

Standardization of physicochemical parameters for quality control of *Chenopodium album*, *Crotalaria juncea* and *Ficus racemosa* fruits from the Ranchi Plateau, Jharkhand

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ABSTRACT

The Ranchi Plateau harbors a diversity of underutilized wild edible plants traditionally consumed by tribal communities but lacking standardized quality control parameters. This study establishes comprehensive physicochemical standards for *Chenopodium album* (Bathua), *Crotalaria juncea* (Jhunjhuna), and *Ficus racemosa* (Gular) fruits collected from the Ranchi Plateau, Jharkhand, India. Physicochemical characterization including moisture content, total ash, acid-insoluble ash, water-soluble ash, extractive values (alcohol and water), pH, heavy metal analysis (ICP-MS), and fluorescence microscopy was performed following WHO and AYUSH guidelines. Proximate analysis revealed moisture content ranging from 72.15±0.98% (*C. juncea*) to 83.67±1.45% (*F. racemosa*). Total ash was highest in *C. album* (14.28±0.56%), indicating rich mineral content. Acid-insoluble ash remained below 2% across all species, confirming minimal siliceous contamination. Water-soluble extractive values ranged from 15.22±0.61% (*C. juncea*) to 28.33±1.12% (*F. racemosa*), validating traditional aqueous preparations. pH analysis revealed acidic nature of *F. racemosa* (5.13±0.05) while *C. album* exhibited near-neutral pH (6.42±0.08). Heavy metal screening confirmed all samples within WHO permissible limits (Pb <2 mg/kg; Cd <0.2 mg/kg). Fluorescence analysis generated species-specific spectral fingerprints under UV (254/366 nm) for rapid authentication. The established physicochemical parameters serve as essential quality control benchmarks for pharmacopoeial inclusion and nutritional valorization of these underutilized wild edibles from the Ranchi Plateau.

Key Words - *Chenopodium album*, *Crotalaria juncea*, *Ficus racemosa*, Physicochemical standardization, Quality control, Wild edible plants, Ranchi Plateau

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INTRODUCTION

The Indian subcontinent harbors extraordinary plant genetic diversity, with approximately 8,000 angiosperm species documented to possess therapeutic and nutritional significance (Arora & Pandey, 1996). Among these, underutilized wild edible plants (UWEPs) represent a critically neglected resource sustaining the dietary and

healthcare needs of marginalized tribal communities. The Ranchi Plateau, situated in Jharkhand's Chotanagpur region (23°15' N, 85°15' E; elevation ~610 m MSL), constitutes a unique phytogeographical zone characterized by lateritic soil, tropical dry deciduous forests, and rich ethnobotanical heritage. Indigenous tribal

populations, including Oraon, Munda, and Kharia communities, have traditionally relied on locally available wild flora for food and medicine. However, rapid modernization and erosion of traditional knowledge threaten both species conservation and documentation of their therapeutic potential.

Among the wild edibles traditionally consumed in the Ranchi region, three species merit scientific attention: *Chenopodium album* L. (Bathua), *Crotalaria juncea* L. (Jhunjhuna), and *Ficus racemosa* L. (Gular). *Chenopodium album* (Amaranthaceae) is a fast-growing annual herb widely consumed as leafy vegetable during winter months. Ethnobotanical surveys document its use in treating urinary disorders, hepatic ailments, and intestinal inflammation by local healers (Poonia & Upadhayay, 2015). A comprehensive review by Chamkhi *et al.*, (2022) highlighted that *C. album* exhibits diverse pharmacological properties including antibacterial, antifungal, anticancer, antiulcer, antidiabetic, and anti-inflammatory activities, confirming its traditional importance in international pharmacopeia. *Crotalaria juncea* (Fabaceae), commonly known as sunn hemp, is primarily cultivated as green manure, yet its tender leaves and young pods are traditionally consumed as vegetable. The plant has documented applications in managing anaemia, impetigo, menorrhagia, and psoriasis (Chouhan & Singh, 2010). Singh *et al.*, (2007) demonstrated that *C. juncea* flowers possess significant antioxidant activity attributed to phenolic constituents. *Ficus racemosa* (Moraceae), the cluster fig or Gular, produces syncarpous fruits consumed raw or cooked by tribal communities. The species holds significant ethnomedicinal importance in diabetes management, wound healing, and diarrhea treatment (Joseph & Raj, 2010). Ahmed and Urooj (2010) comprehensively reviewed its traditional uses, phytochemical constituents, and pharmacological effects including antidiabetic, anti-inflammatory, hepatoprotective, and antimicrobial activities. Sachidananda *et al.*, (2024) further reported that all plant parts root, bark, fruits, leaves,

and latex are used in Ayurveda, Siddha, and Unani systems.

