Capsicum in the hands of tradition: ethnobotanical knowledge and conservation in Indigenous and Quilombola communities

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Ethnobotany Research and Applications 35:16 (2026) - http://dx.doi.org/10.32859/era.35.16.1-20
Manuscript received: 24/04/2026 - Revised manuscript received: 30/06/2026 - Published: 01/07/2026

Research

Abstract

Background: *Capsicum* peppers are among the oldest domesticated native crops in South America, with their dispersal and usage deeply embedded in the cultural traditions of Indigenous and Quilombola communities. Brazil stands as a significant center of *Capsicum* diversity, however, ethnobotanical knowledge regarding the relationships between these peppers and the communities that shaped their cultural preeminence remains limited. This study reviews the literature on ethnobotanical knowledge documented in previous studies involving Indigenous and Quilombola communities in Brazil, aiming to elucidate the role of these traditional communities in the diversification and conservation of the *Capsicum* genus.

Methods: A literature review was conducted using academic databases, compiling ethnobotanical studies and cookbooks to assess the historical and current uses of peppers. Medicinal applications were classified according to the International Classification of Diseases (ICD), and a Geographic Information System (GIS) analysis was carried out to evaluate *ex situ* conservation coverage of landraces cultivated by the communities.

Results: The cultural significance of *Capsicum* is reflected in its diverse uses. We identified 95 traditional Brazilian food recipes incorporating *Capsicum* fruits, with higher concentration in regions strongly influenced by Indigenous and Quilombola heritage. Medicinal applications were documented across twelve categories of ICD, and transcendental uses are expressive within these communities. There is underrepresentation in *ex situ* strategies due to bureaucratic barriers that limit research and conservation in Indigenous and Quilombola territories.

Conclusions: The study highlights the need for integrated policies that promote germplasm conservation, valuing traditional knowledge and strengthening community participation in agrobiodiversity preservation, contributing to food security, health care, and the maintenance of cultural traditions in Brazil.

Keywords: Plant genetic resources; traditional knowledge; *in situ*/on farm conservation; native landraces

Background

Evidence suggests that *Capsicum* L. peppers possess one of the most ancient domestication histories among crops with a South American center of origin, dating back approximately 6,500 years (Arteaga 2025; Veiga Jr. *et al.* 2022). The primary center of origin of these plants lies in the central Andean region, encompassing southern Peru and Bolivia. However, through dispersal mediated by frugivorous birds, their distribution extended across the American continent (Arteaga 2025; Swamy & Kumar 2024). This process, known as ornithochory, was facilitated by the innate immunity of birds to capsaicinoids, the bioactive alkaloids responsible for the pungency of *Capsicum* fruits (Swamy & Kumar 2024).

Brazil represents a significant center of diversity for domesticated, semi-domesticated, and wild *Capsicum* species (Barboza *et al.* 2020; Bianchi *et al.* 2020; Rivas *et al.* 2023). Domesticated taxa have been extensively investigated due to their economic importance, with emphasis on the numerous landraces of *Capsicum annuum* L. var. *annuum*, the most widely cultivated species in the country (Almeida *et al.* 2020). In contrast, while recent studies on wild and semi-domesticated species have advanced genetic and morphological characterization, ethnobotanical knowledge concerning these taxa remains limited in the Brazilian context. Presently, five species within the genus are recognized as domesticated and are cultivated globally: *C. annuum* var. *annuum*, *Capsicum chinense* Jacq., *Capsicum frutescens* L., *Capsicum baccatum* L. var. *pendulum* (Willd.) Eshbaugh, and *Capsicum pubescens* Ruiz & Pav. (Barboza *et al.* 2019; Barboza *et al.* 2022).

The earliest documented civilizations between the South and Central regions of America, notably the Incas and Aztecs, played a vital role in the domestication of *Capsicum*, as they incorporated its genetic resources into their dietary practices and cultural expressions (Chiou *et al.* 2024; Madala & Nutakki 2020). There is evidence that Indigenous peoples of South America contributed significantly to the diversification and conservation of *Capsicum* landraces, particularly through interethnic exchange networks. These practices have been continuously maintained due to the importance of these plants as food and medicinal resources, as well as their symbolic and religious significance (Nascimento Filho *et al.* 2007; Sousa 2013; ISA 2018).

Following the Treaty of Tordesillas of 1494 and the colonization of the Americas, these genetic resources were transported along the Portuguese trade and maritime routes and became significant worldwide. From this period onward, *Capsicum* peppers reached various African communities, as the African continent was a strategic point on maritime routes: natural resources were exploited, its people were colonized and trafficked as slaves, and the region served as a transit point for trade with the Arabs. Through these interactions and settlements, *Capsicum* peppers gradually began to be cultivated and incorporated into the culture of different African communities (Eshbaugh 1983; Tripodi *et al.* 2021). Furthermore, the colonization of several countries in the Americas leaned on the labor of enslaved Africans (who were forcibly taken from their homelands), and the enduring knowledge sharing with the Indigenous Peoples is deeply embedded in various cultural manifestations throughout South America (Pagnocca *et al.* 2020; Rivas *et al.* 2023; Voeks 1993).

