Reduction in aqueous phase
Kalka attaining appropriate consistency	Degree of moisture removal
Characteristic odour	Extraction/thermal transformation
Desired colour	Extraction and chemical transformation
Desired taste	Transfer of soluble constituents
Proper Pāka	Reproducible physicochemical profile
Excessive Pāka	Possible thermal/oxidative degradation

V. STAGES OF SNEHA PĀKA

5.1 Mṛdu Pāka

Mṛdu Pāka represents an earlier stage of processing in which comparatively greater moisture remains and the Kalka retains a softer consistency. It is associated with selected therapeutic applications depending upon the formulation and route of administration.[2,3]

5.2 Madhyama Pāka

Madhyama Pāka represents a properly processed stage in which the required moisture reduction and pharmaceutical characteristics are achieved. It is commonly considered the desirable stage for many therapeutic applications.[2,3]

5.3 Khara Pāka

Further heating results in a relatively dry and harder Kalka, described as Khara Pāka. Prolonged heating beyond the required endpoint may expose the formulation to unnecessary thermal stress.[2,3]

Therefore, determination of the appropriate endpoint should preferably combine classical Siddhi Lakṣaṇa with objective analytical parameters.

VI. NIRGUNDI TAILA

Nirgundi Taila is a classical medicated oil containing Nirgundi, botanically identified as *Vitex negundo* Linn., processed in an oleaginous medium. The classical literature associates Nirgundi with Vāta and Śūla-related therapeutic applications.[7]

Padmakiran et al. described Nirgundi Taila as a formulation prepared from Nirgundi leaf and root using Tila Taila and reported its analytical profile.[7] The formulation was described as a greenish, viscous, greasy preparation with characteristic Nirgundi odour.[7]

The formulation is particularly useful for studying Pāka Kāla because the medicinal material is incorporated into a lipid phase while the aqueous component undergoes progressive evaporation during heating.

VII. PHARMACEUTICAL SIGNIFICANCE OF PROCESSING DURATION

Processing duration may influence Taila Kalpana through several mechanisms:

1. Evaporation of water.
2. Extraction of medicinal constituents.
3. Transfer of constituents between aqueous and lipid phases.

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4. Concentration of extracted compounds.
5. Modification of physical properties.
6. Possible degradation of thermolabile constituents.
7. Development of characteristic colour and odour.
8. Oxidative and hydrolytic changes.[4–8]

Consequently, processing duration should be regarded as a potentially important critical process parameter.

VIII. CHEMICAL CHANGES DURING TAILA PĀKA

8.1 Moisture evaporation

Drava Dravya introduces an aqueous component into the formulation. Controlled heating gradually removes this water. Inadequate removal may result in residual moisture, whereas excessive heating after completion may expose the lipid phase to prolonged thermal stress.

8.2 Extraction

Extraction is influenced by temperature, duration, particle size, drug-to-Sneha ratio, solvent polarity and agitation. Prolonged heating may initially improve extraction but may eventually result in degradation of susceptible compounds.

8.3 Hydrolysis

Triglycerides may undergo hydrolysis in the presence of water and heat, generating free fatty acids. An increase in free fatty acids can be reflected by an increase in acid value.

8.4 Oxidation

Unsaturated fatty acids are susceptible to oxidation. Primary oxidation results in formation of hydroperoxides, followed by secondary products such as aldehydes and ketones. Peroxide value is therefore useful for monitoring primary oxidation.

8.5 Thermal degradation

Excessive thermal exposure may affect heat-sensitive phytoconstituents. Therefore, longer heating cannot automatically be considered superior.

The theoretical optimum may be represented as:

Optimum Pāka = Maximum desirable extraction + Pāka Siddhi − minimum chemical degradation

IX. PHYSICOCHEMICAL EVALUATION

Physicochemical parameters provide quantitative information regarding identity, consistency and quality.

9.1 Refractive index

Refractive index is influenced by chemical composition, temperature and degree of unsaturation.[8] It can be useful for comparison of different batches.

9.2 Specific gravity

Specific gravity provides information regarding density and can assist in identifying compositional differences.

9.3 Viscosity

Viscosity reflects resistance to flow and may change with temperature, extraction, concentration and degradation.

9.4 Acid value

Acid value indicates free fatty acids and can therefore provide information regarding hydrolytic deterioration.

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9.5 Saponification value

Saponification value provides information about the fatty-acid characteristics of the lipid phase.

9.6 Iodine value

Iodine value reflects the degree of unsaturation and may change following oxidation or alteration of unsaturated fatty acids.

9.7 Peroxide value

Peroxide value is particularly relevant to stability studies because it provides an indicator of primary lipid oxidation.

