# Comparative Pharmaceutical, Physicochemical, Mineralogical, and Spectroscopic Evaluation of Talapatra Kshara Prepared by Four Classical Ayurvedic Methods

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## ABSTRACT

Kshara preparations are classical Ayurvedic alkaline formulations used in traditional practice for disorders such as Arsha, Ashmari, and Grahani. Because the quality of Kshara depends heavily on the processing methods used, it is important to standardize Talapatra Kshara to ensure scientifically robust ethnopharmacological documentation.

**Aim of the study.** The objective is to compare Talapatra Kshara prepared by four classical methods and to determine how differences in the preparation of Ksharodaka influence its physicochemical properties, elemental composition, crystalline mineral phases, and FTIR band profiles.

**Materials and methods.** Dried leaves of Talapatra (Borassus flabellifer L.) were incinerated to ash and processed into Kshara using four classical methods that differed in the extraction liquid, ash-to-liquid ratio, soaking duration, and filtration procedure. The prepared samples (A–D) were evaluated organoleptically, physiochemically, and by flame photometry. X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR) were used for mineralogical and spectroscopic characterization.

**Results.** Marked inter-method variation was observed. pH ranged from 10.15 to 11.24, total ash from 74.205% to 96.794%, and water-soluble ash from 62.033% to 85.471%. Potassium was highest in sample D (317.9 ppm), sodium was highest in sample D (171.0 ppm), and calcium was highest in sample C (160.77 ppm). XRD pattern lists showed sylvine (KCl), halite/sodium chloride (NaCl), and aphthitalite ($K_3Na(SO_4)_2$) as the dominant crystalline phases across the samples. FTIR spectra displayed broad moisture-associated bands and characteristic absorptions in the 1454–1385, 1123–1106, ~991, 877–868, and 620 $cm^{-1}$ regions, supporting a hygroscopic mixed inorganic salt matrix.

**Conclusion.** Classical pharmaceutical variables materially altered the extractive recovery and mineral profile of Talapatra Kshara. Sample A favored extraction efficiency, sample B showed the highest measured alkalinity, sample C showed the lowest mineral recovery, and sample D yielded the most concentrated mixed alkali salt fraction. These findings support process standardization of Talapatra Kshara based on intended pharmaceutical use.

**Keywords:** Talapatra Kshara; Kshara Kalpana; Borassus flabellifer; Ayurvedic pharmaceutics; XRD; FTIR; standardization

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## INTRODUCTION

Traditional Ayurvedic pharmaceutics assigns central importance to Samskara because pharmaceutical processing modifies the physicochemical and therapeutic expression of a formulation [21]. Kshara Kalpana is one of the most distinctive alkaline dosage forms in Ayurveda and is valued both for internal administration and for parasurgical applications [1,4]. Sushruta described a properly prepared Kshara as capable of Chedana, Bhedana, and Lekhana actions, highlighting its importance in controlled therapeutic practice [1, 11].

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Kshara is prepared by dissolving plant ash in a liquid medium, filtering the alkaline extract (Ksharadoka), and concentrating the filtrate to obtain a dry alkali [4, 22]. The final composition depends on the mineral content of the ash, the extracting liquid, the ash-to-liquid ratio, soaking duration, filtration frequency, and heating conditions [3, 15]. For this reason, standardization of Kshara preparations remains essential for reproducible quality, safety, and regulatory acceptance [20, 24].

Talapatra (Borassus flabellifer Linn.) is a traditionally available plant source for Kshara and is considered to be mineral-rich [8]. However, comparative pharmaceutical standardization of Talapatra Kshara prepared by different classical methods remains limited in the published literature. The present study, therefore, compares four classical methods of Talapatra Kshara preparation and correlates physicochemical findings with elemental, XRD, and FTIR observation

## 2. MATERIALS AND METHODS

### 2.1 Raw material and study design

Dried leaves of Talapatra (Borassus flabellifer Linn.) were used as the raw material. The work compiled batch-level pharmaceutical and analytical data for four classical preparations of Talapatra Kshara, coded as samples A–D. The analysis was reported to have been done at the Central Research Facility of Shri B. M. Kankanawadi Ayurveda Mahavidyalaya.

The objective of the study was to compare the influence of classical processing variables on the final characteristics of Talapatra Kshara. The compared variables were the extraction liquid, ash-to-liquid ratio, soaking duration (Nimajjana Kala), and filtration procedure.

### 2.2 Preparation of Talapatra ash

The dried leaves were cut into pieces, thoroughly dried, and ignited in an iron vessel in an open, windless place until complete combustion. The ash was allowed to cool on its own (Svangasita), collected carefully, and preserved in a dry container to avoid moisture uptake.

