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Exploring Indigenous Knowledge and Practices: Cultural and Ecological Dimensions of Spice Diversity in Hadiya and Kambata-Tembaro, Central Ethiopia

OSIE MULATU [1*]

[1] *Department of Biology, College of Natural and Computational Sciences, Wachemo University, Hosana, Ethiopia.*

**Correspondence details: mule4922@gmail.com*

Abstract: This study investigates the indigenous knowledge and cultural traditions linked to spice diversity in Hadiya and Kambata-Tembaro Zones, Ethiopia. Using semi-structured interviews, focus group discussions, and field observations, the research emphasizes the central role of women in preserving and applying this knowledge. A total of 35 spice species mainly herbaceous, with Lamiaceae as the dominant family were identified. The findings underscore the importance of homegardens as hubs for agrobiodiversity and intergenerational knowledge transmission. Spices serve not only culinary purposes but also medicinal and ritual functions, reflecting their deep cultural significance. Community rankings and food preparation practices showed that spice value is rooted in both health benefits and symbolic meaning. The study also exposes gender and economic inequalities, noting women's limited access to land, resources, and decision-making, despite their critical role. It advocates for gender-equitable and culturally sensitive policies to protect traditional ecological knowledge. Furthermore, it calls for locally driven conservation efforts and interdisciplinary research to ensure sustainable spice cultivation. Overall, the research contributes to global discussions on preserving biocultural heritage and supports empowering indigenous communities especially women as vital stewards of biodiversity and cultural continuity amid environmental and social transformations.

Keywords: Culinary practices, Ethiopia, ethnobotany, homegardens, indigenous knowledge, spices

Introduction

Ethiopia's southern highlands, particularly the Hadiya and Kambata-Tembaro zones, are home to a vibrant legacy of spice cultivation that reflects the merging of deep cultural, medicinal, and ecological values. The area rich cultural and culinary heritage is inextricably linked to its diverse array of spices. In these regions, indigenous communities have long nurtured as stewards of diverse spice plants, cultivating species such as *Aframomum corrorima* (Braun) Jansen (korarima), *Ruta chalepensis L.*, *Capsicum frutescens L.* (chili), *Allium sativum L.* (garlic), and *Zingiber officinale* Roscoe (ginger). These plants are far more than culinary ingredients; they are deeply woven into local healing practices, ritual life, and social identity, reflecting generations of accumulated knowledge, symbolic meaning and therapeutic roles in everyday life (Muluneh et al., 2022; Wubu et al., 2023).

These essential spices are predominantly nurtured within household homegardens and small, intimate plots. These agroecosystems function as dynamic reservoirs for the intergenerational

transfer of invaluable knowledge concerning cultivation cycles, optimal planting seasons, and adaptive ecological strategies (Jegora et al., 2025). Within these biocultural landscapes, spice plants flourish alongside medicinal herbs and vital food crops, sustained through intricate community practices that reflect a profound ecological understanding (Terfassa, 2021). The profound indigenous knowledge surrounding plant uses, particularly for medicinal applications, underpins the daily lives of Hadiya and Kambata-Tembaro communities. For instance, *A. corrorima* seeds are widely recognized in traditional medicine as a carminative and tonic, often incorporated into essential spice blends like *berbere*, while *R. chalepensis* is instrumental in treating infections, digestive ailments, and holds a significant place in ceremonial contexts, such as the revered Ethiopian coffee ceremony (Muluneh et al., 2022; Wubu et al., 2023). This critical ethnobotanical wisdom, predominantly held and transmitted through oral tradition by women and elders, underscores a deeply gendered dimension to spice-related practices.

The thriving spice systems within the region are a testament to its inherent ecological diversity. Significant variations in elevation, microclimates, and soil composition across relatively short distances support a wide array of landraces, ensuring both biological resilience and cultural continuity (Woyessa et al., 2025; Shumi et al., 2024). These ecological nuances critically influence the timing and methods of spice cultivation, harvesting, and processing, thereby shaping community norms around agroforestry and conservation practices.

However, this rich biocultural tapestry faces increasing vulnerability from modernizing pressures, including agricultural expansion, urban encroachment, and evolving social structures. These external forces threaten not only the biological diversity of spice plants but also the invaluable indigenous knowledge systems that have sustained them for centuries (Liu et al., 2022). Documenting the intricate cultural narratives, ecological strategies, and the gendered division of labor that underpin spice management is, therefore, an urgent imperative for crafting community-based, gender-responsive conservation policies that concurrently bolster food security and safeguard biodiversity.

This study rigorously investigates the intertwined cultural and ecological dimensions of spice diversity in the Hadiya and Kambata-Tembaro Zones. By meticulously exploring indigenous knowledge systems particularly those centered on cultivation, preparation, and symbolic use the research aims to unveil their gendered, ecologically informed, and deeply socially embedded nature. Ultimately, this work seeks to generate critical insights that would inform the development of community-led, gender-sensitive conservation strategies, thereby supporting both the biological richness of the region and its enduring cultural heritage of spices.

Materials and Methods

Study Area Description

Hadiya and Kambata-Tembaro Zones, the integral to Ethiopia's recently established Central Ethiopia Regional State, present a compelling mosaic of administrative, demographic, and geographical characteristics critical to understanding their unique biocultural landscape (Fig. 1). Administratively, Hadiya Zone is segmented into 17 districts with its capital at Hosanna, situated approximately 267 km southwest of Addis Ababa, while Kembata-Tembaro Zone, comprising 14 districts, centers its administration in Durame, located about 260 km southwest of the capital of Ethiopia. These zones are densely populated, housing over 2.4 million inhabitants, with Hadiya Zone accounting for 1,590,927 people across 3,593.31 km² and Kembata-Tembaro Zone home to 902,073 residents within 1,355.90 km² (CSA, 2018). Geographically, the area lies between 7°05′ and 7°50′ N latitude and 37°15′ and 38°20′ E longitude, a location that imbues them with significant topographical and agroecological diversity. Elevations span a remarkable range from 1,400 to 2,950 m asl, fostering varied microclimates, soil compositions, and vegetation types. This pronounced altitudinal gradient is a key driver of the region's rich agrobiodiversity, supporting a wide array of crops, including

diverse spices and vital indigenous food plants, primarily sustained through smallholder, rain-fed subsistence agriculture.

Beyond their physical and demographic attributes, the Hadiya and Kambata-Tembaro Zones are characterized by a vibrant cultural tapestry woven from centuries of agrarian traditions, deeply held religious observances, and rich indigenous knowledge systems. Annual celebrations such as Meskel, Gena, and Fasika are not merely religious observances but pivotal social events that profoundly reinforce communal bonds and cultural identity. Traditional cuisine plays a central role in cultural expression, with staples like *Kocho* (fermented enset bread), *Atmit* (spiced porridge), and various forms of *Wot* (stews) showcasing the region's culinary ingenuity, often prepared with locally cultivated spices. The communal sharing of food during holidays and ceremonies transcends mere hospitality, acting as a vital mechanism for preserving ethnobotanical heritage and distinct culinary identities. This dynamic interplay between deeply ingrained traditional livelihood systems, remarkable ecological diversity, and enduring cultural values renders the Hadiya and Kambata-Tembaro Zones exceptionally significant for ethnobotanical research, particularly in the study of indigenous plant use, spice diversity, and sustainable rural development within the contemporary Ethiopian context.