9.8 Unsaponifiable matter

This fraction may contain lipid-associated constituents that do not undergo saponification and may therefore be relevant in medicated oils.

X. ANALYTICAL PROFILE OF NIRGUNDI TAILA

Padmakiran et al. reported the following physicochemical findings for Nirgundi Taila.[7]

Table 2. Reported physicochemical profile

Parameter	Reported value
Refractive index at 40°C	1.47171
Weight per mL at 40°C	0.913
Viscosity	60.85
Saponification value	148.66
Iodine value	120.86
Acid value	11.98
Unsaponifiable matter	8.14%

The study also reported TLC and HPTLC fingerprinting of Nirgundi Taila.[7]

XI. CHROMATOGRAPHIC EVALUATION

Complex herbal formulations contain multiple chemical constituents; therefore, a single marker may not adequately represent the entire preparation.

TLC

TLC provides a qualitative fingerprint and can help compare batches.

HPTLC

- HPTLC provides:
- Rf values;
- number of peaks;
- densitometric profile;
- peak area%;
- fingerprint comparison;
- detection of qualitative changes during stability studies.

The published Nirgundi Taila study demonstrated the utility of TLC and HPTLC fingerprinting for characterization of the formulation.[7]

The recent review on analytical parameters of Sneha Kalpana also emphasizes the importance of physicochemical and chromatographic approaches for standardization.[8]

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XII. CHEMICAL MARKERS OF NIRGUNDI

Vitex negundo contains several reported phytoconstituents belonging to flavonoid, iridoid, diterpenoid, triterpenoid and volatile-oil classes.[10–14]

Reported constituents include:

- Vitexin
- Isovitexin
- Casticin
- Luteolin
- Agnuside
- Negundoside
- Ursolic acid
- Oleanolic acid
- Betulinic acid

However, a constituent identified in the raw drug should not automatically be considered a suitable marker for Nirgundi Taila.

A suitable marker should demonstrate:

1. presence in the finished Taila;
2. reproducible extraction;
3. analytical specificity;
4. adequate stability;
5. precision and accuracy;
6. validated quantification.

Therefore, where a validated marker is not established, HPTLC fingerprinting may be more appropriate than relying exclusively on a single compound.

XIII. STABILITY OF TAILA KALPANA

Stability refers to maintenance of the desired physical, chemical and microbiological characteristics during storage.

For medicated oils, important factors include:

- temperature;
- oxygen;
- light;
- moisture;
- container;
- headspace;
- initial lipid quality;
- processing temperature;
- Pāka duration.

The Ayurvedic Pharmacopoeia provides quality-control approaches for Ayurvedic formulations, while contemporary stability guidelines provide frameworks for systematic assessment of pharmaceutical products.[15,16]

A recent 2026 study of Murchchhita and Amurchchhita Tila Taila found that iodine value, acid value and peroxide value changed during six months of accelerated storage, while organoleptic characteristics showed comparatively limited changes.[17]

This finding is important because it demonstrates that chemical parameters may reveal stability-related changes before obvious organoleptic deterioration becomes evident.

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XIV. ROLE OF MŪRCHCHHANĀ

Mūrchchhanā is a preparatory process applied to Sneha in selected classical formulations. It has been described as a process intended to remove undesirable characteristics and improve the pharmaceutical quality of the Sneha.[18]

Previous studies have evaluated the effect of Mūrchchhanā through acid value, peroxide value, iodine value, saponification value, viscosity and related parameters.[18–20]

The 2026 accelerated stability study of Tila Taila specifically compared Murchchhita and Amurchchhita preparations and reported changes in acid value, iodine value and peroxide value during accelerated storage.[17]

Therefore, if the objective is to study Pāka Kāla, Mūrchchhanā must either be standardized across all experimental groups or specifically included as a separate study variable.

XV. CLASSICAL PĀKA KĀLA AND CHEMICAL STABILITY: PROPOSED RELATIONSHIP

The relationship may be represented as:

Pāka duration
↓
Thermal exposure
↓
Moisture removal + extraction
↓
Phytochemical transformation
↓
Physicochemical changes
↓
Chromatographic fingerprint
↓
Storage stability

A shorter duration may result in incomplete moisture removal and extraction, whereas prolonged heating may increase oxidative and thermal stress.

Relationship Between Pāka Kāla and Chemical Stability

Pāka Kāla is an important pharmaceutical aspect of Sneha Kalpana because the duration and intensity of heating influence moisture removal, extraction of medicinal constituents and the physicochemical characteristics of the finished Taila.[1–5] Classical texts primarily determine the completion of Sneha Pāka through Pāka Siddhi Lakṣaṇa rather than through a universally fixed chronological duration.[2,3] Therefore, Pāka Kāla may be understood as the period of controlled thermal exposure required to attain the desired pharmaceutical endpoint.