The long-standing interactions established by Indigenous and Quilombola (descendants of enslaved Africans who formed autonomous centers of resistance and are now recognized as traditional peoples) communities with *Capsicum* genetic resources have shaped a distinctive biocultural heritage in Brazil, safeguarding remarkable genetic diversity within this crop (Barboza *et al*. 2022; Clement *et al.* 2016). This attribute emerges from the continuous transmission of traditional knowledge, local practices, and cultural values associated with these plants over generations, which make the conservation of these plant genetic resources intrinsically linked to the persistence of traditional communities and their knowledge systems (Rivas et al. 2023). The preservation of biocultural heritage provides critical benefits from both biological and socioecological perspectives, enabling crops to continue their evolutionary processes under natural environmental conditions, and supporting the well-being of traditional communities by reinforcing cultural identity and enhancing food security (Hossain *et al*. 2021; Mallagi *et al*. 2020).

Despite the biocultural importance of *Capsicum* species, knowledge regarding their uses, cultural meanings, and symbolic values among Indigenous and Quilombola communities remains fragmented in the literature, hindering a comprehensive understanding of their cultural significance and conservation implications. Addressing these knowledge gaps is particularly relevant given that the conservation and sustainable use of genetic resources for food and agriculture, as well as the recognition and valorization of traditional knowledge associated with genetic heritage, constitute guiding principles of Brazil's National Policy for the Conservation and Sustainable Use of Genetic Resources for Food, Agriculture, and Livestock (Brazil, 2024). These principles are aligned with the commitments established under the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (Brazil, 2000; Brazil, 2008). In this context, the present study aims to conduct a comprehensive literature review on the ethnobotanical

knowledge documented in previous studies involving Indigenous and Quilombola communities in Brazil with *Capsicum* species, as well as to elucidate the role of these traditional communities in the conservation of the genetic resources of this genus.

Materials and Methods

This study adopts an interdisciplinary approach integrating ethnobotanical, linguistic, culinary, and spatial data to examine the relationships between Indigenous and Quilombola communities in Brazil and *Capsicum* species. The methodological design combines a structured literature review with data systematization and geospatial analysis to identify patterns of use, classification, and conservation within a biocultural framework. All ethnobotanical information analyzed in this study was derived exclusively from previously published sources, with no direct interaction with Indigenous or Quilombola communities.

The literature review comprised two complementary searches. The first focused on identifying ethnobotanical information concerning *Capsicum* species applications among Indigenous and Quilombola communities in Brazil. This search was conducted using PubMed, Google Scholar, and Scopus databases with combinations of the keywords "*Capsicum* medicine," "traditional use of *Capsicum*," and "*Capsicum* Brazil." Publications from both the natural and social sciences were considered, without any restrictions of publication date or language, and sources were included when they contained information on the uses of *Capsicum* by Indigenous and Quilombola communities in Brazil. This search resulted in 40 sources, comprising 18 scientific articles, 11 cookbooks, eight natural science books, two technical-scientific documents, and one doctoral thesis.

Given that Brazil encompasses one of the centers of diversity of the genus *Capsicum* and stands out for its remarkable richness of Indigenous languages, a second search was conducted to compile linguistic data on vernacular names of *Capsicum* varieties in Indigenous languages. The search was carried out through the online repository '*Biblioteca Digital Curt Nimuendajú*', where it was possible to gather 20 sources, including dictionaries, academic publications, books, and graduate theses. Information was systematized into a table containing the Indigenous language, the pepper name in the original language, and its corresponding common name in Brazil. By documenting vernacular nomenclature, the analysis sought to highlight the cultural dimensions of *Capsicum* diversity.

To contextualize patterns of use, official regional classifications from the 2022 Brazilian Demographic Census (IBGE) were used, dividing Brazil into five regions: North, Northeast, Central-West, Southeast, and South. Culinary data (e.g., recipes and ingredient use) were analyzed across these regions to identify spatial patterns associated with cultural heritage. Medicinal uses were systematized using the International Classification of Diseases (ICD-11; WHO 2025) as an analytical framework. This classification served as a comparative tool to organize reported therapeutic applications, recognizing its ethic perspective in relation to traditional medical knowledge.