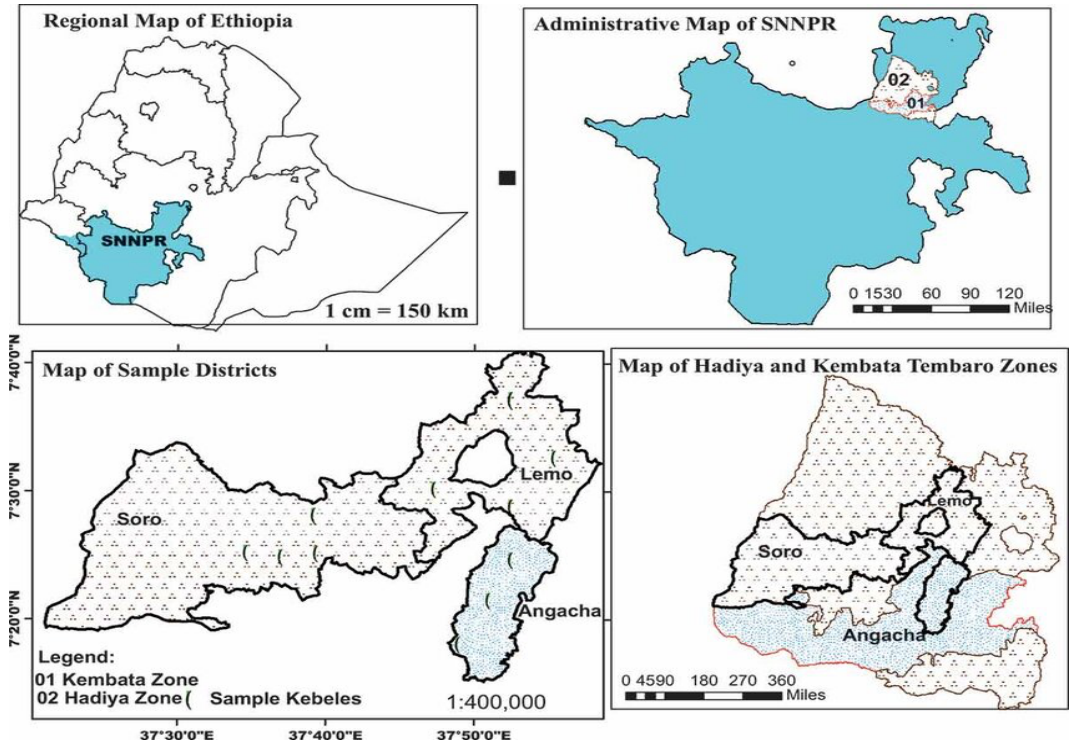

Figure 1. Map of the study area

Study Design

This study rigorously employed a mixed-methods framework to comprehensively investigate spice cultivation, conservation practices, and the intricate indigenous knowledge systems within the study area. Data collection was carried out by employing semi-structured interviews, in-situ observations, and guided field walks in order to gather comprehensive and reliable information. In doing so, this research provides a significant contribution to documenting and safeguarding traditional spice knowledge, a vital component of cultural heritage and a key element in global agrobiodiversity conservation. Moreover, the use of a cross-sectional study design enabled us to integrate ecological and sociocultural perspectives on spice diversity across diverse

agroecological settings. This methodological approach was instrumental in identifying nuanced spatial trends and variations in spice utilization, cultivation intensity, and the efficacy of local conservation strategies.

Sampling and Participant Selection

A purposive sampling approach was adopted to identify eight *kebeles* (the smallest administrative units in Ethiopia) from each of the two study zones. Selection of these *kebeles* was recognized by their significant engagement in homegarden spice cultivation and their abundant indigenous knowledge reservoirs. Within each chosen *kebele*, 48 households were randomly sampled, yielding a robust total of 384 households (192 per zone). The sample notably featured a predominant representation of women, acknowledging their pivotal role and extensive practical knowledge in local spice cultivation, utilization, and management. To cultivate a comprehensive and gender-inclusive understanding of community practices, a smaller proportion of male participants was also thoughtfully included, enabling a nuanced exploration of gender-specific roles, diverse perspectives, and distinct contributions to spice production, utilization, and conservation.

This investigation was entirely prospective, collecting all data directly through interviews and field observations focused on traditional spice use, rather than relying on archived samples, medical records, or previously gathered survey data. Importantly, no personally identifiable information was collected or accessed at any stage of the research; participant identities were rigorously maintained with the strictest confidentiality.

Data Collection Methods

Data for this study were collected using a mixed-methods approach that integrated qualitative techniques to develop a comprehensive understanding of indigenous knowledge systems and community practices related to the use of spices and condiments. The primary data collection methods included semi-structured interviews, participatory observation, and focus group discussions (FGDs), each contributing unique insights into the cultural, culinary, and ecological dimensions of spice use. Additionally, preference ranking exercises were conducted to identify the most valued spices in traditional food preparation and to assess the major threats facing spices in the study area.

Semi-structured Interviews

Key informants were strategically selected to represent a broad spectrum of community knowledge and experience related to spice cultivation and use. These included experienced spice farmers with in-depth expertise in cultivation techniques, knowledgeable women recognized for their practical understanding of spice use in culinary and medicinal contexts, and elderly community members valued for their long-standing engagement with traditional practices and historical perspectives. Interviews were conducted using pre-designed guides that offered a flexible framework, enabling researchers to explore both predetermined themes and emergent insights.

The interviews sought to elicit detailed information on the diversity of spice species cultivated within the community; the multifaceted uses of spices, including culinary, medicinal, and cultural applications; traditional cultivation methods encompassing propagation, maintenance, and harvesting; and the indigenous knowledge systems guiding the conservation and sustainable management of spice resources.

Focus Group Discussions (FGDs)

Focus Group Discussions (FGDs) were conducted to gather collective knowledge and shared experiences related to spice cultivation and use. Each FGD consisted of 6 to 10 participants, purposefully selected to ensure representation from key social groups within the community.

These included farmers, who offered practical insights into cultivation techniques and challenges; women, who shared their expertise in the preparation and domestic use of spices; and elders, who contributed historical perspectives and cultural knowledge.

The discussions focused on the community's shared understanding of spice cultivation, the vital role of spices in sustaining local livelihoods, enhancing food security, and maintaining cultural identity. They also explored the environmental, economic, and social challenges affecting spice production, as well as the community-based strategies employed to conserve spice plant diversity and preserve associated traditional knowledge.

Preference Ranking

Preference ranking was employed to identify both the most culturally valued spices used in traditional food preparation and the most significant threats to spices in the study area. To this end, seven key informants were purposively selected to rank nine commonly used spices. A separate ranking exercise was conducted with the same informants to evaluate seven major threats to spice biodiversity. During this process, participants identified key challenges to spice cultivation, including land pressure, climate change, pest outbreaks, and market fluctuations. Additional data were also collected on local conservation practices, such as traditional preservation methods, seed saving, the use of organic fertilizers, and *in-situ* techniques like fencing and replanting.

Following the method outlined by Martin (1995), each informant ranked five to seven frequently encountered spices and threats by assigning integer values where higher scores indicated greater preference or perceived severity. The scores were then aggregated to produce an overall preference ranking for each spice species and threat factor. This approach enabled the identification of spices regarded as most important in cultural culinary practices and highlighted the most pressing threats to their sustainability within the local context. The Informant Consensus Factor (ICF) values for each use category were calculated as described in the Data Analysis section.

Participatory Observation

Field visits were conducted to homegardens across each of the selected *kebeles*, providing opportunities for the direct observation of spice cultivation practices within their natural agroecological settings. These participatory observations enabled the systematic documentation of various aspects of homegarden management. Particular attention was given to the structural organization and spatial design of the gardens, the diversity of plant species cultivated with a specific focus on spices and the cultivation techniques employed by homegarden owners. Observations also included the conservation practices adopted to sustain spice diversity and productivity, such as organic inputs, mulching, and crop rotation. Furthermore, the spatial arrangement of spice plants was recorded, noting their integration with other crops and their role within the broader agroecological and household production systems.

Plant Identification

During field visits, plant specimens were collected from homegardens for taxonomic identification. Voucher specimens were prepared and initially identified using the *Flora of Ethiopia and Eritrea* (Edwards et al., 1997; Hedberg et al., 2009), and their identification was subsequently confirmed at the National Herbarium of Ethiopia, Addis Ababa University. The authenticated specimens were deposited in both the National Herbarium and the Botany Laboratory of Wachemo University.

Threats to Spice Diversity and Conservation Practices

To identify threats to spice biodiversity, participants were asked about challenges faced in spice cultivation, including factors such as land pressure, climate change, pests, and market demand. Data on conservation practices, including traditional methods of spice preservation, such as seed saving, organic fertilizers, and *in-situ* conservation techniques like fencing and planting, were also gathered through interviews and FGDs. The recruitment of participants took place between 15 February 2024 and 10 August 2024**.**

Data Analysis

Qualitative data obtained from interviews and focus group discussions (FGDs) were transcribed verbatim and analyzed thematically using NVivo software. Thematic analysis involved coding and categorizing responses to identify recurring patterns and themes related to spice cultivation practices, cultural significance, and indigenous knowledge systems. These themes were then interpreted to understand the social and cultural dimensions of spice use in the study communities.