The ash obtained from Talapatra leaves served as the starting material for the preparation of Ksharadoka and, subsequently, Talapatra Kshara.

### 2.3 Comparative classical methods for preparation of Ksharadoka

Four classical approaches were followed for the preparation of Ksharadoka from Talapatra ash. The methods differed in extraction liquid, ash-to-liquid ratio, soaking duration, and filtration frequency. The comparative processing parameters are shown in Table 1.

**Table 1. Comparative classical methods for preparation of Ksharadoka from Talapatra ash**

| Sample | Classical source | Extraction liquid | Ash-to-liquid ratio | Soaking duration (Nimajjana Kāla) | Filtration method |
|---|---|---|---|---|---|
| A | Arka Prakasha | Water | 1:8 | 48–72 h | Seven sequential filtrations through cloth (Vastra-galana) |
| B | Caraka Saṃhitā | Water | 1:6 | Overnight (~12 h) | Twenty-one sequential filtrations through cloth |
| C | Suśruta Saṃhitā | Gomūtra | 1:6 | Overnight (~12 h) | Twenty-one sequential filtrations through cloth |
| D | Śārṅgadhara Saṃhitā | Water | 1:4 | Overnight (~12 h) | Decantation followed by cloth filtration |

### 2.4 Preparation of Talapatra Kshara

The ash was mixed with the specified liquid, macerated thoroughly, and left undisturbed until the prescribed Nimajjana Kala. After settling, the supernatant alkaline liquid was collected and filtered according to the respective classical method until a clear Ksharadoka was obtained.

The filtered Ksharadoka was then moved to an iron container. It was heated over a controlled flame, with constant stirring, until the liquid evaporated, leaving behind a dry, alkaline residue. The residue was scraped off, cooled, weighed, and then stored in airtight glass containers because it absorbs moisture.

### 2.5 Analytical evaluation

The organoleptic assessment included an evaluation of color, appearance, and taste. The physicochemical analysis comprised moisture content, total ash, acid-insoluble ash, water-soluble ash, and the pH of a 5% aqueous solution. These tests were interpreted in the context of the Ayurvedic Pharmacopoeia and standard quality-control practice [5, 7, 14].

Flame photometry was used to estimate sodium, potassium, and calcium. XRD was used for crystalline phase identification, and FTIR spectroscopy was used to evaluate the principal absorption bands of the inorganic salt matrix.

### 2.6 XRD analysis

XRD analysis was performed using a powder diffractometer with Cu-Kα radiation (λ = 1.5406 Å). Finely powdered samples were scanned over 5°–80° (2θ) with a step size of 0.02° under standard laboratory conditions.

For the present manuscript, phase interpretation was based on the primary pattern lists provided in the instrument printouts. Low-score candidate phases that were chemically implausible for an alkali ash preparation were not treated as principal constituents.

**2.7 FTIR analysis**

FTIR spectra were obtained by the KBr pellet method over the range 4000–400 $cm^{-1}$. The supplied spectra were interpreted primarily for broad hydroxyl/moisture bands and for the fingerprint region relevant to carbonate-, sulfate-, halide-, and metal–oxygen-associated vibrations.

Because the supplied manuscript contained figure images rather than a complete peak table for every sample, the FTIR interpretation in the present draft is intentionally conservative and centered on the clearly annotated bands visible in the spectra.

**2.8 Data handling**

The available dataset consisted of one reported value per prepared sample in the compiled laboratory record. Accordingly, the present revision emphasizes descriptive inter-method comparison rather than inferential statistics. Replicated batch preparation with replicate analytical measurements is recommended for future confirmatory studies.

**3. RESULTS**

**3.1 Organoleptic characteristics**

All four samples were alkaline, salty, hygroscopic powders ranging from off-white to light grey in appearance. These shared organoleptic features were consistent with classical expectations for Kshara preparations.

**3.2 Physicochemical parameters**

The physicochemical findings are summarized in Table 2. Sample A showed the highest total ash (96.794%) and water-soluble ash (85.471%), indicating the greatest overall extractive recovery of inorganic matter. Sample B showed the highest pH (11.24) and the highest acid-insoluble ash (16.406%). Sample C showed the highest moisture (5.155%) and the lowest total ash (74.205%) and water-soluble ash (62.033%). Sample D showed a comparatively lower pH (10.15) despite high mineral recovery, indicating that concentration and measured alkalinity were not identical outcomes.

