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An ethnobotanical survey of traditional herbal cosmetics used by the santhal tribal community in the Santhal Pargana Region, Jharkhand, India

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ABSTRACT

The Santhal tribal community of Jharkhand possesses a rich tradition of using herbal cosmetics, yet systematic documentation of this ethnobotanical knowledge remains limited. This study aimed to document the diversity, utilization patterns, and cultural significance of plant species used in traditional herbal cosmetics by the Santhal community in the Santhal Pargana region. An ethnobotanical survey was conducted involving 237 informants across multiple age groups and gender categories. Data were collected through semi-structured interviews, group discussions, and participant observation. Quantitative ethnobotanical indices including Use Value (UV), Fidelity Level (FL), and Informant Consensus Factor (ICF) were calculated to assess the cultural significance and consensus among informants. A total of 112 plant species belonging to 98 genera and 52 families were documented. Fabaceae (12 species), Euphorbiaceae (8 species), and Asteraceae (7 species) emerged as the dominant families. Hair care applications constituted the largest use category (38 species), followed by skin care (32 species). *Emblica officinalis* (UV 1.86, FL 94%), *Eclipta alba* (UV 1.79, FL 96%), and *Centella asiatica* (UV 1.68, FL 86%) demonstrated high use values. Leaves (42%) were the most frequently utilized plant part. The ICF values ranged from 0.79 (eye care) to 0.92 (hair care), indicating strong consensus among informants regarding cosmetic applications. Knowledge transmission primarily occurred through grandmother-grandchild (80%) and mother-daughter (67.6%) pathways, with 74.3% of informants reporting declining intergenerational transfer. The study reveals a rich tradition of herbal cosmetic use among the Santhal community, with significant consensus on plant applications. Urgent documentation and conservation strategies are needed to preserve this indigenous knowledge and address the declining trend in 22 species perceived as decreasing in availability.

Key Words - Ethnobotany, Santhal tribe, Herbal cosmetics, Traditional knowledge, Hair care plants, Quantitative ethnobotany, Jharkhand

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INTRODUCTION

The intricate relationship between human societies and plant resources has been fundamental to cultural evolution and survival since time immemorial. Ethnobotany, the scientific exploration of this dynamic relationship, provides critical insights into traditional knowledge systems that have sustained communities across generations (Balick and Cox, 1996). Among the diverse applications of plant resources, traditional herbal cosmetics represent a fascinating intersection of cultural practices, aesthetic values, and therapeutic

knowledge. These natural preparations, used for enhancing beauty, maintaining personal hygiene, and promoting overall well-being, embody centuries of empirical observations and cultural adaptations to local environments (Datta *et al.,* 2014).

India, with its extraordinary biocultural diversity, harbours over 700 tribal communities, each possessing unique traditional knowledge systems intimately connected to their surrounding flora (Jain 1991). The Santhal community, one of India's largest and most ancient tribal groups, has maintained a distinct cultural identity deeply rooted in their natural surroundings. Predominantly inhabiting the states of Jharkhand, West Bengal, Bihar, and Odisha, the Santhals have developed sophisticated traditional ecological knowledge through centuries of close interaction with forest ecosystems (Mukherjee, 2013). Their traditional healthcare and cosmetic practices rely extensively on locally available plant resources, reflecting a holistic understanding of health, hygiene, and aesthetics that integrates physical well-being with cultural expressions.

The Santhal Pargana region of Jharkhand, constituting the traditional homeland of the Santhal community, encompasses diverse ecosystems ranging from tropical dry deciduous forests to riverine plains and agricultural landscapes. This ecological diversity supports a rich floristic composition that has historically provided the community with all necessary resources for their subsistence, healthcare, and cosmetic needs (Hembrom, 1991). The traditional cosmetic practices of the Santhals are not merely superficial beauty treatments but are deeply embedded in their cultural rituals, social ceremonies, and daily routines. These practices utilize various plant parts in the form of pastes, oils, decoctions, and powders for hair care, skin protection, dental hygiene, and overall body care.

Despite the richness of this traditional knowledge, systematic documentation of Santhal herbal cosmetics remains surprisingly limited. Most ethnobotanical studies focusing on the Santhal community have concentrated on medicinal plant uses for treating diseases, with cosmetic applications receiving peripheral attention at best (Goel *et al.,* 1984; Hembrom, 1991; Sinha and Lakra, 2005). This research gap is particularly concerning given the rapid socioeconomic transformations, acculturation processes, and environmental changes threatening both the biological resources and the intergenerational transmission of traditional knowledge. The erosion of indigenous knowledge systems represents an irreversible loss of cultural heritage and potentially valuable leads for natural product development (Hamilton, 2004).