Quantitative data were analyzed using SPSS software. Descriptive statistics were used to summarize socio-demographic characteristics and spice-related variables. Species diversity was assessed using ecological indices such as the Shannon-Wiener diversity index. Preference ranking data were analyzed to determine the most valued spices for culinary and medicinal uses. The Informant Consensus Factor (ICF) was calculated to evaluate the level of agreement among informants on the use of spice species for specific purposes, following Trotter and Logan (1986) and Heinrich et al. (1998). The formula applied was:

ICF = (Nur – Nt) / (Nur – 1)

where *Nur* is the total number of use-reports (citations) for a given use category, and *Nt* is the number of species used in that category. ICF values range from 0 to 1, with higher values indicating greater consensus among informants. In this study, three broad use categories were recognized: culinary**,** medicinal, and ritual and use-reports were derived from coded interview and focus-group data in NVivo, in which each informant's mention of a species for a specific use counted as one use-report. The integration of qualitative and quantitative analyses provided a comprehensive understanding of the ethnobotanical and sociocultural dynamics of spice use in the study area.

Ethical Statement

All participants were adults who provided verbal informed consent, appropriate for the cultural context in which written agreements are uncommon. The consent process was clearly explained, voluntary, and recorded in detailed field notes, often with community elders or local guides serving as witnesses. No minors were included, so parental or guardian consent was not necessary. Given that the study involved non-invasive ethnobotanical interviews, institutional ethical approval was not required. Throughout the research, confidentiality was maintained, ethical principles were respected, and indigenous knowledge was acknowledged with care, ensuring trust and mutual respect between researchers and participants.

Results

Demographic Profiles of the Respondents

A total of 384 respondents (70 males and 314 females) were sampled for the study. The higher proportion of female respondents reflects the better knowledge and practice of female of spices in the study area (Table 1).

Age distribution ranged from 20 to 67 years, with a mean age of 43.45 (±9.95 SD). In terms of education, 42.4% had completed primary school, while 33.6% had attained secondary education (Table 1).

The average family size was 5.76 (±2.24 SD), with 89.1% of households having 4 to 7 members. The remaining 10.9% had 1 to 3 members. Although rare, the largest family size recorded was 9, observed in all study sites except Ashie.

Table 1. Respondents Profile

Demographic characters		Sample sites: Hadiya Zone				Kambata-Tembaro Zone				Total
		Ashie	Hadara	Jajura	Bonosha	Wonko	Masafe	Lesho	Belela	
Gender	M	11	10	15	6	9	9	6	4	70
	F	35	41	40	38	41	44	35	40	314
	Total	46	51	55	44	50	53	41	44	384
Age category	Young	7	12	11	8	12	15	9	8	82
	Middle	24	30	32	22	19	25	23	19	194
	Old	15	9	12	14	19	13	9	17	108
	Total	46	51	55	44	50	53	41	44	384
Education Status	Illiterate	4	4	6	6	10	11	5	9	55
	Religious	4	2	4	4	9	4	4	6	37
	Primary	22	26	27	23	12	18	19	16	163
	Secondary	16	19	18	11	19	20	13	13	129
	Total	46	51	55	44	50	53	41	44	384

** Age category = Young (20 -35), Middle (36-50) and Old age (51^{+}) (ILO, 2011); Educational status = Religious school (Non-formal education), Primary (Grade 1-8), Secondary (Grade 9-12) and Tertiary (College and University education) (MoE, 2018)*

Spices in the study area

A total of 35 spice and condiment species were documented in the Hadiya and Kambata-Tembaro zones, representing 27 genera and 17 botanical families (Table 2). The species display diverse growth forms, with herbaceous plants comprising the majority (22 species, 63%), followed by shrubs (8 species, 23%) and trees (5 species, 14%). This dominance of herbaceous species reflects their accessibility, rapid growth cycles, and suitability for small-scale cultivation, which make them particularly prominent in both culinary and medicinal applications.

The most commonly used and culturally significant spices were predominantly herbaceous, reinforcing their centrality in the community's ethnobotanical practices. Lamiaceae emerged as the most species-rich family with 8 representatives, followed by Apiaceae (5 species), Zingiberaceae (4), Rutaceae (3), and Asteraceae (2). The remaining families were represented by single species, collectively contributing to the region's rich phytocultural landscape.

In terms of habitat distribution, the majority of species (28 species, 80%) were sourced from homegardens, emphasizing the role of household agroecosystems in conserving spice diversity. The remaining 7 species (20%) were obtained from cultivated fields, suggesting a supplementary role of formal agriculture in spice production. This pattern aligns with ethnobotanical trends observed in other Ethiopian regions, where homegardens serve as dynamic reservoirs of both biodiversity and traditional knowledge.

Table 2. provides a detailed listing of these spices, including their growth forms, vernacular (Amharic) names, their occurrence in homegardens, and total use reports (URs).

S/No	Scientific Name	Family	Amharic Name	Habit	URs
1	*Aframomum corrorima* (Braun) Jansen	Zingiberaceae	Kororima	Herbaceous	85
2	*Allium sativum* L.	Amaryllidaceae	Nech Shinkurt	Herbaceous	92
3	*Anethum foeniculum* L.	Apiaceae	Ensilal	Herbaceous	48
4	*Artemisia afra* Jacq. ex Willd.	Asteraceae	Hintam	Shrub	60
5	*Artemisia rehan* Chiov.	Asteraceae	Rehan	Herbaceous	35
6	*Brassica nigra* (L.) Koch	Brassicaceae	Tikur Senafich	Herbaceous	40
7	*Brucea antidysenterica* Mill.	Simaroubaceae	Emismael	Shrub	28
8	*Camomum subulatum* Roxb.	Zingiberaceae	K'amomum	Herbaceous	50
9	*Capsicum annuum* L.	Solanaceae	Berbere	Herbaceous	78
10	*Cinnamomum zeylanicum* Blume	Lauraceae	Qerenfud/Kerenfud	Tree	70
11	*Citrus aurantifolia* (Christm.) Swingle	Rutaceae	Lomi Marany	Shrub/Tree	55
12	*Citrus limonia* Osbeck	Rutaceae	Lomi Ambasah	Shrub/Tree	42
13	*Coriandrum sativum* L.	Apiaceae	Dimbilal	Herbaceous	65
14	*Curcuma longa* L.	Zingiberaceae	Ird	Herbaceous	75
15	*Cuminum cyminum* L.	Apiaceae	Kemen	Herbaceous	68
16	*Elsholtzia spp.* Willd.	Lamiaceae	Embamaarish	Herbaceous	30
17	*Foeniculum vulgare* Mill.	Apiaceae	Ensilal	Herbaceous	45
18	*Lippia abyssinica* Cufod.	Verbenaceae	Koseret	Shrub	88
19	*Lippia adoensis* Hochst. ex Walp.	Verbenaceae	Koseret	Shrub	72
20	*Nigella sativa* L.	Ranunculaceae	Tikur Azmud	Herbaceous	50
21	*Ocimum americanum* L.	Lamiaceae	Osim	Herbaceous	60
22	*Ocimum basilicum* L.	Lamiaceae	Besobila	Herbaceous	70
23	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	Demakese	Herbaceous	55
24	*Origanum vulgare* L	Lamiaceae	Oregano	Herbaceous	38
25	*Osyris quadripartite* Decn.	Santalaceae	Emtaw	Shrub	25
26	*Piper nigrum* L.	Piperaceae	Kundo Berbere	Vine	80
27	*Rhamnus prinoides* L'Hér.	Rhamnaceae	Gesho	Shrub	90
28	*Rosmarinus officinalis* L.	Lamiaceae	Rozmari	Shrub	35
29	*Ruta chalepensis* L.	Rutaceae	Tenadam	Herbaceous	58
30	*Salvia officinalis* L.	Lamiaceae	Salviya	Herbaceous	40
31	*Syzygium aromaticum* (L.) Merr. & Perry	Myrtaceae	Kerenfuz	Flower bud/Tree	65
32	*Thymus vulgaris* L.	Lamiaceae	Tosina	Herbaceous	48
33	*Trachyspermum ammi* (L.) Sprague	Apiaceae	Ajowan	Herbaceous	52
34	*Trigonella foenum-graecum* L.	Fabaceae	Abish	Herbaceous	60
35	*Zingiber officinale* Roscoe	Zingiberaceae	Zinjibil	Herbaceous	80

Notably, the local communities exhibit profound indigenous knowledge related to these spices, including detailed vernacular nomenclature, morphological identification, and multi-purpose applications spanning culinary, medicinal, and ritual domains. This highlights the importance of preserving both the biological and cultural dimensions of spice diversity as integral components of local heritage and sustainable livelihoods.