**Table 2. Physicochemical profile of Talapatra Kshara samples**

| Parameter | Sample A | Sample B | Sample C | Sample D |
|---|---|---|---|---|
| Moisture (%) | 1.924 | 1.128 | 5.155 | 4.107 |
| Total ash (%) | 96.794 | 96.020 | 74.205 | 94.934 |
| Acid-insoluble ash (%) | 9.860 | 16.406 | 7.720 | 8.486 |
| Water-soluble ash (%) | 85.471 | 75.802 | 62.033 | 80.715 |
| pH (5% aqueous solution) | 10.52 | 11.24 | 10.87 | 10.15 |

**3.3 Elemental composition by flame photometry**

Elemental values are shown in Table 3. Potassium was the dominant cation in all samples, with the highest value in sample D (317.9 ppm), followed by sample A (276.4 ppm). Sodium was highest in sample D (171.0 ppm) and very similar in sample A (170.3 ppm). Calcium was highest in sample C (160.77 ppm), despite the lower total ash and water-soluble ash values of that sample.

**Table 3. Elemental composition of Talapatra Kshara samples**

| Sample | Sodium (ppm) | Potassium (ppm) | Calcium (ppm) |
|---|---|---|---|
| A | 170.3 | 276.4 | 139.31 |
| B | 57.38 | 209.0 | 155.48 |
| C | 92.90 | 187.4 | 160.77 |
| D | 171.0 | 317.9 | 138.5 |

**3.4 XRD analysis**

XRD pattern lists demonstrated a consistent mixed inorganic salt system across all four samples. Sylvine (KCl), halite/sodium chloride (NaCl), and aphthitalite ($K_3Na(SO_4)_2$) were the dominant crystalline phases in every sample, although their relative pattern scores varied. Low-score candidate matches in the software output that were chemically implausible for an alkali ash preparation were not considered principal phases

**Table 4. Dominant crystalline phases identified by XRD**

| Sample | Top XRD phase matches from pattern list | Interpretive summary |
|---|---|---|
| A | Sodium chloride (61), sylvine (57), aphthitalite (36) | Mixed Na/K chloride plus sulfate phase |
| B | Sylvine (59), halite (57), aphthitalite (30) | Chloride-rich matrix with lower sulfate than D |
| C | Sodium chloride (60), sylvine (58), aphthitalite (29) | Same principal phases as A/B; weaker secondary matches |
| D | Halite (67), sylvite (61), and aphthitalite (59). | Strongest mixed chloride-sulfate crystallinity |

Sample D showed the strongest combined crystallinity of halite, sylvine, and aphthitalite, corresponding well with its high sodium and potassium values. Sample A also showed a robust mixed-salt profile, whereas sample C retained the same principal phase pattern but with less compelling secondary phase support. The XRD data therefore suggest that Talapatra Kshara, under the present preparation conditions, behaves as a mixed alkali chloride-sulfate system rather than as a purely carbonate-dominated crystalline material