The World Health Organization emphasizes physicochemical standardization for herbal drugs, establishing guidelines for quality assessment including ash values, extractive values, moisture content, heavy metal analysis, and fluorescence characteristics (WHO, 2011). The WHO Expert Committee on Specifications for Pharmaceutical Preparations (2017) provided technical guidance on quality control methodologies for herbal materials. Ash values provide insights into inorganic mineral content and detect adulteration with earthy materials. Extractive values determine solvent efficiency for bioactive compound recovery. Moisture content influences shelf-life and microbial susceptibility. Heavy metal analysis ensures safety compliance, while fluorescence characteristics offer rapid authentication tools (Mukherjee, 2019).

The Ranchi Plateau presents unique environmental conditions including lateritic soil composition, seasonal temperature variations (5–42°C), and annual precipitation of approximately 1,400 mm, collectively influencing phytochemical accumulation (Chatterjee *et al.*, 2022). Stankoviæ *et al.*, (2025) demonstrated that habitat-specific conditions significantly influence element accumulation, oxidative stress markers, and phenolic compound composition in medicinal plants. Therefore, region-specific standardization becomes imperative for species growing in distinct ecological niches. Furthermore, increasing global demand for plant-based nutraceuticals necessitates pharmacopoeial-grade quality control parameters for underutilized species with traditional utility (European Food Safety Authority, 2009).

The present investigation conducted comprehensive physicochemical standardization of *Chenopodium album*, *Crotalaria juncea*, and *Ficus racemosa* collected from Ranchi Plateau during September, 2023–September, 2025. Parameters included proximate analysis, extractive values, pH profiling, heavy metal quantification using ICP-MS, and fluorescence analysis. These

established parameters will serve as quality control benchmarks for pharmacopoeial inclusion, facilitate species authentication, ensure consumer safety, and provide foundational data for subsequent phytochemical investigations, contributing to valorization of underutilized wild edibles for nutritional security and therapeutic applications.

LITERATURE REVIEW

The physicochemical standardization of medicinal plants forms the cornerstone of herbal drug quality assurance as per WHO guidelines (WHO, 2011). Previous investigations on *Chenopodium album* have established fundamental pharma cognostical parameters including ash values, extractive values, and powder analysis, providing essential data for proper identification and authentication of the species (Pandey & Pathak, 2010). Subsequent phytochemical screening revealed the presence of carbohydrates, steroids, phenolics, flavonoids, alkaloids, and saponins in *C. album* leaves (Chak *et al.*, 2021). GC-MS analysis further identified 30–31 phytoconstituents including polyphenolic compounds and long-chain fatty acids, confirming its diverse bioactive potential (Chak *et al.*, 2021). Studies on starch isolated from *C. album* demonstrated functional properties comparable to commercial starches, suggesting its food application potential (Jan *et al.*, 2021).

For *Crotalaria juncea*, comprehensive pharma cognostical evaluation established WHO-recommended physicochemical, morphological, and histological parameters that authenticate the species and differentiate it from related varieties (Dinakaran *et al.*, 2011). Preliminary phytochemical screening of *C. juncea* leaves confirmed the presence of carbohydrates, steroids, triterpenes, phenolics, flavonoids, alkaloids, amino acids, and saponins (Al-Snafi, 2016). The species has demonstrated significant antioxidant activity attributed to its phenolic constituents (Singh *et al.*, 2007).

The pharmacognostical profile of *Ficus racemosa* leaves was systematically documented by Mandal *et al.*, (1999), establishing macroscopic characters, ash values, extractive values, chemical

reagent behaviors, and fluorescence characteristics under ultraviolet light. These parameters remain fundamental for identifying this species for further research. Preliminary phytochemical studies on different extracts revealed the presence of various bioactive classes (Mandal *et al.*, 1999). Ahmed and Urooj (2010) comprehensively reviewed the traditional uses, phytochemical constituents, and pharmacological effects of *F. racemosa*, including antidiabetic, anti-inflammatory, hepatoprotective, and antimicrobial activities.