To assess patterns related to the conservation of *Capsicum* genetic resources, data on *ex situ* collections were compiled from the Global Biodiversity Information Facility (GBIF, 2025) and the AleloVegetal database for plant genetic resources maintained by Embrapa (Embrapa, 2025). Taxonomic nomenclature followed Plants of the World Online (POWO, 2025). Records from both databases were systematized to quantify the number of herbarium specimens and germplasm accessions available for each *Capsicum* species. Furthermore, the records containing geographic coordinates were retained for geospatial analysis. Geographic coordinates of herbarium specimens and germplasm accessions were imported into QGIS and plotted together with officially recognized Indigenous and Quilombola territories obtained from INPE (2024) and INSA (2024). Spatial overlap between collection records and traditional territories was visually assessed to identify areas where *ex situ* conservation records coincide with regions historically occupied by Indigenous and Quilombola communities.

Results and Discussion

Uses of *Capsicum* by Indigenous and Quilombola communities

Historically, *Capsicum* peppers held considerable cultural and subsistence value among Indigenous and Quilombola Peoples all over the American continent (Katz *et al*. 2024; Rivas *et al.* 2023). Beyond written culinary sources, such as cookbooks, material evidence (including kitchen utensils or the preserved food remains recovered from diverse contexts) can offer valuable information for reconstructing the particularities of each time and place where peppers were processed, consumed and stored (Carneiro 2005).

Several studies embedded in distinct cultural contexts of the Amazon have revealed other forms of relationship with *Capsicum* peppers, such as their important role in religious ceremonies and myths (Heiser Jr. 1995) and their use for prophylactic and therapeutic purposes (Roman *et al.* 2011). In this sense, a study with Quilombola communities in the Amazon revealed that of the uses attributed to peppers, 65% are related to food, 15% medicinal, 14% ritualistic, among other less frequent uses, such as repellent and ornamental plants (Pereira *et al.* 2017).

This diversity of uses is accompanied by a high level of biological and sensory variation. In Brazil, *Capsicum* diversity is extensive, encompassing a wide range of fruit colors, shapes, sizes, flavors, and aromas. Among the *Capsicum* species in Brazil, only domesticated ones have recorded culinary uses and medicinal applications for the body and mind, specifically: *C. annuum*, *C. baccatum*, *C. chinense*, and *C. frutescens*, whose variability is represented in Figure 1.

Figure 1. Landraces of *Capsicum annuum* (A, B, E, H, I), *Capsicum baccatum* (C, D), *Capsicum frutescens* (F), and *Capsicum chinense* (G, J) cultivated in Brazil. (Pictures: Rosa Lía Barbieri, and Juliana Castelo Branco Villela).

Taken together, the compiled data indicate that *Capsicum* peppers in Brazil cannot be understood through discrete categories such as food, medicine, or ritual use. Instead, these uses are deeply interconnected and form part of a continuum of practices embedded in the daily life of Indigenous and Quilombola communities. Like other Mesoamerican contexts, *Capsicum* operates simultaneously at multiple levels – as nourishment, therapeutic agent, and symbolic element – reflecting a holistic conception of health and well-being (Aguilar-Meléndez *et al.* 2021).

Accordingly, the distribution of uses identified in the literature (predominantly food-related, followed by medicinal and ritual uses) should not be interpreted as separate domains, but rather as overlapping expressions of a single biocultural system. For instance, culinary preparations may incorporate ingredients and techniques that enhance both flavor and perceived health benefits, while ritual uses often involve plants that are also consumed or applied medicinally. This convergence highlights that *Capsicum* is not merely a crop, but a multifunctional cultural resource.

The food uses

One of the earliest European accounts documenting the use of *Capsicum* peppers by Indigenous Peoples was recorded by the German traveler Hans Staden in the 16th century. In his chronicles, the traveler described peppers that the natives cultivated for food, one yellow and the other red, comparing their immature-green fruits to those of the wild rose. The Indigenous Peoples harvested them when ripe and dried them in the sun (Staden 2008). During the same period, Gabriel Soares de Sousa published an ethnobotanical description of *Capsicum* peppers in Bahia in his work '*Tratado descritivo do Brasil em 1587*' (Descriptive Treatise of Brazil in 1587). The historian described the rich diversity of shapes, colors, and flavors of the peppers cultivated by the Indigenous Peoples, who commonly prepared them cooked with fish and ate them mixed with flour. Furthermore, the author describes the Portuguese habit of imitating the Indigenous Peoples, drying the fruits and mixing them with salt to season fish and vegetables, and highlights that enslaved Africans named the peppers in their original language (Sousa 2013).

By the early seventeenth century, the French missionary Claude d'Abbeville took part in an expedition to the region that is now the state of Maranhão, Northeast Brazil. During this journey, he observed that thrushes (*sabiás*) played an important role in the dispersal of *Capsicum* pepper seeds. He also reported that these fruits were collected by Indigenous Peoples (Abbeville 1874). Two centuries later, the French explorer Henri Coudreau undertook an expedition along the Tapajós River (current state of Pará, Northern Brazil) and observed that peppers were part of the "roças" (small-scale agricultural plots) of the Sateré-Mawé and Apiaká Indigenous Peoples (Pinheiro 2024).