Diversity of spices

Our study revealed distinct patterns of spice species diversity across the investigated sites. Homegardens exhibited the highest Shannon diversity (2.62), indicating a richer and more diverse spice composition compared to farmland (1.68) and the wild area (0.64) (Table 3).

Table 3. Spices Diversity Indices

OCCURRENCE	H'	D1	D2	RI
Homegarden	2.62	0.88	0.81	7.63
Farmland	1.68	0.69	0.71	11.92
Wild area	0.64	0.42	0.31	12.44

H' = Shannon diversity index, D1 = Simpson diversity index, D2 = Simpson evenness, RI = Richness index (Margalef index)

Consistent with this, the Simpson diversity index also showed the highest values in homegardens (0.88), followed by farmland (0.69) and the wild area (0.42). The elevated Shannon diversity in homegardens appears to be linked to a more equitable distribution (higher evenness) of spice and condiment species within these systems, contrasting with the less even distribution observed in farmland and wild areas.

Ethnobotanical Roles of Spices

This study's findings reveal the significant and interconnected roles that spices fulfill within the culinary traditions, medicinal systems, and ritual practices of the Hadiya and Kambata-Tembaro zones in Central Ethiopia (Table 4). These roles are indicative of both rich ecological knowledge and enduring cultural heritage, positioning spices as a crucial biocultural nexus that bridges environment, health, and identity. By situating these findings within the broader ethnobotanical literature, this discussion identifies both commonalities and unique regional expressions.

Table 4. Integrated Ethnobotanical Roles of Spices in the Hadiya and Kambata-Tembaro Area (Culinary uses, Medicinal values, and Ritual Applications)

SCIENTIFIC NAME	CULINARY USE	MEDICINAL VALUES	RITUAL APPLICATIONS
Aframomum corrorima	Key in *berbere*, stews, spiced butter	Treats coughs, colds, digestion	Burned in incense, postpartum steam baths
Allium sativum	Universally used in sauces and meats	Antibacterial, cardiovascular health	Used in protective charms
Anethum foeniculum	Flavoring, herbal teas	Relieves bloating, aids lactation	Used in postpartum steam
Artemisia afra	Rarely culinary	Cold, malaria, digestive aid	Fumigation, cleansing spaces
Artemisia rehan	Spiced butter in some areas	Antiseptic, digestive aid	Used in smoke rituals and healing
Brucea antidysenterica	Not culinary	Treats dysentery, parasites	Associated with healing rituals
Camomum subulatum	Occasional tea flavoring	Sedative, pain relief	Used in purification baths
Capsicum annuum	Vital in *berbere*, sauces	Stimulates appetite, circulation	Occasionally burned or ingested ritually
Cinnamomum zeylanicum	Used in drinks, sweets, meat dishes	Antimicrobial, anti-inflammatory	Incense, aromatic ceremonies
Citrus aurantifolia	Marinades, souring agent	Detoxification, throat soother	Cleansing rituals
Citrus limonia	Fresh consumption, beverages	Immunity and digestion booster	Minor ritual cleansing
Coriandrum sativum	Seeds in spice mixes	Bloating, mild laxative	Rarely ritual
Cuminum cyminum	Seasoning *shiro*, sauces	Digestion, gas relief	Rarely ritual
Curcuma longa	Coloring and flavoring stews	Anti-inflammatory, skin healing	Postpartum painting, ritual baths
Elsholtzia spp.	Herbal teas	Treats fever, headaches	Used in *tish* and fumigation
Foeniculum vulgare	Herbal teas	Gas relief, lactation stimulant	Occasionally used postpartum
Hagenia abyssinica	Not culinary	Powerful antiparasitic (tapeworm)	Consumed ceremonially once a year
Lippia abyssinica	Flavoring in butter, sauces	Cold remedy, appetite stimulant	Burned in postpartum rituals
Lippia adoensis	Mild spice for butter and drinks	Respiratory and stomach ailments	Steam and bath rituals
Nigella sativa	Baked goods, spice blends	Immune boosting, anti-inflammatory	Protective and blessing uses
Ocimum americanum	Stews and teas	Fever, colds, stomach issues	Smudging, spiritual baths
Ocimum basilicum	Spiced butter, sauces	Relieves stress, digestion	Used in steam healing rituals
Ocimum lamiifolium	Not culinary	Headache, fever, eye infection	Used in postpartum, child healing rituals
Origanum vulgare	Meat and sauce seasoning	Respiratory, antimicrobial	Used in fumigation
Osyris quadripartita	Rarely culinary	Bone fractures, gynecological aid	Used in ancestral rituals
Piper nigrum	Meat seasoning, sauces	Digestion, warming effect	Included in protective mixtures
Rhamnus prinoides	Fermentation of *t'ej*, *tella*	Mild laxative, digestion	Central in brewing rituals
Rosmarinus officinalis	Seasoning meat and stews	Circulation, memory stimulant	Incense in blessings and ceremonies
Ruta chalepensis	Spiced butter, drinks	Menstrual cramps, stomach pain	Wards off evil, ritual protection
Salvia officinalis	Mild butter or herbal use	Anti-inflammatory, sore throat	Used in cleansing smudges
Syzygium aromaticum	Drinks, sweets, spice blends	Toothaches, antiseptic	Burned for fragrance and blessing
Thymus vulgaris	Meat and soup flavoring	Cough relief, digestive aid	Used in ritual purification
Trachyspermum ammi	Rare spice mix use	Relieves gas, indigestion	Postpartum bath ingredient
Trigonella foenum-graecum	*Shiro*, *berbere*, porridge	Promotes lactation, blood sugar balance	Used in postpartum healing drinks
Zingiber officinale	Meats, drinks, spice blends	Nausea, inflammation relief	Healing rituals and tonics

Informant Consensus Factor (ICF)

Analysis of informant agreement revealed consistently high consensus levels across the three principal use categories (Table 5). The culinary category exhibited the highest ICF (0.79),

indicating strong collective knowledge of flavoring and preservation practices. The medicinal category also showed a high ICF (0.80), reflecting shared understanding of therapeutic applications of spices. Ritual uses presented a slightly lower ICF (0.69), suggesting greater variability in symbolic or context-specific applications among households.

Table 5. Informant Consensus Factor (ICF) values for major use categories (Nur = the total number of use-reports and Nt = the number of species used).

USE CATEGORY	NUR	NT	ICF
Culinary	132	28	0.79
Medicinal	96	21	0.80
Ritual	54	18	0.69

Culinary Preparation Techniques of Spices

Our findings (Table 6) provide comprehensive documentation of the culinary use of various spices in the study area, highlighting both the plant parts utilized and the preparation methods employed in local food traditions. The results reveal a rich body of indigenous culinary knowledge tied to plant diversity that a wide range of plant parts including seeds, fruits, leaves, bulbs, and rhizomes are utilized in local cuisine, depending on the species and the specific dish being prepared. Seeds and fruits are predominantly used for flavoring stews and sauces, while leaves and bulbs often serve as essential ingredients in the preparation of spice mixtures. Preparation techniques vary widely and include drying and grinding, roasting, crushing, boiling, and blending, each contributing to the unique flavor profiles of traditional dishes. Many of the spices are key components in staple culinary preparations such as *wot*, *berbere*, and *mitmita*, underscoring their integral role in the local food culture. Beyond flavor enhancement, these spices also fulfill functional roles as preservatives and digestive aids, reflecting the deep interconnection between culinary practice and traditional knowledge.