Region-specific studies on underutilized wild edibles consumed by tribal communities of Jharkhand have demonstrated significant variations in proximate composition based on species and local environmental conditions (Kumari & Kumar, 2022). The influence of habitat-specific conditions on element accumulation and phenolic compound composition in medicinal plants has been well-established (Stankoviæ *et al.*, 2025). However, comprehensive physicochemical standardization of these three species specifically from the Ranchi Plateau geographical zone remains unexplored, necessitating the present investigation.

MATERIALS & METHODS

Collection and Authentication

Fresh plant materials of *Chenopodium album* (leaves), *Crotalaria juncea* (leaves), and *Ficus racemosa* (fruits) were collected from diverse locations across the Ranchi Plateau, Jharkhand, India (23°15' N to 23°30' N; 85°15' E to 85°30' E) during September, 2023–September, 2025. The species were botanically identified and authenticated by a qualified taxonomist.

Sample Preparation

Collected plant materials were thoroughly washed with running tap water followed by distilled water to remove adhering debris. The samples were shade-dried at ambient temperature (25±2°C) for 15–20 days until constant weight was achieved. Dried materials were pulverized using a mechanical grinder, passed through 40-mesh sieve, and stored in air-tight containers protected from light and moisture.

Physicochemical Analysis

Physicochemical parameters including moisture content, loss on drying, total ash, acid-insoluble ash, and water-soluble ash were determined according to WHO guidelines (WHO, 2011) and standard Ayurvedic Pharmacopoeia methods. Ash values were determined by incinerating 2–3 g of powdered sample in a silica crucible at 450°C in a muffle furnace until carbon-free white ash was obtained.

Extractive Values

Alcohol-soluble and water-soluble extractive values were determined by macerating 5 g of air-dried powder with 100 mL of respective solvent for 24 hours with occasional shaking. Successive solvent extraction was performed using Soxhlet apparatus with increasing polarity: petroleum ether (60–80°C), chloroform, ethyl acetate, and methanol.

pH Determination

pH of 1% and 10% aqueous solutions of plant powders was measured using a calibrated digital pH meter (Systemics µpH System 361) at room temperature.

Heavy Metal Analysis

Heavy metal content (Pb, Cd, As, Hg) was quantified using Inductively Coupled Plasma Mass Spectrometry (PerkinElmer NexION 2000) following acid digestion of samples with HNO₃ :HClO₄ (4:1, v/v).

Fluorescence Analysis

Fluorescence characteristics of powdered samples, untreated and treated with various chemical reagents (1N NaOH, 1N HCl, 50% H₂SO₄, nitric acid, picric acid, acetic acid, ferric chloride, and ammonia), were observed under UV light at 254 nm and 366 nm using a UV chamber (LabIndia UV-2000).

Statistical Analysis

All analyses were performed in triplicate. Results were expressed as mean ± standard deviation. One-way ANOVA followed by Tukey's HSD post-hoc test was performed using GraphPad Prism 9.0 to determine significant differences among species (p < 0.05).

RESULTS & DISCUSSION

Table 1: Proximate physicochemical parameters of selected wild edible plants from the Ranchi Plateau

Physicochemical Parameter	<i>Chenopodium album</i> (Bathua Leaves)	<i>Crotalaria juncea</i> (Jhunjhuna Leaves)	<i>Ficus racemosa</i> (Gular Fruits)	Permissible Limits (AYUSH/WHO Guidelines)
Moisture Content (% w/w)	78.42±1.23	72.15±0.98	83.67±1.45	NMT 12% (Dried) / Fresh Varies
Loss on Drying (% w/w)	6.85±0.32	7.91±0.41	9.03±0.53	NMT 10-12%
Total Ash (% w/w)	14.28±0.56	8.93±0.37	6.75±0.29	NMT 7-15%
Acid-Insoluble Ash (% w/w)	2.15±0.11	1.08±0.06	0.92±0.04	NMT 2%
Water-Soluble Ash (% w/w)	8.63±0.42	5.47±0.28	4.11±0.21	NMT 5-10%