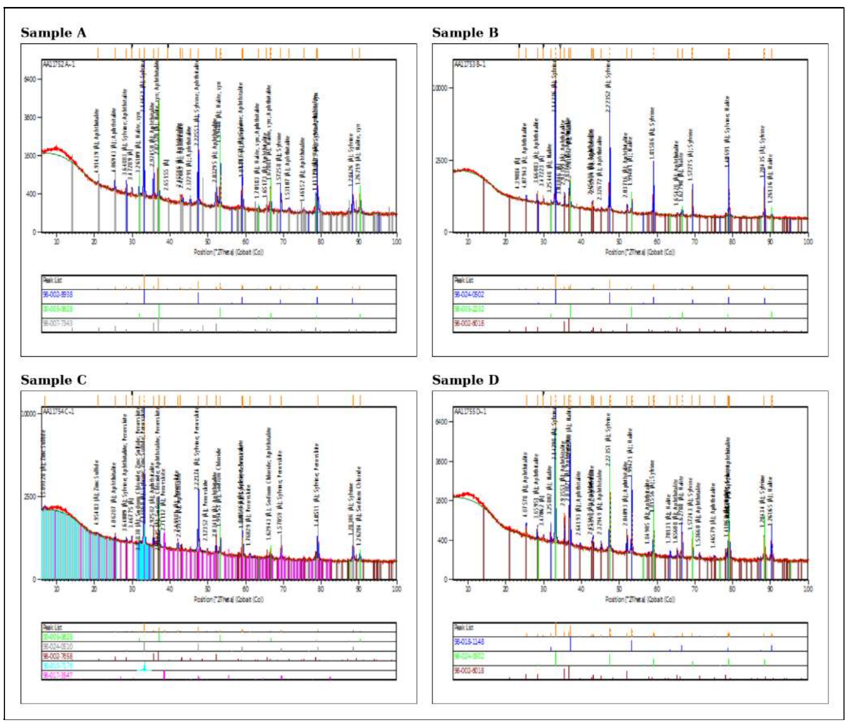


**Figure 1. XRD diffractograms of Talapatra Kshara samples A–D.**

### 3.5 FTIR analysis

The supplied FTIR spectra showed a shared pattern of broad moisture-associated bands and diagnostically useful absorptions in the fingerprint region. Broad bands in the ~3400–3200 cm$^{-1}$ region together with bending near ~1638 cm$^{-1}$ support the presence of adsorbed moisture and hydroxylated species, which is consistent with the hygroscopic behaviour of Kshara. Bands near 1454–1385 cm$^{-1}$ may be assigned to carbonate/bicarbonate or sulfate-associated stretching. Bands in the 1123–1106 and ~991 cm$^{-1}$ region support sulfate/C–O stretching and mixed inorganic salt vibrations, while bands at 877–868 cm$^{-1}$ are compatible with carbonate out-of-plane vibration. Lower-wavenumber bands around 718–620 and ~512 cm$^{-1}$ indicate lattice, halide or metal–oxygen-associated vibrations

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**Table 5. Representative FTIR bands observed in the supplied spectra**

| Observed band region ($cm^{-1}$) | Tentative assignment | Interpretive note |
|---|---|---|
| ~3400–3200 | O–H stretching / adsorbed moisture | Consistent with hygroscopic inorganic salts |
| ~1638–1640 | H–O–H bending / bound moisture | Supports retained moisture in the salt matrix |
| 1454–1385 | Carbonate/bicarbonate or sulfate-associated stretching | Seen in the more mineral-rich spectra |
| 1123–1106 | Sulfate / C–O stretching | Compatible with aphthitalite-related chemistry and mixed salt vibrations |
| ~991 | Fingerprint-region inorganic salt vibration | Seen with the 1100 $cm^{-1}$ band in richer spectra |
| 877–868 | Carbonate out-of-plane bending | Supports a carbonate contribution even if not strongly crystalline by XRD |
| 718–620 and ~512 | Lattice / metal–oxygen / halide-associated vibrations | Reflects the inorganic crystalline framework |

Among the available spectra, sample C showed a comparatively simplified band pattern with fewer resolved absorptions, whereas sample D showed the richest fingerprint region and clearer bands around ~1454, 1385, 1106, 991, 877, and 620 $cm^{-1}$. These observations are congruent with the lower total ash of sample C and the concentrated mineral profile of sample D.