The study identified eight distinct traditional dishes that are commonly prepared using locally cultivated spices. These dishes including *Anaqaala*, *Ataakana*, and *Hanissabela* are primarily prepared by women, who serve as both caregivers and culinary experts within their households, locally referred to as *Ammo'o*. The consistent use of key spices such as *Allium sativum* (garlic), *Capsicum frutescens* (chili), and *Ruta chalepensis* (rue) not only enhances the flavor and aroma of these dishes but also contributes to their perceived medicinal value. These traditional preparations are deeply embedded in the local diet and serve as expressions of cultural identity, highlighting the important role of women in preserving and transmitting culinary knowledge across generations.

Table 6. Overview of Spice Plant Parts utilized and Their Corresponding Culinary Preparation Techniques

SCIENTIFIC NAME	LOCAL NAME	PART USED	CULINARY PREPARATION METHOD
Aframomum corrorima	Korarima	Seeds, pods	Roasted and ground for wot, sauces, and spiced butter (*kibe*); added to coffee ceremonies.
Allium sativum	Nech Shinkurt	Bulbs	Crushed fresh or fried in oil; base for most sauces and stews (*wot*, *shiro*).
Anethum foeniculum	Shilshilo	Leaves, seeds	Fresh leaves used in salads and sauces; seeds used for flavoring and digestive herbal drinks.
Artemisia afra	Chikugn	Leaves	Rarely used in cuisine; sometimes infused for medicinal herbal tea with bitter notes.
Artemisia rehan	Rehan	Leaves	Used to flavor traditional stews and legumes; also added to fermented beverages.
Brucea antidysenterica	Abalo	Seeds	Not commonly culinary; seeds may be used sparingly due to bitterness (mainly medicinal).
Cinnamomum zeylanicum	Karafa	Bark	Ground bark added to holiday stews, ceremonial drinks (*tella*, *tej*), coffee spice mix
Capsicum annuum	Berbere, Mitmita	Fruits (fresh/dried)	Sun-dried and ground into berbere or mitmita powder; key in spicy dishes and condiments.
Coriandrum sativum	Dimbilal	Seeds, leaves	Seeds toasted and ground in spice blends; leaves used fresh in salads or garnishing stew.
Cuminum cyminum	Kimmem	Seeds	Dry roasted and ground; used in meat dishes, lentil stews, and pickles.
Curcuma longa	Erid	Rhizome	Ground into powder; adds color and earthy flavor to niter kibe, stews, and breads.
Foeniculum vulgare	Ensilal	Seeds	Used in baking, herbal infusions, and sweet spice blends for bread and porridge.
Lippia adoensis	Koseret	Leaves	Dried and added to niter kibe or meat stews; aromatic and preservative effect.
Nigella sativa	Tikur Azmud	Seeds	Added to flatbreads, lentil stews, and spice blends; often roasted lightly before use.
Ocimum lamiifolium	Damakessie	Leaves	More medicinal, but occasionally added to herbal teas or aromatic broths.
Ocimum basilicum	Besobila	Leaves	Fresh or dried leaves used in sauces and spice butters; fragrant and mild.
Origanum vulgare	Zengule	Leaves, flowers	Dried and crumbled into sauces and flatbreads; culinary and preservative roles.
Piper nigrum	Tikur Mitmita	Seeds (black pepper)	Crushed or ground; used in meat dishes, kitfo, and stews for heat and aroma.
Rhamnus prinoides	Gesho	Leaves, stems	Fermented for brewing tella and tej (traditional alcoholic drinks).
Rosmarinus officinalis	Yedoro meblat	Leaves	Infused into oils or used fresh/dried in meat dishes and broths.
Ruta chalepensis	Tenadam	Leaves	Added in small amounts to sauces and coffee; has a strong, slightly bitter aroma.
Syzygium aromaticum	Kiref	Dried flower buds	Used in spiced tea, desserts, and holiday sauces; crushed or whole.
Thymus vulgaris	Tosign	Leaves	Crushed into spice blends for meats and lentils; used in teas as well.
Trigonella foenum-graecum	Abish	Seeds	Lightly roasted and ground; used in berbere, sauces, and pickled vegetables.
Zingiber officinale	Zinjibil	Rhizome	Fresh or dried; grated or sliced into tea, stews, and kibe; also for desserts and juices.

Community Preference Ranking of Spices

The results of the preference ranking exercise, as presented in Table 7, offer a clear depiction of the local communities' prioritization of spices based on a multidimensional valuation system. Each spice was assigned a score reflecting its perceived importance, determined by factors such as frequency of use, culinary versatility, symbolic and ritual significance, and degree of cultural embeddedness in daily and ceremonial life. Higher scores indicate stronger local preference and wider cultural relevance, while lower scores correspond to more specialized use.

Table 7. Results of preference ranking of spices based on frequency of use-values exercised by key informants (KI) and focus group discussants (FGD). Scores in the table indicate ranks given to multipurpose trees based on their use-values (highest number (10) was given for the tree species which informants thought most-preferred in its use-values, and the lowest number (1) was given for its least-preference). The highest total scores were the most-preferred tree species by the farmers. Letters A-J represent KI and FGD.

Spices	Key informants and focus group discussants labeled A-J										Total score	Rank
	A	B	C	D	E	F	G	H	I	J		
Aframomum corrorima	8	7	6	10	9	7	10	9	6	8	80	2
Allium sativum	6	5	10	7	5	8	8	5	9	10	73	3
Coriandrum sativum	4	9	5	4	6	9	4	8	7	4	60	6
Ruta chalepensis	3	3	4	5	3	1	3	2	3	1	28	8
Nigella sativa	7	4	3	9	7	5	9	7	8	7	63	5
Lippia adoensis	5	6	9	6	4	4	5	4	4	5	52	7
Zingiber officinale	9	8	7	3	8	6	6	6	5	6	64	4
Capsicum annuum	10	10	8	8	10	10	7	10	10	9	92	1
Curcuma longa	2	1	1	2	2	3	2	3	2	2	20	9
Ocimum basilicum	1	2	2	1	1	2	1	1	1	3	15	10

Beyond flavoring, *Capsicum annuum L.* serves as a marker of hospitality and communal feasting, contributing to its symbolic value. In Ethiopian culture, dishes prepared with chili-based spice blends such as *berbere* or *mitmita* notably *doro wot*, *shiro*, and *kitfo* are central to festive occasions, weddings, and religious holidays. Serving these richly spiced dishes signifies generosity, respect, and honor toward guests, while the abundance and quality of spices used often reflect the host's social standing and commitment to strengthening communal bonds. Thus, the cultural value of *Capsicum annuum* extends beyond its sensory appeal, embodying principles of unity, reciprocity, and identity within shared food traditions. Other spices, such as *Aframomum corrorima* and *Allium sativum*, also ranked highly due to their dual use in flavoring and ritual or medicinal contexts, highlighting the multifunctionality of spice plants in Hadiya and Kambata-Tembaro traditions.

Conservation status and Threats to Spices

Figure 2 presents the key threats identified by the community as impacting the sustainability and diversity of spices within the study area. This figure synthesizes the findings from multiple data collection methods, offering a comprehensive understanding of the pressures these valuable plants face. The figure is organized around distinct Threat Categories**,** which emerged as recurring themes during the semi-structured interviews and focus group discussions. These categories provide a framework for understanding the multifaceted nature of the threats.

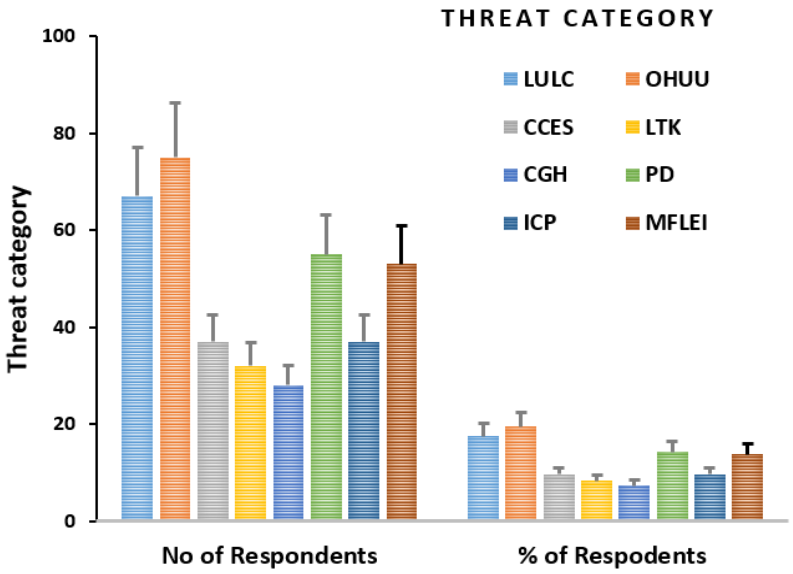

Figure 2. Threats category to Spices (LULC= Land-Use Change & Habitat Loss, OHUU= Overharvesting & Unsustainable Use, CCES= Climate Change & Environmental Stress, LTK= Loss of Traditional Knowledge, CGK= Commercialization & Genetic Homogenization, PD=Pests and Diseases, ICP=Inadequate Conservation Policies, MFLEI= Market Fluctuations & Low Economic Incentives).