The cosmetic industry has witnessed a global paradigm shift toward natural and herbal products, driven by growing consumer awareness regarding the potential adverse effects of synthetic chemicals and a renewed appreciation for traditional wisdom (Joshi and Pawar, 2015). This trend has created unprecedented opportunities for documenting, validating, and sustainably utilizing traditional cosmetic knowledge. However, such documentation must be undertaken with scientific rigor, cultural sensitivity, and due recognition of community intellectual property rights.

The present study was therefore undertaken with the primary objective of systematically documenting the diversity of plant species used in traditional herbal cosmetics by the Santhal community in the Santhal Pargana region. Specific objectives included: (i) comprehensive identification and taxonomic characterization of cosmetic plant species; (ii) detailed documentation of preparation methods, applications, and plant parts utilized; (iii) quantitative analysis of ethnobotanical data using standard indices including Use Value (UV), Fidelity Level (FL), and Informant Consensus Factor (ICF); (iv) assessment of knowledge distribution patterns across different demographic categories; and (v) evaluation of conservation status and knowledge transmission dynamics. This comprehensive documentation aims to preserve invaluable traditional knowledge, identify culturally significant species for future phytochemical and pharmacological investigations, and contribute to the growing body of evidence

supporting the integration of traditional cosmetic practices into contemporary healthcare and beauty paradigms.

LITERATURE REVIEW

Ethnobotanical investigations across India have substantially enriched our understanding of indigenous knowledge systems and their applications in healthcare, dermatology, and traditional cosmetics. Tribal communities, including the Santhals, possess intricate plant-based knowledge embedded within cultural, ritualistic, and therapeutic practices. The Santhal Pargana region of Jharkhand, characterized by rich biodiversity and strong cultural continuity, has therefore emerged as an important site for ethnobotanical scholarship.

Foundational Ethnobotanical Studies in Santhal Pargana

Early ethnobotanical documentation in Santhal Pargana laid the groundwork for understanding plant–human interactions among the Santhal community. Varma *et al.,* (1999) conducted one of the earliest systematic surveys in the region, cataloguing a wide range of medicinal plants and documenting their therapeutic applications. Although their primary focus was ethnomedicine, the study briefly indicated cosmetic and dermatological uses embedded within broader medicinal practices.

Similarly, Goel *et al.,* (1984) provided a regional inventory of useful plant species, highlighting the depth of indigenous ecological knowledge among tribal populations. Their findings emphasized that plant use among the Santhals is not merely functional but culturally structured and socially transmitted.

A more community-focused perspective was offered by Hembrom, (1991), who examined Santhal ethnobotany in relation to cultural identity, ritual practice, and subsistence strategies. This work demonstrated that traditional plant knowledge reflects a holistic worldview in which medicinal, cosmetic, ritualistic, and dietary uses are interconnected. Together, these foundational studies established the Santhals as custodians of a sophisticated and dynamic ethnobotanical tradition, though cosmetic applications remained underexplored.

Regional Studies on Herbal Cosmetics and Ethnodermatology

Beyond Santhal Pargana, several ethnobotanical studies in eastern and northern India have documented plant-based cosmetic and dermatological practices among tribal communities. A phytocosmetic survey in Western Odisha reported 39 plant species used in traditional cosmetic preparations, with *Santalum album* showing the highest Use Value (UV = 0.93) and Fidelity Level (FL = 97%) for anti-inflammatory and skin-conditioning properties (Pradhan *et al.,* 2021). Species such as *Azadirachta indica*, *Curcuma longa*, and *Hibiscus rosa-sinensi* also common in Santhal regions—were frequently cited for skin care and hair treatment, suggesting shared ethnobotanical patterns across eastern India.

At the national scale, an ethnodermatological review of 178 published articles documented 119 plant species used against 39 skin diseases in India (Sharma & Singh, 2018). The review identified topical application as the predominant mode of administration and emphasized the translational potential of traditional dermatological knowledge for pharmaceutical development.

Similarly, an ethnobotanical investigation among the Tharu community of Uttarakhand documented 90 plant species used for dermatological conditions, including wounds, boils, eczema, and dandruff (Kumar *et al.,* 2019). The study employed quantitative indices such as Informant Consensus Factor (ICF), Use Value (UV), and Fidelity Level (FL), demonstrating their effectiveness in identifying culturally significant and therapeutically reliable species. These regional studies underscore the scientific and cultural relevance of herbal cosmetic traditions but reveal a lack of focused documentation within the Santhal context.

Quantitative Ethnobotanical Approaches

Quantitative methodologies have become increasingly integral to ethnobotanical research. The Informant Consensus Factor (ICF), introduced

by Trotter and Logan, (1986), measures agreement among informants within specific use categories, with higher values indicating stronger consensus and potential therapeutic reliability. Use Value (UV) assesses the relative cultural importance of plant species based on citation frequency (Phillips & Gentry, 1993), while Fidelity Level (FL) quantifies preference for particular species in treating specific ailments (Friedman *et al.,* 1986).