In line with these observations, numerous other pepper fruits have been recorded by historians, naturalists, and archaeologists across many historical periods and diverse geographic regions (Reifschneider 2000). For example, microbotanical analyses of *pães-de-índio* (processed and buried plant-based doughs that remain edible even after years) reveal that some ancient peoples used *Capsicum* peppers in the preparation of these products (Santos *et al.* 2021).

In Brazil, gastronomy must be analyzed in relation to the country's profound cultural heterogeneity and the diverse ways in which this plurality engages with Brazil's vast biological wealth (Mascarenhas 2007). Despite the many cultural influences, Brazilian cuisine results primarily from the fusion and transculturation of the dietary habits of Portuguese colonizers, Indigenous Peoples, and slaved Africans. This fusion is expressed in delicious dishes where certain categories and possible cultural roots are recognized, symbolizing different regions in constant transformation (Campos *et al.* 2009).

Currently, as part of the cultural heritage of these peoples, peppers are used in various culinary recipes and are featured in important cookbooks, such as: '*Coleção Cozinha Regional Brasileira*' (Editora Abril 2009 a, b, c, d, e, f) and related in the books '*Dicionário Gastronômico: Pimentas com Suas Receitas*' (LiguanottoNeto 2007), '*Viagem Gastronômica pelo Brasil*' (Fernandes 2001), '*Dicionário Gastronômico: Ervas e Especiarias com Suas Receitas*' (Liguanotto Neto 2003), '*Pimenta Baniwa jiquitaia*' (ISA 2018), '*Bolas na Mesa: A Simplicidade do Sofisticado*' (Costa 2010), and '*Cozinha de Origem*' (Castanho 2013).

The data analysis in this study identified 95 traditional recipes that reveal clear regional patterns linked to Brazil's cultural and ecological diversity: 40 recipes from the North Region of Brazil (39 savory and 1 sweet), 17 from the Northeast (all savory), 20 from the Central-West (all savory), 6 from the Southeast (all savory), and 12 from the South (11 savory and 1 sweet). The higher concentration of recipes in the North and Northeast regions corresponds to areas of strong Indigenous and Quilombola presence, suggesting that culinary diversity reflects historical processes of knowledge transmission and cultural continuity (Figure 2).

A few recipes had the species identified, among them *C. annuum* var. *annuum*, *C. baccatum*, *C. chinense*, and *C. frutescens*. The main common names recorded were: "*Pimenta malagueta*" (*C. frutescens*) with 14 savory recipes, "*Pimenta de cheiro*" (*C. chinense*) with 22 savory recipes, "*Pimenta dedo de moça*" (*C. baccatum* var. *pendulum*) with 14 records (4 sweet and 10 savory), "*Pimenta cumari do* Pará" (*C. chinense*) with 8 savory recipes, "*Pimenta biquinho*" (*C. chinense*) with 5 savory

recipes, "*Pimentão*" (*C. annuum*) with 31 savory recipes, and "*Pimenta doce*" (*C. annuum* var. *annuum*) with 3 savory recipes.