Socioeconomic and Gendered Dimensions of Spice Livelihoods

Table 8 presents key findings on the gendered and socioeconomic roles in spice production and trade across the study area. The findings reveal that while both men and women are deeply involved in spice-related activities, there are significant inequalities in access to resources, participation in training, and control over income. For example, although 48% of women reported that spices are their main income source, only 12% owned the land used for spice cultivation. Access to capacity-building opportunities is similarly limited, with just 15% of women having received any form of training, compared to much higher participation by men. Additionally, in male-headed households, 77% of decisions regarding spice income were made by men, indicating a clear gender gap in financial control and autonomy.

Table 8. Socioeconomic and Gendered Dimensions of Spice

PARAMETER	FINDINGS	GENDER DISAGGREGATION
Household Income from Spices	62% of households earn >40% of annual income from spice-related activities.	48% of women say spice is their main income source.
Market Participation	Majority sell at local markets; limited access to regional buyers or value-added chains.	Men more involved in transport and sales.
Access to Land	76% of respondents cultivate spices on small plots (<0.5 ha).	Only 12% of women own land used for spice farming.
Access to Training	35% of respondents have attended spice-related trainings (agronomy, processing).	Only 15% of trainees were women.
Division of Labor	Women: planting, weeding, drying, storage. Men: land prep, marketing.	Labor is heavily gendered.
Control Over Income	In male-headed households, 77% of income decisions made by men.	Only 23% of women control spice income they earn.
Involvement in Cooperatives	40% of respondents are members of spice-related cooperatives.	Women make up only 18% of cooperative members.
Decision-Making Power	Men are primary decision-makers on land use, marketing, and investments.	Women report limited influence on economic decisions.
Time Burden & Constraints	Women cite lack of time due to domestic responsibilities as a major barrier to training or market engagement.	High time poverty among women.
Emerging Opportunities	Women-led microenterprises in fenugreek and turmeric processing noted in Hosaena and Durame.	Early signs of economic empowerment for women.

The data also show that women are underrepresented in formal structures such as cooperatives, with only 18% membership, despite their critical role in cultivation and post-harvest processing. These disparities reflect broader social norms and structural barriers that limit women's economic empowerment. However, the study also identified promising developments, particularly in Hadiya and Kembata-Tembaro areas, where women have begun forming small-scale enterprises in fenugreek and turmeric processing. These emerging trends suggest potential pathways for enhancing women's roles in the value chain. Overall, the results underscore the importance of designing inclusive programs that ensure equitable access to land, training, markets, and decision-making processes for marginalized groups, especially women.

Discussion

Weaving Culture and Ecology in Ethiopian Spice Diversity

This study dives deep into the intricate relationship between indigenous knowledge and spice diversity in Hadiya and Kambata-Tembaro zones. The findings reveal how cultural practices are intrinsically linked to the ecological richness of these regions, emphasizing the vital role of traditional wisdom in sustaining biodiversity. We explore the demographic foundations of this knowledge, the varied habitats where spices thrive, their multifaceted roles in daily life, and the critical socioeconomic and policy implications for their preservation.

Unveiling Knowledge Bearers: Demographics and Gendered Expertise

This study engaged 384 community members, revealing a significant gender dynamic in the preservation of spice-related knowledge. With 314 female respondents compared to 70 male, it is clear that women, particularly elder women, are the primary custodians of spice wisdom in these regions, underscoring their importance in maintaining spice knowledge. Their daily involvement in planting, cooking, and seed saving is crucial for maintaining the diversity and acquaintance surrounding these species. This observation aligns with broader ethnobotanical

research emphasizing women's pivotal role in homegarden management and the intergenerational transfer of plant knowledge (Howard, 2003; Ghimire et al., 2004).

The age range of participants, spanning from 20 to 67 years with a mean of 43.45 years (±9.95 SD), highlights the intergenerational nature of this knowledge system. While younger participants (under 45 years) contributed fresh perspectives, often drawing on exposure to markets, modern appliances, and evolving household needs, older women emphasized practices deeply rooted in oral traditions, rituals, and recipes attributed to grandparents. This contrast enabled us to distinguish knowledge anchored in long-standing traditions such as the preparation of *wot*, *berbere*, or spiced coffee rituals from more recent practices shaped by commercial spice availability and technological change. Together, these intergenerational narratives reveal how ancestral wisdom and contemporary adaptations coexist, ensuring both continuity and innovation in spice utilization (Johns & Sthapit, 2004; Zent, 2009).

Furthermore, the prevalence of large, multi-generational households (averaging 5.76 individuals, with 89.1% having 4 to 7 members) plays a vital role. These extended family units naturally facilitate the seamless passing down of agricultural techniques and diverse plant varieties across generations. This finding echoes recent studies on homegardens in regions like Dawuro and Oromia, which similarly underscore the importance of larger households in sustaining ethnobotanical knowledge (Shiferaw et al., 2025; Goba, 2024). The moderate levels of formal education among respondents (42.4% primary, 33.6% secondary) suggest a dynamic interplay between traditional knowledge systems and external influences, potentially shaping how local practices are preserved and adapted (Zent, 2009).

The Palette of Spices: Diversity and Habitat Distribution

The identification of 35 distinct spice and condiment species, representing 27 genera and 17 botanical families in Hadiya and Kambata-Tembaro, highlights the region's exceptional ethnobotanical richness. This diversity positions the area as a significant reservoir of traditional plant knowledge and utility. The predominance of herbaceous species (63%) is a recurring pattern in Ethiopian ethnobotany. These plants are often favored due to their rapid growth cycles, ease of propagation, and adaptability to household agroecosystems (Addis et al., 2005; Giday et al., 2009). Additionally, herbaceous plants are typically more accessible to women and elders, who are often central to the custodianship of traditional culinary and medicinal knowledge (Kassaye et al., 2006).

Taxonomically, the Lamiaceae family stands out with 8 species. This aligns with global botanical trends, as the Lamiaceae family is renowned for its aromatic members, which are rich in essential oils and various bioactive compounds (Van Wyk & Wink, 2004). Species within this family, such as *Ocimum* and *Thymus*, are indispensable in Ethiopian spice mixtures and traditional medicine, underscoring their profound local importance. Similar observations on the widespread culinary and therapeutic relevance of Lamiaceae species have been reported in other Ethiopian regions (Lulekal et al., 2011).

Homegardens: Biodiversity Hotspots and Knowledge Fortresses

A compelling finding is the high incidence of spices (80%) cultivated within homegardens. These micro-agroecosystems emerge as critical bastions for both plant diversity and the enduring presence of ethnobotanical knowledge (Berkes et al., 2000; Hamilton, 2004). Traditionally managed by women and elders, homegardens facilitate the informal yet effective transmission of knowledge across generations (Pankhurst, 2001). This finding is consistent with studies from southwestern Ethiopia and other highland regions, where homegardens are vital for ethnomedicinal species and play a significant role in *in-situ* conservation (Giday et al., 2007).

The findings unequivocally demonstrate a clear gradient in spice species diversity across different land-use systems. Homegardens consistently exhibited significantly higher Shannon and Simpson diversity indices compared to farmlands and wild areas. This high spice diversity

in homegardens corroborates existing literature that highlights their function as biodiversity reservoirs, particularly for useful plant species (Kumar & Nair, 2004; Fernandes & Nair, 1986). The multi-strata structure and intensive management practices characteristic of homegardens facilitate the integration of a wide array of plant species, addressing diverse household needs **(**Wondimu et al. 2007). This intentional diversification acts as a crucial form of *in-situ* conservation, safeguarding a broader spectrum of genetic resources than the more monoculture-oriented systems seen in farmlands.