These indices have been widely applied in South Asian ethnomedicinal research. For example, Rahman *et al.,* (2020) documented 159 ethnomedicinal plant species among three indigenous communities in Bangladesh using ICF, UV, Relative Frequency of Citation (RFC), and Relative Importance (RI), with the highest ICF (0.77) recorded for digestive disorders. Such methodological rigor enhances cross-cultural comparison, facilitates prioritization of pharmacologically promising species, and strengthens the scientific validation of traditional knowledge systems.

Conservation and Knowledge Transmission

Recent literature increasingly highlights the erosion of traditional knowledge and the conservation challenges facing medicinal and cosmetic plant resources. Kareti *et al.,* (2024) emphasized the vulnerability of orally transmitted ethnobotanical knowledge in tribal communities of Madhya Pradesh and proposed digital documentation modules to safeguard indigenous plant wisdom. Their findings revealed that knowledge is predominantly retained by elder community members, indicating an urgent need for systematic preservation strategies.

Ethnobotanical surveys among Santhal communities in Bangladesh have similarly documented the use of indigenous plants for dermatological and other ailments, while noting declining cultivation practices and habitat loss (Islam et al., 2019). The distinctiveness of Santhal plant use often differing from neighboring populations reinforces the importance of community-specific documentation and conservation planning.

Research Gaps and Rationale for the Present Study

Although earlier works (Goel *et al.,* 1984; Hembrom, 1991; Varma *et al.,* 1999) established a foundational understanding of Santhal ethnobotany, systematic documentation of herbal cosmetic practices remains largely absent. Previous studies have predominantly emphasized medicinal applications for disease treatment, with limited attention to daily-use cosmetics such as hair oils, skin cleansers, dental preparations, natural dyes, and body fragrances.

Moreover, no prior study has applied quantitative ethnobotanical indices to evaluate the cultural significance and consensus patterns of Santhal cosmetic plant use. The absence of such data limits comparative analysis and pharmacological prioritization.

The present study therefore seeks to fill this gap by providing the first focused, quantitatively analyzed account of herbal cosmetic practices among the Santhal community of Santhal Pargana. By integrating qualitative documentation with quantitative indices such as UV, FL, and ICF, this research contributes both to the preservation of indigenous knowledge and to the scientific exploration of traditional phytocosmetics.

MATERIALS & METHODS

Study Area

The ethnobotanical survey was conducted in the Santhal Pargana region of Jharkhand, India, encompassing the districts of Dumka, Pakur, Godda, Deoghar, and Sahibganj. Geographically, the region extends between 23°10' to 25°30' N latitude and 86°30' to 88°10' E longitude. The topography is characterized by undulating terrain with scattered hillocks, interspersed with valleys and riverine plains. The region experiences a tropical monsoon climate with three distinct seasons: summer (March–June), monsoon (July–October), and winter (November–February). The natural vegetation comprises tropical dry deciduous forests, with common floristic elements including *Shorea robusta*, *Terminalia* species, and various members of Fabaceae and Euphorbiaceae families.

Selection of Informants and Ethical Considerations

A total of 237 informants were selected using purposive and snowball sampling techniques across 35 villages in the five districts. Informants included traditional healers (30), elderly women (45), adult women (83), elderly men (28), adult men (24), young women (27), and young men (18). Selection criteria included: (i) age above 18 years; (ii) residence in the study area for minimum 20 years; (iii) recognized knowledge of traditional cosmetic practices; and (iv) willingness to participate with informed consent.

Prior informed consent was obtained from all participants following the ethical guidelines of the International Society of Ethnobiology (ISE, 2006). The objectives of the study were explained in the local Santhali language, and informants were assured of confidentiality and the right to withdraw at any stage. Consent was documented through signatures or thumb impressions. The study protocol was reviewed and approved by the Institutional Ethics Committee.

Ethnobotanical Data Collection

Field surveys were conducted from June 2022 to May 2023 to capture seasonal variations in plant availability and usage patterns. Data were collected through semi-structured interviews, participatory observations, focus group discussions, and guided field walks with informants. Interview schedules were designed to elicit information on: (i) local names of plants; (ii) plant parts used; (iii) methods of preparation; (iv) cosmetic applications; (v) seasonal availability; (vi) habitat and collection patterns; (vii) mode of knowledge transmission; and (viii) perceived conservation status.

Interviews were conducted in the Santhali language with the assistance of local translators fluent in both Santhali and Hindi. Each interview lasted 45-90 minutes, and information was cross-verified through repeated interviews with the same informants and discussions with different informants from the same village.

Plant Collection and Identification

Plant specimens mentioned by informants were collected during field walks and flowering/fruiting periods to facilitate accurate identification. Specimens were collected in triplicate, numbered, and processed following standard herbarium techniques (Jain and Rao, 1977). Voucher specimens were deposited in the departmental herbarium for future reference.