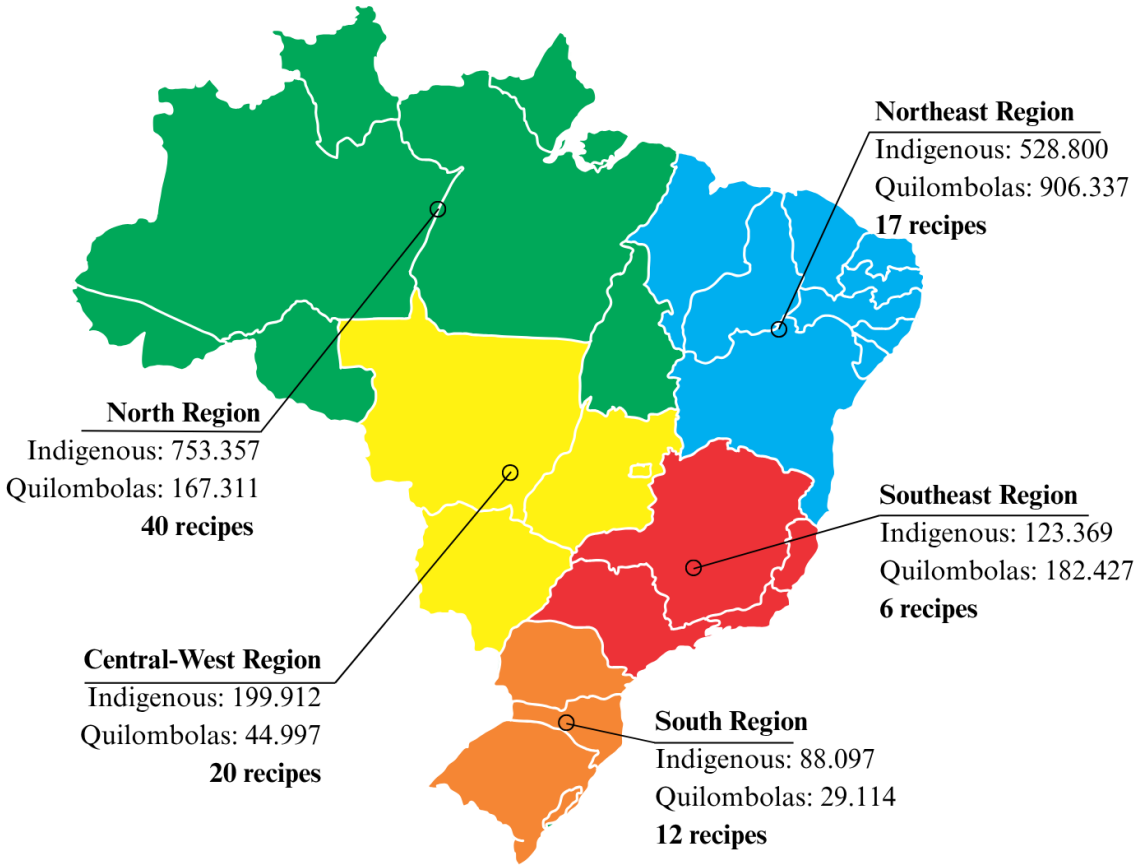

Figure 2. Indigenous and Quilombola population by geographic region in Brazil (IBGE, 2024) and number of recipes with *Capsicum* peppers reported for each one.

However, beyond numerical distribution, the data indicates that culinary practices are shaped by territorial specificities, including ingredient availability, local preferences, and cultural heritage. The use of vernacular names (e.g., *pimenta malagueta*, *pimenta de cheiro*, *cumari*) reflects not only taxonomic diversity but also culturally embedded classifications that emphasize sensory, ecological, and social attributes of the peppers. In addition, there are also documented instances of *Capsicum* fruit consumption *in natura*, as reported by Nascimento *et al.* (2024), who investigated the food plants consumed within a Quilombola community in the state of Bahia, northeastern Brazil. The authors identified consumption of two species within the genus, *C. annuum* and *C. frutescens*, with the latter also being consumed by the community in canned form.

Finally, the limited identification of species in recipes highlights a gap between scientific taxonomy and local knowledge systems, in which classification operates according to cultural, sensory, and ecological criteria rather than formal botanical categories. This reinforces the need to interpret culinary data within a linguistic and cultural framework, recognizing that *Capsicum* species contribute not only to culinary diversity but also to food security and food sovereignty among Indigenous and Quilombola communities. Through the continued cultivation, exchange, classification, and consumption of locally adapted pepper varieties, these communities maintain resilient food systems closely linked to cultural identity and traditional ecological knowledge. In this sense, *Capsicum* represents not merely a food resource, but an important component of biocultural heritage that supports community well-being and adaptive capacity in the face of environmental and socioeconomic change (Aguilar-Meléndez *et al*. 2021; Martha 2021).

The medicinal uses

Studies demonstrate a high consumption of medicinal plants, mainly linked to the inheritance of traditional knowledge passed down through generations (Albuquerque & Hanazaki 2006; Silva *et al.* 2023). The medicinal properties of the *Capsicum* genus have gained prominence in contemporary medicine due to their recognized effects in the prevention and treatment of chronic diseases (Antonious 2018; Salehi *et al.* 2018), particularly for their antioxidant and anticancer

activities (Sharma *et al.* 2017; Sarpras *et al.* 2018; Sherova *et al.* 2019). However, these species have already been used for generations by traditional communities, which attribute to them various therapeutic applications. In this review, records of medicinal uses of *Capsicum* were found for twelve types of diseases according to the ICD-11 of the World Health Organization (Figure 3), and most of the records refer to Indigenous communities of the Amazon.