Conversely, the lower spice diversity in farmlands (Shannon: 1.68, Simpson: 0.69) is primarily attributed to agricultural intensification and a concentrated focus on a limited number of primary crops. Modern agricultural practices often prioritize high-yielding staple varieties, leading to the simplification of agroecosystems and the displacement of associated biodiversity, including spices (Reyes-García et al., 2005). This aligns with studies documenting reduced biodiversity in agricultural landscapes compared to more traditional, diversified farming systems (Altieri et al., 2015).

Interestingly, the significantly lower spice diversity in the wild area (Shannon: 0.64, Simpson: 0.42) presents a nuanced perspective. While wild habitats are often assumed to harbor high biodiversity, The results suggest a less even distribution and lower richness of spice species in the specific wild area studied. This could stem from the "wild area" representing a particular ecological niche that naturally supports a limited range of spice species, or from factors like habitat degradation due to human encroachment and resource extraction. It is also plausible that the sampling intensity in the wild area captured a localized patch with lower spice concentration. These findings emphasize the necessity of precise definition and characterization of "wild areas" in biodiversity studies, as they are not universally more diverse for all plant groups than managed systems (Bharucha & Pretty, 2010).

The higher evenness of spice species in homegardens, reflected by the relatively smaller difference between Shannon and Simpson indices, indicates a more equitable distribution of abundance among different spice species. This contrasts with farmlands and wild areas, where a few dominant species likely account for a larger proportion of observed spice occurrences. This even distribution in homegardens is likely a result of deliberate selection and management by households to ensure a consistent supply of a variety of spices for diverse uses. Ultimately, the findings strongly affirm the indispensable role of homegardens as crucial reservoirs of spice species diversity within the study area, highlighting their significance for *in situ* conservation and agrobiodiversity maintenance.

The Multifaceted Essence of Spices: Culinary, Medicinal, and Ritual Dimensions

The diverse applications of spices culinary, medicinal, and ritual underscore their profound multifunctionality in local livelihoods. Spices such as *Aframomum corrorima*, *Artemisia afra* Jacq. ex Willd., and *Nigella sativa* L. transcend mere dietary additives; they are integral to healing practices and ceremonial life. This aligns with the concept of "biocultural keystone species," which are culturally significant plants central to identity, tradition, and well-being (Garibaldi & Turner, 2004).

Furthermore, the detailed vernacular taxonomy and morphological identification practices observed in the study area point to a sophisticated local classification system. This system, often diverging from Western Linnaean taxonomy, is deeply rooted in practical knowledge and sensory cues (Kebebew et al, 2015). Such indigenous classification systems are vital for ethnobiological resilience and the conservation of traditional ecological knowledge (TEK).

Comparatively, the results echo earlier ethnobotanical studies from other Ethiopian regions, such as those among the Meinit (Giday et al., 2007) and Zay communities (Giday et al., 2009), which similarly highlight the intricate connections among biodiversity, culture, and livelihood. However, this study contributes novel regional insights by focusing on the central highlands of

Hadiya and Kambata-Tembaro, areas previously underrepresented in ethnobotanical research. The observed patterns of spice use offer a counter-narrative to the often commodity-driven perception of spices, instead illustrating their profound embeddedness in everyday health, ritual, and culinary practices. These findings strongly reinforce the need for inclusive conservation policies that respect and integrate local knowledge systems. Recognizing the interwoven cultural and ecological dimensions of spices can significantly bolster both biodiversity conservation and food security initiatives in Ethiopia and beyond.

The high ICF values observed for culinary and medicinal categories further underscore the coherence and transmission of indigenous knowledge among community members. Strong agreement on species selection for flavoring and healing reflects well-established cultural norms and shared ecological understanding, while the comparatively lower consensus in ritual applications illustrates the localized and household-specific nature of symbolic plant use. Similar patterns have been reported in other Ethiopian ethnobotanical contexts (Giday et al., 2007; Bahru et al., 2014), confirming that high informant consensus often corresponds with species of elevated cultural salience and functional versatility.

Culinary Arts: Spice Use in Traditional Ethiopian Dishes

The culinary application of spices in the study area reflects a deep integration of biodiversity, traditional knowledge, and cultural identity. The findings (detailed in Table 6, not provided here but implied from the original text) document the extensive use of various plant parts, including seeds, fruits, leaves, bulbs, and rhizomes, in local food traditions. This diversity of plant parts corresponds to the multifunctionality of spices in culinary systems, enhancing flavor and aroma, improving texture, extending shelf life, and providing therapeutic benefits (Pieroni & Price, 2006).

Seeds and fruits were predominantly used, often dried and ground into powders, for preparing stews and sauces. Leaves and bulbs, conversely, were frequently used fresh or crushed to form aromatic bases for essential Ethiopian spice blends like *berbere* and *mitmita*. These traditional preparation methods drying, roasting, boiling, and crushing demonstrate the community's nuanced understanding of how different techniques influence flavor, potency, and storage life. Similar processing practices are well-documented in other ethnobotanical studies, where traditional culinary methods serve to preserve both the physical integrity and bioactive properties of spices (Oryan et al., 2021).

The study also identified eight culturally significant traditional dishes, including *Anaqaala*, *Ataakana*, and *Hanissabela*, which are deeply embedded in local dietary habits and frequently prepared using homegrown spices. These dishes are primarily prepared by women, known locally as Ammo'o, who possess specialized knowledge in food preparation, spice blending, and associated ritual practices. This aligns with ethnographic literature emphasizing the gendered dimensions of culinary knowledge and women's role as primary custodians of traditional plant-based knowledge (Howard, 2003).

Spices such as *Allium sativum* (garlic), *Capsicum frutescens* (chili), and *Ruta chalepensis* (rue) were frequently mentioned for their dual roles in flavoring and health. Their widespread use extends beyond taste, encompassing functional properties as digestive aids, antimicrobial agents, and traditional remedies for common ailments. This food-medicine continuum is a broader ethnobotanical principle, where culinary plants serve both nutritional and therapeutic functions (Pieroni & Quave, 2006). The persistence of these practices amid evolving dietary patterns and market integration underscores the resilience and adaptability of local knowledge systems. Moreover, the centrality of spice use in everyday meals and ceremonial contexts highlights their symbolic and social roles, reinforcing group identity and intergenerational continuity (Johns & Sthapit, 2004).

Preference Ranking: Beyond Sensory Appeal to Cultural Significance

The preference ranking exercise provided crucial insights into the socio-cultural dynamics and ethnobotanical valuation of spice species in Hadiya and Kambata-Tembaro. The multidimensional criteria employed by local participants including frequency of use, culinary versatility, symbolic resonance, and embeddedness in daily life and ceremonial contexts mirror broader ethnobotanical frameworks that emphasize the cultural salience and functional diversity of plant species (Albuquerque et al., 2006).

Capsicum annuum emerged as the most preferred spice, exemplifying this cultural salience. As observed in other Ethiopian ethnobotanical studies (Giday et al., 2009; Yineger & Yewhalaw, 2007), *Capsicum annuum* is central to the flavor profile of traditional dishes and plays a significant role in social rituals such as communal feasts and weddings. Its widespread use in national dishes like *doro wot* and *shiro*, and its association with essential spice mixtures like *berbere* and *mitmita*, solidify its status as a cornerstone of Ethiopian culinary identity (Jansen, 2005; Mesfin, 2007). Its high demand and continuous homegarden cultivation also point to its economic and agronomic relevance.

Other highly ranked species, such as *Aframomum corrorima* and *Allium sativum*, illustrate the intersecting culinary, medicinal, and ritual values that define spice usage in the region. *Aframomum corrorima*, an indigenous spice also documented in the Gamo and Kaffa zones (Bahru et al., 2014), is not only a flavoring agent in ceremonial dishes and spiced butter (*niter kibe*) but also features in coffee rituals and healing practices, highlighting its symbolic and therapeutic roles. Similarly, *Allium sativum* is widely valued for its antimicrobial properties (Teklehaymanot & Giday, 2007) while simultaneously serving as a staple in sauces and traditional broths, showcasing its functional duality.