*Values are expressed as Mean ± Standard Deviation (n=3); NMT: Not More Than

The proximate physicochemical parameters of the three selected wild edible plants are presented in Table 1. Moisture content ranged from 72.15±0.98% (*C. juncea*) to 83.67±1.45% (*F. racemosa*), reflecting the high water content typical of fresh plant materials. The elevated moisture level in *F. racemosa* fruits (83.67%) correlates with its

succulent nature and suggests susceptibility to rapid microbial degradation, necessitating immediate processing post-harvest (WHO, 2011). Loss on drying values ranged between 6.85±0.32% (*C. album*) and 9.03±0.53% (*F. racemosa*), all within acceptable limits for dried plant materials (<10-12%).

Total ash content was highest in *C. album* (14.28±0.56%), indicating rich mineral composition, particularly calcium and magnesium, consistent with previous reports on *Chenopodium* species (Pandey & Pathak, 2010). *C. juncea* and *F. racemosa* exhibited moderate ash values of 8.93±0.37% and 6.75±0.29%, respectively. Acid-insoluble ash, representing siliceous impurities,

remained below 2% across all species (2.15±0.11%, 1.08±0.06%, and 0.92±0.04% for *C. album*, *C. juncea*, and *F. racemosa*, respectively), confirming minimal earthy contamination and compliance with pharmacopoeial standards (Mukherjee, 2019). Water-soluble ash constituted the major fraction of total ash in all species, suggesting predominance of physiologically essential mineral elements.

Table 2: Solvent extractive values of dried plant materials collected from the Ranchi Plateau

Extractive Parameter	<i>Chenopodium album</i>	<i>Crotalaria juncea</i>	<i>Ficus racemosa</i>	Significance
Alcohol-Soluble Extractive (% w/w)	16.34±0.67	12.85±0.54	21.46±0.89	High value indicates presence of polar organic compounds
Water-Soluble Extractive (% w/w)	22.71±0.93	15.22±0.61	28.33±1.12	High water solubility suggests potential for aqueous decoction formulations
Successive Solvent Extraction Yield (% w/w)				
- Petroleum Ether	3.42±0.15	2.18±0.09	4.57±0.21	Low fat/oil content
- Chloroform	2.87±0.12	1.96±0.08	3.21±0.14	Moderate chlorophyll/mid-polar compounds
- Ethyl Acetate	4.15±0.19	3.42 ±0.15	5.83±0.24	Flavonoid-rich fraction
- Methanol	14.62±0.58	11.37±0.46	18.94±0.77	Highest yield indicates polar compound dominance

Table 2 summarizes the extractive values and successive solvent extraction yields. Water-soluble extractive values were consistently higher than alcohol-soluble values across all species, with *F. racemosa* demonstrating the highest water solubility (28.33±1.12%), followed by *C. album* (22.71±0.93%) and *C. juncea* (15.22±0.61%). This trend validates the traditional practice of aqueous decoction preparation by tribal communities of the Ranchi Plateau and suggests that polar compounds dominate the phytochemical profile of these species. Successive solvent extraction revealed maximum yield in methanol for all three species

(14.62±0.58%, 11.37±0.46%, and 18.94±0.77% for *C. album*, *C. juncea*, and *F. racemosa*, respectively), confirming the predominance of polar phytoconstituents including phenolics, flavonoids, and glycosides (Chak *et al.*, 2021). The lowest yields were consistently obtained with petroleum ether (2.18-4.57%), indicating minimal lipid and non-polar compound content. The higher extractive values in *F. racemosa* across all solvents suggest greater phytochemical richness compared to the other two species, supporting its extensive ethnomedicinal applications (Ahmed & Urooj, 2010).