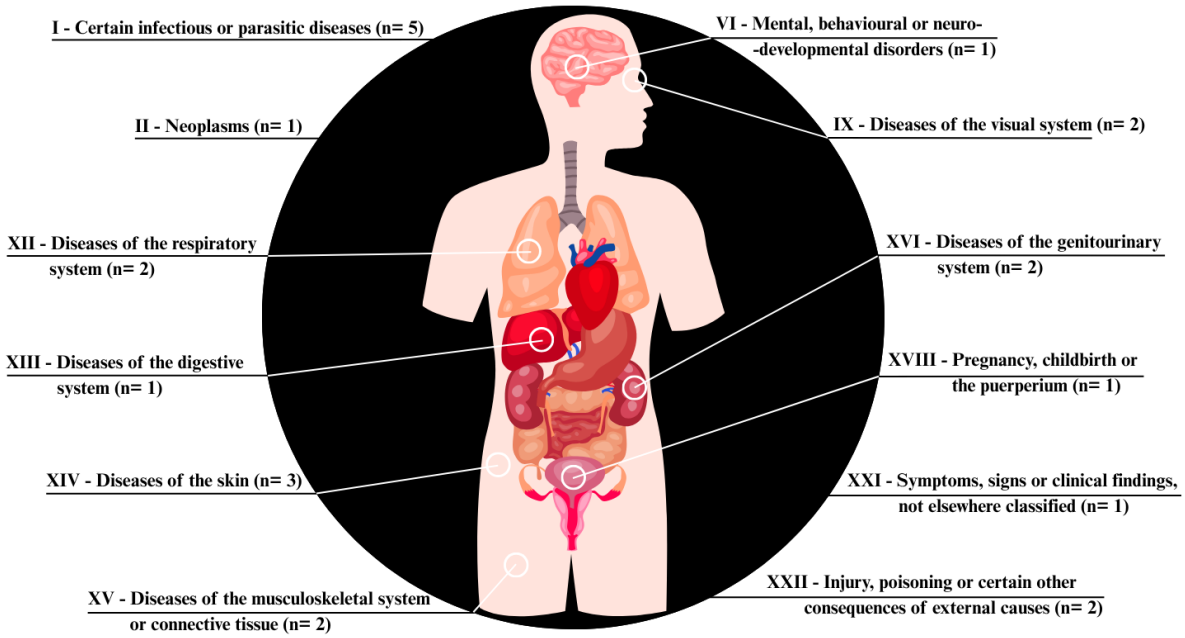

Figure 3. Medicinal uses by Indigenous and Quilombola Peoples in Brazil according to the International Classification of Diseases (ICD-11), with roman numerals indicating ICD-11 chapters code and arabic numerals (n) indicating the number reports of *Capsicum* medicinal application on the literature.

A survey conducted with the Guariba community in Roraima found that 68% of respondents use *Capsicum* peppers for medicinal purposes (Marques *et al.* 2024). The medicinal uses reported in the Guariba community include pain relief and the treatment of parasitic infections, cancer, and wounds (ICD-11, Chapters 1, 2 and 22). The authors also relate the high usage rate to several factors, such as the distance from urban centers, the abundance of these plants, and the traditional knowledge passed across generations.

The community "Cabeça D'Onça," located on the banks of the Amazon River in Pará, makes use of *C. frutescens* fruits for various treatments. According to Roman *et al.* (2011), the leaves are applied for dermatological treatment (ICD-11, Chapter 14), and the fruits are used against parasitic infections, toothaches, and stingray stings (ICD-11, Chapters 1, 13 and 22). The authors also reported that the women of the community employ the pepper fruits in pregnancy-related practices (ICD-11, Chapter 18), massaging the belly with green peppers to "straighten" the fetus and drinking tea to accelerate labor.

Furthermore, riverside communities in the state of Amazonas prepare tea with *Capsicum* leaves to relieve back and kidney pain (ICD-11, Chapters 15 and 16) (Vásquez *et al.* 2014). The Yanomami peoples use *C. frutescens* to treat ocular and respiratory inflammations (ICD-11, Chapters 9 and 12) (Milliken et al., 1999). Also, Nascimento-Filho *et al.* (2007) reported that Indigenous Peoples of Roraima, such as the Yanomami, Macuxi, Wapichana, and Taurepang, use *C. frutescens* to treat malaria, fever, and ophthalmia (ICD-11, Chapters 1, 9 and 21).

As for Afro-descendant communities in Brazil, Pereira *et al.* (2007) highlighted the importance of *C. chinense* and *C. frutescens* for Quilombola communities in Amapá, who use the leaves to treat fungal and bacterial diseases, rheumatism, and colic (ICD-11, Chapters 1, 15 and 16). Another assessment of these communities revealed that their members use *Capsicum* pepper leaves to treat erysipelas, pimples, and prickly heat (ICD-11, Chapters 1 and 14) (Pereira *et al.* 2017).

In the Recôncavo region of Bahia, in northeastern Brazil, the Quilombola community of Salamina Putumuju reports that the consumption of Capsicum fruits serves a therapeutic aphrodisiac function (ICD-11, Chapter 6) (Santana *et al.* 2022). A systematization of traditional medicinal knowledge conducted in another Quilombola community in the state of Bahia

identified the use of leaves and roots in the preparation of teas aimed at treating respiratory and skin diseases (ICD-11, Chapters 12 and 14) (Silva *et al.* 2012).