The high preference scores attributed to such multifunctional spices align with findings from other ethnobotanical studies across Ethiopia and East Africa, which report that species with broader utility across culinary, medicinal, and ritual contexts tend to be more culturally valued and better conserved (De Boer & Lamxay, 2009; Asfaw, 2001). This supports the argument that preference ranking is not merely a reflection of taste or familiarity but also an indicator of integrated ecological knowledge and cultural identity.

Conversely, some spices with limited use in ritual or medicinal settings, such as *Cinnamomum zeylanicum* or *Piper nigrum*, received moderate scores. This is likely due to their imported status or restricted availability in local agroecosystems. This aligns with research suggesting that locally accessible and culturally entrenched species are prioritized over globally traded but culturally peripheral spices (Kujawska et al., 2015). In essence, the preference rankings not only reveal the practical and symbolic significance of spices but also echo broader patterns in traditional societies where plant multifunctionality, cultural familiarity, and ecological access intersect to shape use priorities. These findings underscore the importance of preserving local ethnobotanical knowledge, especially in the face of cultural homogenization and agricultural modernization.

Socioeconomic Dynamics and Gender Disparities in Spice Value Chains

This study offers a nuanced understanding of the socioeconomic and gendered roles embedded within the spice value chains in southern Ethiopia. While spices contribute significantly to rural household incomes, particularly for smallholders, women face persistent structural barriers. Despite their substantial involvement in labor-intensive aspects such as cultivation, harvesting, drying, and storage, women continue to have limited access to land, training, cooperative networks, and decision-making power. These observations align with previous studies that highlight gender disparities in agricultural systems, where women contribute significantly to production but remain marginalized in terms of benefits and agency (Quisumbing et al., 2014; Farnworth et al., 2013).

The gendered division of labor observed in this study corroborates patterns where women are often concentrated in low-return, labor-intensive tasks within agricultural value chains, while men dominate more profitable roles like marketing and transportation (Doss, 2001). The limited land ownership by women (12% in this study) is consistent with national analyses in Ethiopia, where patriarchal inheritance practices and limited legal awareness often prevent women from holding title deeds (Bezu & Holden, 2014). This lack of land access directly impedes women's eligibility for loans, extension services, and market-based contracts, perpetuating a cycle of exclusion.

Furthermore, access to agricultural training remains highly unequal. Only 15% of women in this study had received training related to spice agronomy or processing. This echoes findings from the World Bank (2015), which show that women are disproportionately underrepresented in formal capacity-building programs in sub-Saharan Africa. This disparity not only limits women's capacity to innovate and improve productivity but also affects the quality of spices entering the value chain. Thus, low access to training and technology remains a critical constraint on enhancing both gender equity and product competitiveness.

Control over income is another significant area of disparity. The study revealed that in 77% of households, men were the sole decision-makers regarding the use of spice-related earnings. This is consistent with findings by Meinzen-Dick et al. (2011), who emphasized that even when women contribute labor or generate income, cultural norms often restrict their control over financial resources. This has direct implications for household well-being and nutrition, as women's control over income is often associated with increased spending on food, health, and children's education (Smith et al., 2003).

However, the emergence of women-led microenterprises in fenugreek and turmeric processing presents a promising development, signaling potential for transformative change. These grassroots initiatives reflect a broader trend of rural women engaging in value-added production to circumvent traditional gender barriers. Similar trends have been documented in Uganda and India, where women's involvement in processing and niche marketing of spices has enhanced their income and bargaining power (Njuki et al., 2011; Bhattarai et al., 2020). This study also underscores the vital role of social capital and informal networks. Women, despite being underrepresented in formal cooperatives, often rely on informal trade relationships and women's groups, which provide alternative pathways for support and knowledge exchange. Building on this foundation through targeted support, such as women-led cooperative models or tailored training programs, could foster inclusive and sustainable growth of the spice sector.

In summary, the study confirms and extends existing literature on gendered value chains, demonstrating that systemic barriers continue to limit women's full participation and benefit-sharing in spice economies. Addressing these gaps necessitates integrated strategies that combine asset redistribution (e.g., land rights), service accessibility (e.g., training and credit), and empowerment interventions (e.g., leadership and decision-making spaces). This is not merely a matter of gender justice but also crucial for enhancing productivity, value chain efficiency, and community resilience.

Policy and Ethical Imperatives: Safeguarding Indigenous Knowledge

The findings of this study carry significant policy and ethical implications, particularly concerning the integration of indigenous ecological knowledge (IEK) into national biodiversity conservation and food security agendas. The socioeconomic and gendered dimensions of spice livelihoods clearly demonstrate that traditional knowledge, especially as held and transmitted by women, plays a crucial role in sustaining agrobiodiversity, ensuring food security, and supporting rural economies. These findings reinforce arguments that indigenous knowledge systems are not only reservoirs of ecological wisdom but also strategic assets for climate resilience and sustainable agriculture (Berkes et al., 2000; Altieri et al., 2015).

However, the undervaluation of this knowledge in formal policy frameworks remains a key challenge. Despite the significant contributions of women to spice cultivation, seed selection, and preservation practices, their knowledge is often excluded from institutional agricultural research and development processes. This exclusion not only reinforces existing gender inequalities but also undermines the potential of indigenous systems to inform sustainable development. As argued by Adnan et al. (2020), gendered ecological knowledge must be systematically recognized and incorporated into policy for conservation efforts to be both effective and just.

Furthermore, the study raises critical questions regarding intellectual property rights (IPRs) and the ethics of knowledge extraction. As the commercial value of spices and traditional formulations increases, so does the risk of biopiracy—the unauthorized appropriation of community-held biological and cultural resources for commercial gain. This phenomenon has been extensively documented in other regions, as seen in the neem and turmeric patent disputes in India (Wondimu et al., 2007). Without appropriate legal safeguards, there is a tangible risk that indigenous communities particularly women, who are often the custodians of such knowledge may be excluded from the benefits derived from their own practices and innovations.

Accordingly, this study supports growing calls for community ownership and protection of biocultural heritage, as outlined by Reyes-García et al. (2005). National policies must incorporate provisions for Free, Prior, and Informed Consent (FPIC), community-defined benefit-sharing mechanisms, and the recognition of customary rights. For instance, the implementation of Access and Benefit Sharing (ABS) frameworks under the Nagoya Protocol (CBD, 2011) should be localized and operationalized with gender-sensitive tools to ensure that women's contributions to spice-based knowledge systems are properly acknowledged and rewarded.

Moreover, ethical engagement with indigenous communities necessitates a shift from extractive research paradigms toward participatory and reciprocal models of knowledge co-production. Researchers and policymakers must ensure that community members are not merely consulted but are active collaborators and beneficiaries of biodiversity and food system interventions. This ethical commitment is particularly crucial when working with marginalized or underrepresented groups whose knowledge might otherwise be exploited without compensation or recognition.

In conclusion, this study underscores the urgency of creating inclusive, equitable, and ethically sound policies that recognize indigenous knowledge as a living and evolving system. Safeguarding this knowledge through legal protection, community empowerment, and gender-responsive institutional frameworks is vital for both cultural survival and ecological sustainability. By elevating the voices of rural women and local knowledge holders, future biodiversity and food security strategies can become more socially just and ecologically effective.

Conclusion

This study offers a comprehensive ethnobotanical exploration of spice diversity in the Hadiya and Kambata-Tembaro zones of Central Ethiopia, unveiling a vibrant repository of traditional knowledge deeply embedded in local cultures and livelihoods. The demographic profile of respondents, characterized by significant female involvement and representation across age groups, reinforces the pivotal role women play as knowledge bearers and transmitters within their communities. The identification of 35 spice species, predominantly herbaceous and with the Lamiaceae family being prominent, underscores the area's rich plant diversity. Homegardens emerged as vital ecological niches, serving not only as sources of sustenance but also as hubs of *in situ* conservation and intergenerational knowledge transfer. The multifaceted

uses of spices in culinary practices, traditional medicine, and cultural rituals position these plants as biocultural keystone species, essential to the region's social fabric.

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Declaration of Interest statement

The author declares no competing financial interests or personal relationships that could have influenced the reported work.

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