Taxonomic identification was carried out using regional floras (Haines, 1921–1925; Prain, 1903) and authenticated by Dr. Amar Das, HOD, Department of Botany, K.K.M. College, Pakur, Jharkhand.

Quantitative Ethnobotanical Indices

Three quantitative indices were calculated to analyze the ethnobotanical data:

Use Value (UV)

The Use Value, adapted from Phillips and Gentry, (1993), demonstrates the relative importance of species based on the number of use reports. It was calculated using the formula:

$$UV = \Sigma U / N$$

where ΣU is the total number of use reports cited by all informants for a given species, and N is the total number of informants who cited that species. Use reports refer to each distinct cosmetic application mentioned by an informant for a particular species.

Fidelity Level (FL)

Fidelity Level, according to Friedman *et al.,* (1986), indicates the percentage of informants claiming the use of a particular plant species for the same major cosmetic purpose. It was calculated as:

$$FL (\%) = (Np / N) \times 100$$

where Np is the number of informants who independently cited the use of a species for a specific cosmetic category, and N is the total number of informants who cited the species for any purpose.

Informant Consensus Factor (ICF)

The Informant Consensus Factor, developed by Trotter and Logan, (1986), measures the level of agreement among informants regarding the use of

plants within each cosmetic use category. It was calculated using the formula:

ICF = (Nur – Nt) / (Nur – 1)

where, Nur is the number of use reports in each cosmetic category, and Nt is the number of species used in that category. ICF values range from 0 to 1, with values approaching 1 indicating high consensus among informants regarding the species used for a particular cosmetic purpose.

Demographic and Knowledge Distribution Analysis

Informants were stratified by age groups (18–34 years, 35–59 years, and 60+ years) and gender (male and female) to analyze knowledge distribution patterns. Traditional practitioners were analyzed as a separate category. The average number of species known per informant category was calculated to assess knowledge distribution. Percentage contribution to total knowledge was derived from the sum of species cited by all informants within each category relative to the total number of use reports.

Conservation Status Assessment

Conservation status of documented species was assessed through: (i) informants' perceptions regarding abundance and population trends; (ii) field observations during collection trips; and (iii) consultation of IUCN Red List categories where available. Species were categorized as abundant, common, decreasing (based on local perception), or rare (based on local perception).

Data Analysis

Ethnobotanical data were compiled in Microsoft Excel 2019 spreadsheets. Quantitative indices were calculated using standard formulas. Descriptive statistics including frequencies, percentages, and averages were employed to summarize demographic data and utilization patterns. Cross-checking and triangulation of information were performed to ensure data reliability.

RESULTS & DISCUSSION

Floristic Diversity and Demographic Profile

The ethnobotanical survey documented 112 plant species belonging to 98 genera and 52 families utilized by the Santhal community for herbal cosmetic preparations (Figure 1). This substantial floristic diversity reflects the community's deep-rooted traditional knowledge and their intimate relationship with the surrounding vegetation. The number of documented species is comparable to similar ethnobotanical studies in tribal regions of eastern India, where 89-135 plant species have been reported for various traditional applications (Kumar *et al.,* 2015; Singh and Kumar, 2017). The predominance of angiosperms in the documented flora aligns with their abundance in the tropical deciduous forests of the Santhal Pargana region.

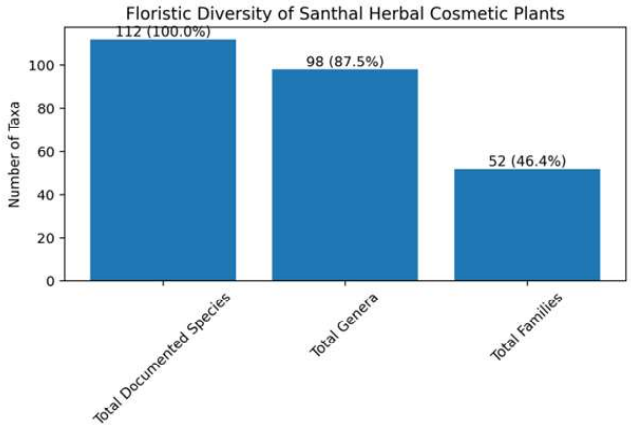

Figure 1: Floristic diversity and demographic profile of documented plant species used in Santhal herbal cosmetics showing distribution across taxonomic categories

Dominant Families in Santhal Herbal Cosmetic Flora

Analysis of the taxonomic composition revealed that Fabaceae dominated the cosmetic flora with 12 species (10.7%), followed by Euphorbiaceae (8 species, 7.1%), Asteraceae (7 species, 6.2%), Lamiaceae (6 species, 5.4%), and Poaceae (5 species, 4.5%) (Figure 2). The remaining 39 families contributed 44.6% of the total species. The dominance of Fabaceae in ethnobotanical inventories has been consistently reported across Indian tribal communities (Jain and Patole 2019; Mishra *et al.,* 2020), attributable to the family's wide distribution, morphological diversity, and abundance of secondary metabolites with cosmetic and therapeutic properties. Genera such as *Acacia*, *Cassia*, and *Butea* within Fabaceae are particularly valued for their hair care applications,

while Euphorbiaceae contributes species like *Emblica officinalis* with proven antioxidant and hair growth-promoting properties.