The systematization of medicinal uses using ICD-11 categories allowed for the organization of therapeutic applications across different disease groups. However, this classification should be understood as an analytical tool rather than a representation of local medical systems. Traditional uses of *Capsicum* encompass treatments for a wide range of conditions, and these applications are often embedded within broader healing systems that integrate physical, spiritual, and social dimensions. For example, treatments involving *Capsicum* may simultaneously address bodily symptoms and restore balance within the individual and their environment.

Thus, the diversity of medicinal uses reflects not only the pharmacological properties of *Capsicum*, but also the plurality of medical epistemologies in which these practices are situated. The translation of these uses into biomedical categories may oversimplify their meanings, underscoring the importance of maintaining a critical perspective on classification frameworks. At the same time, the recurrence of medicinal applications across geographically distant Indigenous and Quilombola communities suggests a broad recognition of the medicinal value of *Capsicum*. In many communities, these plants constitute accessible treatment resources whose uses are reinforced through generations of accumulated experience and cultural transmission. As reported by Aguilar-Meléndez *et al*. (2021), it is observed that several medicinal applications are unique to each community and are not repeated in other locations, with the authors suggesting that the high number of *Capsicum* varieties are the result of selections carried out and maintained only locally.

The transcendental uses

Conventional medicine tends to understand illness solely as a biological phenomenon, whereas the anthropology of health seeks to recognize that illness carries different conceptions and representations for the various established sociocultural groups. These are personal experiences felt, perceived and lived by individuals and their communities, in which therapeutic choices are directly linked to these meanings (Astolfo 2014). In recent years, endemic diseases have increased, and there has been a movement to rediscover ancient healing practices worldwide, traditional therapeutic methods, as well as spiritualist and esoteric approaches (Peixoto 2018).

There is a range of magical-religious-spiritual uses associated with *Capsicum* peppers in traditional villages in Brazil. Among the Macuxi, an Indigenous group inhabiting the state of Roraima, it is customary for traditional healers (*pajés*) to employ peppers as therapeutic agents to treat illnesses believed to be removable only through their specialized knowledge. Additionally, within the community, there exists a cultural norm that prohibits directly handing pepper fruits to another person, as this act is believed to harm interpersonal relationships. Instead, the peppers should be placed in a designated location where the intended recipient may retrieve them (Nascimento Filho *et al.* 2007).

For the Baniwa peoples, an Indigenous group inhabiting a transboundary region spanning Brazil, Colombia, and Venezuela, peppers play a central role in initiation rituals. During these rites, young individuals consume fruits that have been ritually blessed by adults, a practice believed to “cook” their bodies and generate an invisible protective shield against harmful spiritual forces. In addition, everyday practices involving peppers are also associated with protection against evil influences. For instance, peppers may be used cosmetically to prevent facial deterioration attributed to evil agents, and they may be thrown into the fire as a means of preventing forest spirits from turning against the community when offended (ISA 2018).

Traditional spiritual medicine associated with different religions, as *macumba*, *candomblé* and *umbanda*, known Afro-Brazilian religious rites are also noteworthy (Gomes *et al.* 2008). In the rituals, practitioners aim to heal harm that has been mysteriously inflicted upon a person or to eradicate the evil responsible for their suffering, and peppers are often used in such contexts. As accurately stated by Barbieri & Stumpf (2008), malagueta pepper is more than just a condiment, it is a versatile cultural element. One of the popular beliefs in Brazil is that peppers, along with other plants such as Saint George’s sword (*Sansevieria trifasciata Prain*), rue (*Ruta graveolens* L.), guinea plant (*Petiveria alliacea* L.), *comigo-ninguém-pode* (*Dieffenbachia seguine* [Jacq.] Schott), rosemary (*Salvia rosmarinus* Schleid.), and basil (*Ocimum basilicum* L.), can be cultivated together to ward off “the evil eye” (negative energy) and bad vibrations.

Torres (2018), in her work on the list of botanical species used in the temples of Umbanda Nagô, revealed that the *Capsicum* species most frequently employed in rituals were *C. baccatum* var. *pendulum* (known as *dedo-de-moça* pepper), *C. frutescens* (malagueta pepper), and *C. annuum* (bell pepper). In this context, *Capsicum* peppers have also been

mentioned by healers from a community in Porto Alegre composed of descendants of Indigenous Peoples and Afro-Brazilians, where they are used to ward off the evil eye (Casagrande & Ritter 2023). Moreover, in Afro-Brazilian communities located in Santa Catarina, *C. frutescens* and *C. baccatum* are plants commonly used in rituals as offerings to deities, either in gratitude for blessings received or as requests for assistance in solving problems (Pagnocca *et al.* 2020).