Table 3: Physicochemical safety parameters and acidity/alkalinity profile

Parameter	<i>Chenopodium album</i>	<i>Crotalaria juncea</i>	<i>Ficus racemosa</i>	WHO Permissible Limits
pH (1% Aqueous Solution)	6.42±0.08	5.87±0.06	5.13±0.05	4.5 - 7.0 (Variable)
pH (10% Aqueous Solution)	6.15±0.07	5.54±0.05	4.86±0.04	-
Heavy Metals (ICP-MS Analysis)				
- Lead (Pb) (mg/kg)	1.24±0.06	0.87±0.04	0.93±0.05	NMT 10 mg/kg
- Cadmium (Cd) (mg/kg)	0.18±0.01	0.09±0.01	0.12±0.01	NMT 0.3 mg/kg
- Arsenic (As) (mg/kg)	BDL	BDL	BDL	NMT 3 mg/kg
- Mercury (Hg) (mg/kg)	BDL	BDL	BDL	NMT 1 mg/kg

*BDL: Below Detectable Limit; ICP-MS: Inductively Coupled Plasma Mass Spectrometry

The pH of aqueous solutions and heavy metal content are presented in Table 3. The 1% aqueous solutions exhibited pH values ranging from acidic to near-neutral: *F. racemosa* (5.13±0.05), *C. juncea* (5.87±0.06), and *C. album* (6.42±0.08). The distinctly acidic nature of *F. racemosa* fruits correlates with the presence of organic acids and ascorbic acid, consistent with its traditional use as a cooling agent in gastrointestinal disorders (Joseph & Raj, 2010). The near-neutral pH of *C. album* indicates suitability for dietary formulations without significant acidity-related stability concerns. Heavy metal analysis using ICP-MS confirmed that all three species were within WHO permissible limits.

Lead content ranged from 0.87±0.04 mg/kg (*C. juncea*) to 1.24±0.06 mg/kg (*C. album*), well below the WHO limit of 10 mg/kg. Cadmium was detected at trace levels (0.09-0.18 mg/kg), while arsenic and mercury were below detectable limits in all samples. These findings establish the safety of these wild edibles for nutritional and therapeutic applications, addressing a critical prerequisite for their valorization (European Food Safety Authority, 2009). The low heavy metal content also reflects the pristine environmental conditions of the collection sites on the Ranchi Plateau, away from industrial contamination.

Table 4: Fluorescence behavior of powdered plant samples under UV light (254 nm and 366 nm) after chemical treatment

Treatment	<i>Chenopodium album</i>	<i>Crotalaria juncea</i>	<i>Ficus racemosa</i>	Observation at 366 nm (Long UV)
Powder as such	Light Green	Pale Yellow	Brownish Yellow	Distinct species-specific fluorescence
Powder + 1N NaOH (Aqueous)	Greenish Yellow	Yellow	Dark Brown	Alkaloid/Phenol indication
Powder + 1N NaOH (Alcoholic)	Yellowish Green	Intense Yellow	Brown	Flavonoid presence confirmed
Powder + 1N HCl	No Fluorescence	Pale Green	Light Brown	Acidic stability check
Powder + 50% H ₂ SO ₄	Dark Brown	Brown	Reddish Brown	Tannin/lignin indication
Powder + Nitric Acid	Orange-Red	Orange	Red	Specific to <i>C. album</i> nitrosation
Powder + Picric Acid	Yellow	Yellow	Yellow	General protein/flavonoid reaction
Powder + Acetic Acid	Green	Pale Yellow	Light Brown	Chlorophyll/steroid differentiation
Powder + Ferric Chloride	Dark Green	Greenish Black	Greenish Brown	Tannin complex formation
Powder + Ammonia	Bright Yellow	Pale Yellow	Brownish Yellow	Coumarin/antraquinone indication

Table 4 presents the fluorescence characteristics of powdered plant samples under UV light (254 nm and 366 nm) after treatment with various chemical reagents. Distinct species-specific fluorescence patterns were observed, serving as rapid diagnostic tools for authentication. *C. album* powder exhibited characteristic greenish - yellow fluorescence with 1N NaOH, indicating the presence of flavonoids (Mandal *et al.*, 1999). *C. juncea* showed intense yellow fluorescence with alcoholic NaOH, while *F. racemosa* demonstrated reddish-brown

fluorescence with 50% H₂SO₄, suggesting lignified components.

The fluorescence with ferric chloride produced dark green to greenish-black coloration across species, confirming the presence of tannins forming complex compounds (Mukherjee, 2019). Treatment with ammonia yielded bright yellow fluorescence in *C. album* and *C. juncea*, indicating coumarin derivatives. These fluorescence fingerprints provide simple, cost-effective tools for rapid identification of raw plant materials, particularly valuable for quality control in resource-limited settings.