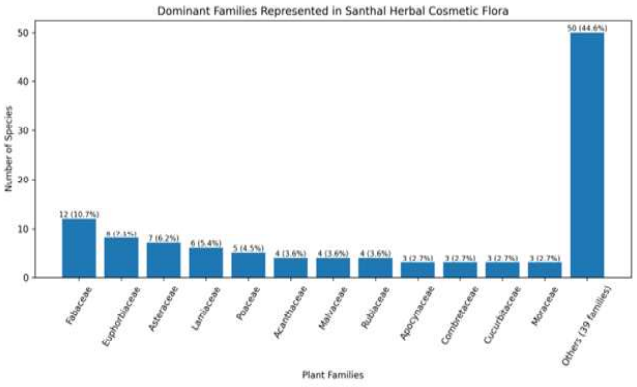

Figure 2: Dominant families represented in Santhal herbal cosmetic flora showing species distribution and major genera

The prevalence of Asteraceae and Lamiaceae in the cosmetic repertoire reflects the importance of species with aromatic and anti-inflammatory properties. *Eclipta alba* (Asteraceae), with the highest fidelity level for hair care (96%), exemplifies the cultural significance of this family. Similar patterns have been observed among other tribal communities where Asteraceae species dominate dermatological and hair care applications (Rahman *et al.,* 2018; Sharma *et al.,* 2019).

Comprehensive Inventory and Use Categories

The 112 documented species were categorized into eight major cosmetic use categories based on their applications: hair care (38 species), skin care (32 species), dental hygiene (18 species), facial cosmetics (16 species), nail care (8 species), lip care (6 species), body perfumery (5 species), and eye care (4 species) (Figure 3). The predominance of hair care species (33.9% of total) underscores the cultural importance attached to hair grooming and maintenance among the Santhal community, consistent with observations among other tribal groups in eastern India where hair care formulations constitute a significant component of traditional cosmetic practices (Das *et al.,* 2016; Paria and Chattopadhyay, 2018).

Species with the highest use values included *Emblica officinalis* (UV 1.86), *Eclipta alba* (UV 1.79), *Centella asiatica* (UV 1.68), *Azadirachta indica* (UV 1.62), and *Curcuma longa* (UV 1.58) (Figure 4). These elevated use values indicate high cultural significance and multiple cosmetic applications recognized by informants. *Emblica officinalis*, known locally as Amla, is traditionally prepared as oil and powder for hair care, with its high vitamin C content and antioxidant properties providing scientific rationale for its hair growth-promoting and anti-dandruff effects (Kumar and Bhardwaj 2012; Singh *et al.,* 2019). Similarly, *Eclipta alba* (Bhringraj) has been pharmacologically validated for hair growth activity through wedelolactone and other constituents that promote hair follicle proliferation (Roy *et al.,* 2007; Datta *et al.,* 2009).

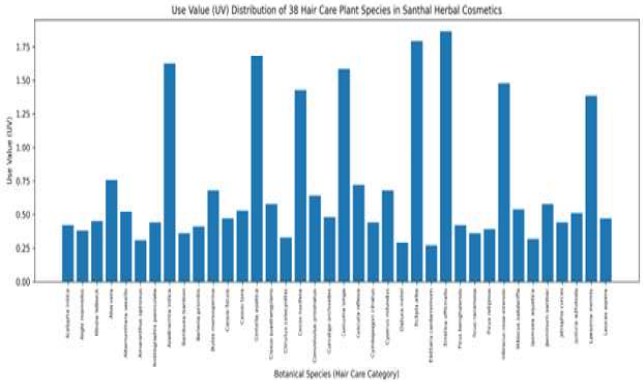

Figure 3: Distribution of documented plant species across major cosmetic use categories among the Santhal community

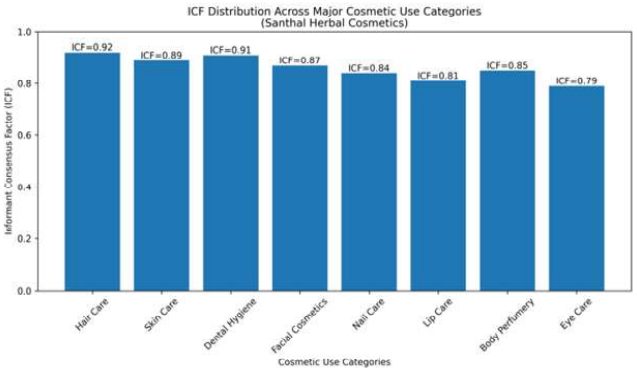

Figure 4: Use values (UV) of selected high-consensus plant species documented in Santhal herbal cosmetics