During the initial stage of Taila Pāka, the preparation contains a considerable aqueous component derived from Drava Dravya. Progressive heating facilitates evaporation of water and concentration of the Sneha phase. Adequate processing may therefore be associated with appropriate moisture reduction and extraction of medicinal constituents. However, prolonged thermal exposure after attainment of the desired Pāka may potentially increase oxidative and thermal stress on the lipid medium and heat-sensitive phytoconstituents.[4,5]

The relationship may therefore be conceptually represented as:

Pāka Kāla → Thermal exposure → Moisture removal + Extraction → Chemical transformation → Quality and stability of Taila

The chemical stability of Taila can be assessed through parameters such as acid value, peroxide value, iodine value, saponification value, viscosity and chromatographic fingerprinting. Acid value may provide information regarding free fatty acids and hydrolytic changes, whereas peroxide value is useful for monitoring primary lipid oxidation. Iodine value provides information regarding the degree of unsaturation of the lipid phase.[6–8]

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The available analytical study of Nirgundi Taila reported refractive index, weight per millilitre, viscosity, saponification value, iodine value, acid value and unsaponifiable matter, together with TLC and HPTLC fingerprinting.[9] These parameters provide a useful analytical framework for evaluating the quality of Nirgundi Taila, although the reported values should not be considered universal standards without validation through multiple batches.

Studies on other Sneha preparations also indicate that pharmaceutical processing can influence physicochemical characteristics and stability. Investigations involving Mūrchchhita and Amūrchchhita Sneha have demonstrated changes in parameters such as acid value, peroxide value and iodine value during storage.[7],[10] More recently, an accelerated stability study of Tila Taila reported changes in acid value, peroxide value and iodine value during storage, demonstrating the usefulness of these parameters for monitoring chemical changes in lipid-based Ayurvedic preparations.[11]

Thus, the available evidence supports a **possible relationship** between processing conditions and chemical stability, but it does not establish a universally applicable Pāka duration for all Taila formulations. The optimum Pāka should be considered formulation-specific because it may depend upon the nature of Sneha Dravya, Kalka, Drava Dravya, quantity of ingredients, heating conditions and classical Pāka Siddhi Lakṣaṇa.

For Nirgundi Taila specifically, the available literature provides analytical characterization but comparatively limited evidence directly correlating the duration of Pāka with subsequent chemical stability. Therefore, Pāka Kāla may be considered an important area for further pharmaceutico-analytical investigation.

Table. Conceptual relationship between Pāka Kāla and chemical stability

Stage of processing	Pharmaceutical interpretation	Possible analytical implication
Insufficient Pāka	Incomplete moisture removal/extraction	Possible higher residual moisture and variable fingerprint
Appropriate Pāka	Attainment of classical Siddhi	Reproducible physicochemical and chromatographic profile
Prolonged Pāka	Excessive thermal exposure	Possible increase in oxidation or degradation
Storage after Pāka	Progressive chemical changes	Changes in acid value, peroxide value, iodine value and HPTLC profile

XIV. CONCLUSION

Taila Kalpana is a systematic pharmaceutical process in which the duration and progression of heating play an important role in achieving the desired Sneha Siddhi. The classical concept of Pāka Kāla is not limited to a fixed duration of heating but is determined in relation to characteristic Pāka Siddhi Lakṣaṇa. Modern analytical parameters provide an opportunity to understand the pharmaceutical significance of these classical observations in measurable terms.

The available literature indicates that processing conditions may influence moisture removal, extraction of medicinal constituents and physicochemical characteristics of medicated oils. Parameters such as acid value, peroxide value, iodine value, viscosity, refractive index and HPTLC fingerprint can therefore be useful for evaluating the quality and stability of Taila preparations. The available analytical data on Nirgundi Taila provide a preliminary basis for such evaluation.

However, a direct and universally applicable relationship between Pāka Kāla and chemical stability cannot presently be established from the available literature. The optimum Pāka duration is likely to be formulation-specific and may depend upon the nature and proportion of Sneha, Kalka and Drava Dravya, heating conditions and attainment of classical Pāka Siddhi Lakṣaṇa. Therefore, integration of classical pharmaceutical observations with physicochemical and chromatographic evaluation may provide a more scientific and reproducible approach to understanding Pāka Kāla.

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Nirgundi Taila may serve as a suitable model for further investigation of this relationship. Such studies may contribute to improved standardization, reproducibility and stability assessment of Taila Kalpana while retaining the fundamental principles of classical Ayurvedic pharmaceutics.

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