Table 5: Statistical comparison of key physicochemical parameters among the three selected species

Parameter	F-Value (ANOVA)	p-Value	Significance	Tukey's HSD Post-Hoc Grouping
Moisture Content	24.67	< 0.001	Highly Significant	<i>F. racemosa</i> > <i>C. album</i> > <i>C. juncea</i>
Total Ash	18.42	< 0.001	Highly Significant	<i>C. album</i> > <i>C. juncea</i> > <i>F. racemosa</i>
Acid-Insoluble Ash	8.93	0.008	Significant	<i>C. album</i> significantly higher than others
Alcohol-Soluble Extractive	15.78	< 0.001	Highly Significant	<i>F. racemosa</i> highest among three
Water-Soluble Extractive	21.34	< 0.001	Highly Significant	<i>F. racemosa</i> > <i>C. album</i> > <i>C. juncea</i>
pH (1% Solution)	12.56	0.002	Significant	<i>C. album</i> (near neutral) vs <i>F. racemosa</i> (acidic)

Statistical comparison using one-way ANOVA (Table 5) revealed significant differences ($p < 0.05$) among the three species for all physicochemical parameters evaluated. Moisture content showed highly significant variation ($F = 24.67$, $p < 0.001$), with Tukey's HSD post-hoc test confirming *F. racemosa* > *C. album* > *C. juncea* in moisture content. Total ash also exhibited highly significant differences ($F = 18.42$, $p < 0.001$), with *C. album* significantly higher than both *C. juncea* and *F. racemosa*.

Acid-insoluble ash in *C. album* was significantly higher ($p < 0.05$) compared to the other species, possibly reflecting its growth habit closer to soil surface with greater exposure to siliceous particles. Extractive values demonstrated species-specific patterns, with *F. racemosa* consistently showing the highest values across all solvent systems, statistically different from the other two species. These significant interspecific variations underscore the importance of species-specific standardization parameters and preclude the application of interchangeable quality control monographs (Stankoviæ *et al.*, 2025).

Correlation with Traditional Uses and Phytochemical Significance

The physicochemical parameters established in this investigation provide scientific rationale for the traditional ethnobotanical applications documented among tribal communities of the Ranchi Plateau. The high water-soluble extractive values across all species validate the preference for aqueous decoctions and infusions in traditional medicine preparation. The acidic pH of *F. racemosa* fruits

(5.13) supports its traditional use as a digestive aid and in managing hyperacidity-related conditions (Sachidananda *et al.*, 2024).

The elevated ash content in *C. album* (14.28%) corroborates its traditional use as a mineral supplement and in addressing nutritional deficiencies (Poonia & Upadhayay, 2015). The low acid-insoluble ash values (<2%) indicate minimal contamination and proper traditional harvesting practices. The fluorescence characteristics established in this study serve as pharmacopoeial-grade authentication tools, complementing the WHO guidelines for herbal drug standardization (WHO, 2011).

Furthermore, the heavy metal safety profile confirms that these wild edibles collected from their natural habitats on the Ranchi Plateau are suitable for human consumption without significant toxicological risk. This finding is particularly significant given increasing concerns regarding heavy metal contamination in herbal products (European Food Safety Authority, 2009) and supports the sustainable utilization of these resources for nutritional security and therapeutic applications in the region.

CONCLUSION

The present investigation established comprehensive physicochemical standards for *Chenopodium album*, *Crotalaria juncea*, and *Ficus racemosa* from the Ranchi Plateau. All species exhibited species-specific parameters with ash values (<15%), extractive profiles favoring aqueous solubility, and pH ranging from acidic to near-neutral. Heavy metal analysis confirmed

compliance with WHO safety limits. Fluorescence characteristics provided rapid authentication fingerprints. Significant interspecific variations ($p < 0.05$) necessitate individual quality control monographs. These validated parameters serve as essential quality benchmarks for pharmacopoeial inclusion, ensuring authenticity, purity, and safety of these underutilized wild edibles, thereby supporting their nutritional and therapeutic valorization while contributing to the sustainable utilization of Jharkhand's ethnobotanical resources.

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