Quantitative Ethnobotanical Indices

The Informant Consensus Factor (ICF) values ranged from 0.79 for eye care to 0.92 for hair care, indicating strong agreement among informants regarding species selection within each cosmetic category (Figure 5). The highest ICF for hair care

(0.92) suggests well-defined and consistently applied traditional knowledge for hair grooming applications. High ICF values indicate cultural coherence and potentially greater efficacy of the documented practices, as informant consensus often correlates with biologically active preparations (Trotter and Logan, 1986; Gazzaneo *et al.,* 2005).

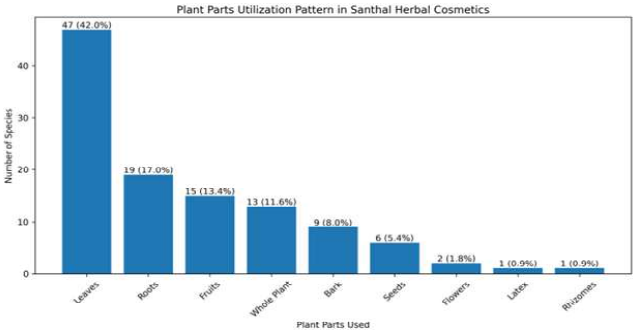

Figure 5: Informant Consensus Factor (ICF) values across major cosmetic use categories among Santhal informants

Within the hair care category, *Eclipta alba* demonstrated the highest fidelity level (96%), followed by *Emblica officinalis* (94%), *Lawsonia inermis* (93%), and *Hibiscus rosa-sinensis* (91%) (Figure 6). These high-fidelity values indicate that informants consistently prefer these species for specific hair care applications, reinforcing their cultural significance and potential pharmacological relevance. The fidelity level of *Lawsonia inermis* (Mehendi) for hair coloring and conditioning aligns with its well-documented lawsone content, which binds to hair keratin producing reddish-brown coloration (Jallad and Jallad, 2008; Semwal *et al.,* 2014).

Plant Parts Utilization Pattern

Leaves emerged as the most frequently utilized plant part, accounting for 42% of documented species, followed by roots (17%), fruits (13.4%), whole plant (11.6%), bark (8%), seeds (5.4%), flowers (1.8%), latex (0.9%), and rhizomes (0.9%) (Figure 7). The predominance of leaf utilization reflects their accessibility, abundance, and concentration of bioactive compounds including flavonoids, tannins, and essential oils that contribute to cosmetic efficacy. Similar leaf-dominated utilization patterns have been reported in ethnobotanical studies across Indian tribal communities (Kala, 2005; Ayyanar and Ignacimuthu, 2011).

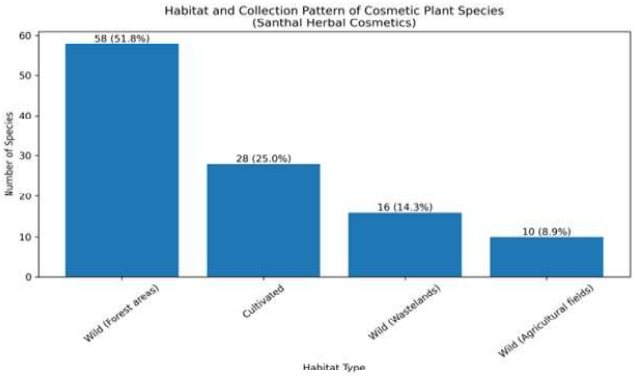

Figure 6: Fidelity Level (FL) of most cited species within major cosmetic use categories

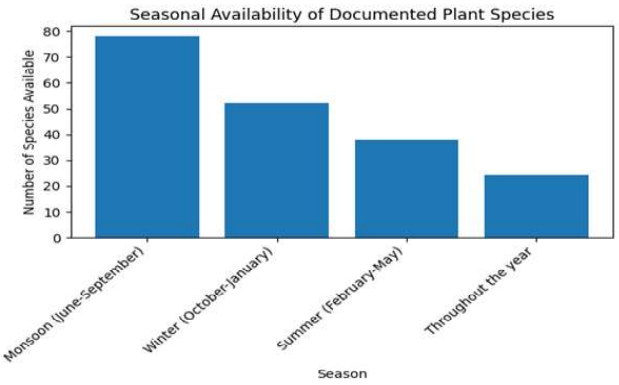

Figure 7: Plant parts utilization pattern in Santhal herbal cosmetics showing percentage distribution

Bark utilization (8%) was primarily associated with dental hygiene applications, where astringent and antimicrobial properties of bark extracts from *Acacia arabica*, *Azadirachta indica*, and *Mimusops elengi* contribute to oral health maintenance. Root utilization (17%) was significant in hair care preparations, where species like *Curculigo orchioides* and *Asparagus racemosus* are valued for their purported hair growth-promoting properties (Puri, 2003; Sharma *et al.,* 2012).