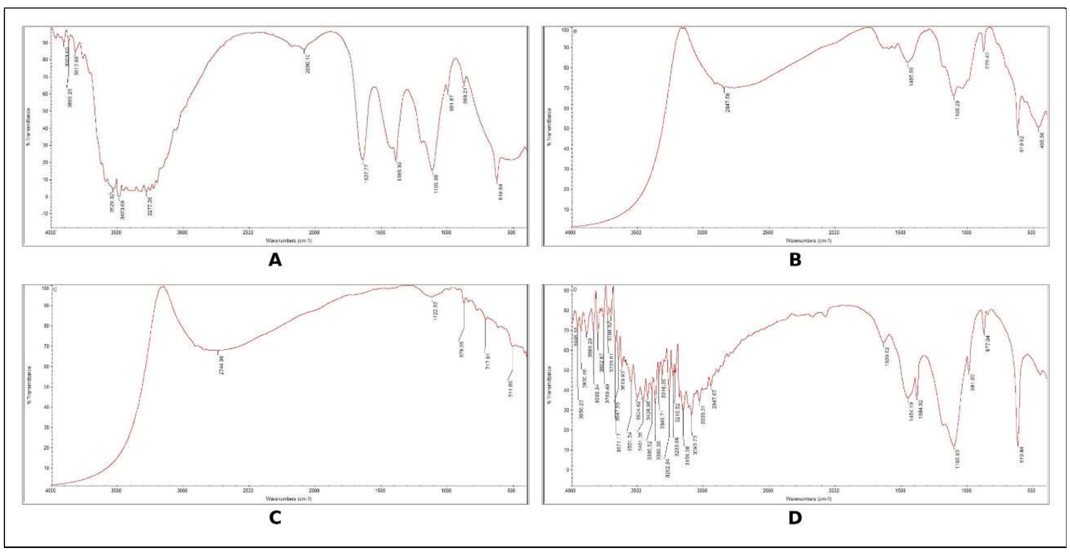


**Figure 2. FTIR spectra of Talapatra Kshara samples A–D.**

## 4. DISCUSSION

The present comparative evaluation shows that classical pharmaceutical variables materially alter the final character of Talapatra Kshara. In particular, the ash-to-liquid ratio, the soaking interval, and the filtration strategy changed not only the gross extractive values but also the elemental and crystalline salt profile of the final product. This observation is entirely consistent with the Ayurvedic concept that Saṃskara modifies the expression of a formulation [1,3,21]. Sample A, prepared with the largest liquid volume and the longest soaking interval, showed the highest total ash and water-soluble ash. This pattern suggests that prolonged contact between ash and liquid promoted more exhaustive dissolution of soluble inorganic matter. By contrast, sample D, prepared with the most concentrated 1:4 ratio, showed the highest sodium and potassium values together with the strongest mixed-salt crystallinity by XRD. This indicates that a more concentrated Ksharadoka can favor retention or precipitation of a mineral-rich final fraction rather than maximal bulk extractive recovery.

Sample B showed the highest measured pH, although it did not show the highest potassium or sodium value. This implies that measured alkalinity is influenced not simply by the total amount of mineral matter but by the chemical form and relative balance of the dissolved salts. Sample C, prepared with Gomūtra as extraction liquid, showed the lowest total ash, the lowest water-soluble ash, and the lowest potassium value, together with a simplified FTIR pattern. Within the limits of the present dataset, this suggests a lower recovery of crystallizable alkali salts under that method, or a different transformation pathway during drying.

The XRD findings are particularly important because the dominant crystalline phases were not purely carbonate salts. Instead, the major crystalline constituents across the four samples were sylvine, halite/sodium chloride, and aphthitalite. This means that Talapatra Kshara, at least under the present preparation and drying conditions, should be interpreted as a mixed K–Na chloride-sulfate mineral system. Carbonate species may still contribute to alkalinity in poorly crystalline or amorphous form, and this possibility is supported by the FTIR bands in the 1454–1385 and 877–868 $cm^{-1}$ regions, but they were not the dominant crystalline signature in the XRD pattern lists.

The FTIR spectra complement the XRD results. Broad hydroxyl and moisture bands were expected because Kshara is hygroscopic. The 1100–1000 $cm^{-1}$ and ~620 $cm^{-1}$ regions are also compatible with sulfate-bearing inorganic phases, which aligns well with the recurrent aphthitalite match in the XRD data. Accordingly, the most defensible integrated interpretation is that the formulation contains a mixed inorganic salt matrix with chloride- and sulfate-bearing crystalline phases together with variable contributions from moisture-associated and carbonate-like groups.

From a pharmaceutical standardization perspective, the four methods do not appear interchangeable. Method A appears advantageous when a preparation with high total mineral recovery and high water-soluble ash is desired. Method B yields the highest pH and may therefore be preferred when stronger measured alkalinity is prioritized. Method D gives the most concentrated mixed alkali salt fraction and the highest potassium level, making it the most mineral-dense preparation in the present comparison. Sample C, while still a valid Kshara, showed the lowest extractive and potassium profile among the four methods.

The practical implication is that future standardization of Talapatra Kshara should define the intended pharmaceutical purpose before fixing the process. A method chosen for maximal extractive yield may not be the same as a method chosen for concentrated mineral content or the highest measured pH. This distinction is important for downstream formulation design, safety evaluation, and rational comparison across classical sources [20,24].

## 5. CONCLUSION

This study confirms that Talapatra Kshara prepared by different classical methods shows meaningful variation in physicochemical behavior, elemental composition, and mineralogical profile. Sample A favored extraction efficiency, sample B showed the highest measured alkalinity, sample C showed the lowest mineral recovery, and sample D yielded the most concentrated mixed alkali salt fraction. XRD identified sylvine, halite/sodium chloride, and aphthitalite as the dominant crystalline phases, while FTIR supported a hygroscopic mixed inorganic salt matrix with carbonate-/sulfate-associated bands. Taken together, these findings support method-specific standardization of Talapatra Kshara rather than assuming equivalence among classical procedures

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## 6. LIMITATIONS AND FUTURE SCOPE

The present revision is based on batch-level compiled values and instrument printouts. Replicated batch preparation with replicate analytical measurements is needed before inferential statistics are applied with confidence.

Complete peak-list tables were not available for every FTIR spectrum in the supplied material; therefore, the spectroscopic interpretation has been kept deliberately conservative. Future studies should include standardized peak tables, heavy-metal analysis, microbial quality testing, ICP-based trace element profiling, and biological or clinical correlation.

## 7. FUNDING, CONFLICT OF INTEREST, AND ETHICAL STATEMENT

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Ethical statement: The work was analytical and pharmaceutical in nature and did not involve human or animal subjects

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