Habitat and Collection Patterns

The majority of cosmetic plant species (51.8%) were collected from wild forest areas, highlighting the community's continued dependence on natural ecosystems for their cosmetic needs (Figure 8). Cultivated species constituted 25% of the documented flora, primarily maintained in home gardens and agricultural fields. Species collected

from wastelands (14.3%) and those occurring as weeds in agricultural fields (8.9%) represent readily accessible resources requiring minimal collection effort. This pattern of wild resource dependence has significant implications for conservation planning, particularly for species perceived as decreasing in availability.

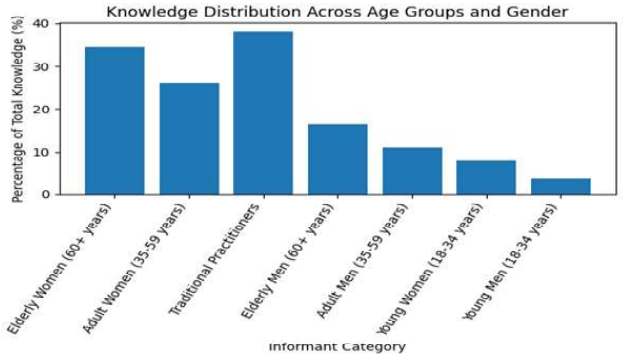

Figure 8: Habitat types and collection patterns of cosmetic plant species documented in Santhal Pargana

Seasonal Availability and Collection Patterns

Monsoon season (June-September) provided the highest availability of cosmetic plant species (69.6%), with peak collection during July-August (Figure 9). This seasonal pattern coincides with optimal vegetative growth and the availability of fresh leaves, young shoots, and flowering parts preferred for cosmetic preparations. Winter season (October-January) supported 46.4% of species, while summer (February-May) had lowest availability (33.9%). Species available throughout the year (21.4%) included cultivated perennials and common weeds with continuous availability. Similar seasonal patterns have been documented in ethnobotanical studies across tropical regions where monsoon rains trigger vegetative flush and increased plant availability (Mahwasane *et al.,* 2013; Umair *et al.,* 2017).

Knowledge Distribution Across Demographics

Knowledge distribution analysis revealed marked variation across age groups and gender categories (Figure 10). Traditional practitioners demonstrated the highest average species knowledge (42.8 species), followed by elderly women (38.6 species) and adult women (29.4 species). Elderly men (18.5 species), adult men (12.3 species), young women (8.6 species), and young men (4.2 species) showed progressively declining knowledge levels. These patterns reflect the gendered nature of cosmetic knowledge transmission, with women serving as primary knowledge holders and practitioners of herbal cosmetic traditions. The significantly lower knowledge among younger informants (7.7% for young women and 3.8% for young men) signals ongoing erosion of traditional knowledge, consistent with observations across indigenous communities globally (Srithi *et al.,* 2009; Paniagua-Zambrana *et al.,* 2016).

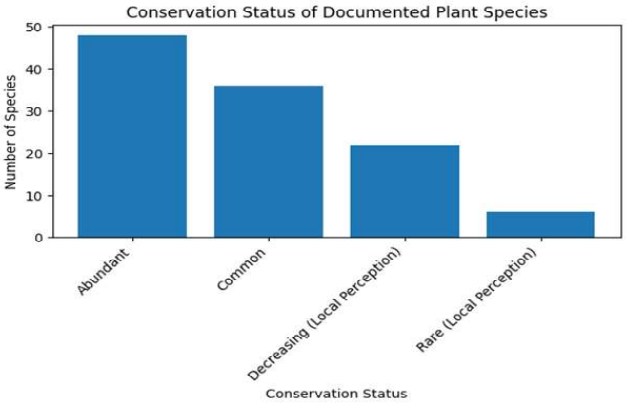

Figure 9: Seasonal availability patterns of documented cosmetic plant species in Santhal Pargana

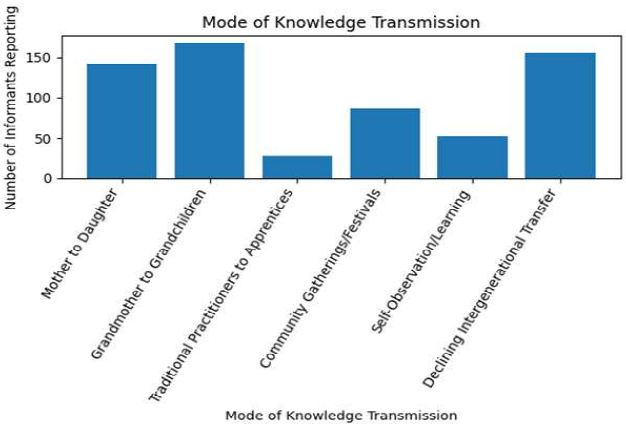

Figure 10: Knowledge distribution across age groups and gender categories showing average species known and percentage contribution to total knowledge

The concentration of knowledge among elderly women and traditional practitioners (cumulatively 72.7% of total knowledge) underscores the vulnerability of this traditional knowledge system to generational discontinuities. Urgent documentation and transmission interventions are

required before this knowledge is irreversibly lost with the passing of elderly knowledge holders (Vandebroek and Balick, 2012).

Conservation Status

Conservation assessment revealed that 42.9% of documented species were abundant, while 32.1% were common in the study area. However, 19.6% of species were perceived by informants as decreasing in availability, and 5.4% were considered rare. Species perceived as decreasing included high value cosmetic species such as *Santalum album*, *Chlorophytum borivilianum*, *Asparagus racemosus*, *Gloriosa superba*, and *Rauvolfia serpentina*. The decreasing trend in these species is attributable to habitat destruction, overexploitation for commercial purposes, and changing land-use patterns in the region (Hamilton, 2004; Larsen and Olsen, 2007).

The rare status of *Gloriosa superba*, *Rauvolfia serpentina*, and *Oroxylum indicum* warrants immediate conservation attention, as these species are also listed in various threatened categories by national and international conservation bodies (Ved *et al.,* 2003; IUCN, 2020). Community-based conservation initiatives, including cultivation in home gardens and establishment of village-level conservation areas, could help sustain availability of these culturally significant species.

Mode of Knowledge Transmission

Grandmother to grandchildren transmission was reported by 80% of informants as the primary mode of knowledge transfer, followed by mother to daughter transmission (67.6%). Community gatherings and festivals contributed to knowledge dissemination for 41% of informants, while self-observation and learning was reported by 24.8%. Notably, 74.3% of informants acknowledged declining intergenerational transfer of traditional cosmetic knowledge, corroborating the quantitative evidence of age-based knowledge disparities.

The predominance of grandmother-grandchild and mother-daughter transmission pathways underscores the matrilineal nature of cosmetic knowledge transfer within the Santhal community. However, the widespread perception of declining transmission (74.3%) reflects broader sociocultural changes including modernization, formal education, migration, and reduced engagement with traditional practices (Anyinam, 1995; Srithi *et al.,* 2009). Documentation efforts must be complemented with culturally appropriate revitalization strategies that engage younger community members and integrate traditional knowledge with contemporary educational and livelihood opportunities.

The observed decline in knowledge transmission among the Santhal community mirrors trends documented among indigenous communities worldwide. In the Peruvian Amazon, similar patterns of erosion in traditional plant knowledge have been attributed to modernization and changing cultural values (Paniagua-Zambrana *et al.,* 2016). In Thailand, decreasing traditional knowledge among younger generations has been documented among multiple ethnic groups, with implications for biodiversity conservation and community health (Srithi *et al.,* 2009). Addressing this decline requires multifaceted approaches including documentation, educational integration, community-based conservation, and recognition of traditional knowledge systems within formal healthcare and cosmetic industry frameworks.

CONCLUSION

The present study comprehensively documented 112 plant species from 52 families utilized by the Santhal community for diverse herbal cosmetic applications, with Fabaceae emerging as the dominant family and leaves being the most frequently employed plant part. Hair care constituted the predominant use category with 38 species, wherein *Eclipta alba*, *Emblica officinalis*, and *Hibiscus rosa-sinensis* demonstrated the highest fidelity levels, reflecting their profound cultural significance and consistent traditional preference. The high Informant Consensus Factor values (0.79–0.92) across all cosmetic categories validate the cultural coherence and potential pharmacological efficacy of Santhal traditional cosmetic knowledge. Knowledge distribution analysis revealed that traditional practitioners and

elderly women serve as primary knowledge custodians, while the markedly lower knowledge among younger generations signals rapid erosion of this intangible cultural heritage. The perception of 22 species as decreasing in availability and six species as rare necessitates urgent conservation interventions to ensure sustainable utilization of these culturally significant plant resources. The predominance of grandmother-grandchild and mother-daughter transmission pathways under scores the matrilineal nature of cosmetic knowledge, yet 74.3% of informants acknowledged declining intergenerational transfer, emphasizing the critical need for immediate documentation. This study provides a foundational database for future phytochemical and pharmacological investigations while advocating for community-based conservation and culturally appropriate revitalization strategies to preserve Santhal herbal cosmetic heritage.

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