In a Quilombola community in the state of Amapá, Northern Brazil, the cultivation of peppers is notably influenced by local mysticism. According to the ethnobotanical study by Pereira *et al.* (2017), these plants are grown in front of houses to ward off the *"mau olhado"* and *"olho gordo"* (the evil eye). Additionally, some community members remarked that *Capsicum* peppers are considered plants that bring good luck in all aspects of life.

The persistence of these practices underscores the resilience of traditional knowledge systems, even under conditions of social and environmental change. Rather than constituting a distinct domain, these practices are deeply intertwined with culinary and medicinal uses. The same *Capsicum* species employed in food preparation, for example, may also be used in rituals associated with protection or healing. This convergence reinforces the view that *Capsicum* operates within a continuum of meanings in which material and symbolic dimensions are inseparable.

Traditional Communities in the Conservation of *Capsicum* Genetic Resources

The way we refer to *Capsicum* peppers is due to the early Spanish explorers and colonists, who, upon encountering them, gave them the name *pimiento* because of their flavor and use as a condiment, which reminded them of the Asian pepper *Piper nigrum* L. (Chiou *et al.* 2014). However, the oldest recorded name in South America for this crop is *axí / ají*, designated in the proto-Arawakan languages of northwestern and southwestern Amazonia (Brown *et al.* 2013). A total of 75 records of names in different Indigenous languages has been found, used to designate different landraces of *Capsicum* (Table 1).

Table 1. Indigenous languages, pepper names in the Indigenous language, and its common name in Brazil.

Indigenous language	Pepper name in the Indigenous language	Common name	Reference
***Capsicum baccatum* L. var. *pendulum* (Willd.) Eshbaugh**			
Arawak	*Dzawietsha*	*Dente de onça* pepper	ISA (2018)
***Capsicum chinense* Jacq.**			
Arawak	*Aamo*	Purple pepper	ISA (2018)
Arawak	*Botaothe*	*Bode* pepper	ISA (2018)
Arawak	*Dzakoithe*	*Cheiro* pepper	ISA (2018)
Arawak	*Kerekerethe*	*Cumari* pepper	ISA (2018)
Macuxi	*Pimi'ró*	Small pepper	Nascimento Filho *et al.* (2007)
***Capsicum frutescens* L.**			
Arawak	*Aawi*	*Agulha* pepper	ISA (2018)
Arikapu	*Tɔrɔtə piriɔ*	Malagueta pepper	Ribeiro (2008)
Baniwa	*Kapitstrhíwi*	Malagueta pepper	Ramirez (2001)
Tupi (tembé-ténêtéhar)	*Ta-z-äih*	Malagueta pepper	Boudin (1978)
Tupi (tembé-ténêtéhar)	*Ta-z-aka'i*	Malagueta pepper	Boudin (1978)
Yanomami (wakathautheri)	*Prika*	Malagueta pepper	Emiri (1987)
***Capsicum* spp.**			
Aikanã	*Urukine*	Pepper	Silva (2012)

Aparai	*Aixi*	Pepper	Camargo (2008)
Arawak	*Aalihitako*	*Bico de Jaburu* Pepper	ISA (2018)
Arawak	*Dzaka inapa*	*Braço de camarão* pepper	ISA (2018)
Arawak	*Dzaatte hitako*	*Bico de Tucano* pepper	ISA (2018)
Arawak	*Dzoodzo hitako*	*Bico de peixe lápis* pepper	ISA (2018)
Arawak	*Eewaapa*	*Caba amarela* pepper	ISA (2018)
Arawak	*Halene*	White pepper	ISA (2018)
Arawak	*Haliakalithe*	*Haliakali* fruit pepper	ISA (2018)
Arawak	*Hemalithe*	*Abiu* fruit pepper	ISA (2018)
Arawak	*Holito Iattite*	*Pombo* pepper	ISA (2018)
Arawak	*Ixedonithe*	*Ixedoni* fruit pepper	ISA (2018)
Arawak	*Kadzaliwi*	*Molongó* flower pepper	ISA (2018)
Arawak	*Kamapo*	*Camapu* pepper	ISA (2018)
Arawak	*Kapatane*	*Parede acanalada* fruit pepper	ISA (2018)
Arawak	*Kapatsidalipe*	Flat fruit pepper	ISA (2018)
Arawak	*Kapitsiriwi*	*Flechinha de zarabatana* pepper	ISA (2018)
Arawak	*Katoto*	*Jolokia baniwa*	ISA (2018)
Arawak	*Kawathsidalipe*	*Camuti* pepper	ISA (2018)
Arawak	*Koitsi Hitako*	*Bico de mutum* pepper	ISA (2018)
Arawak	*Koori Hitako*	*Bico de corocoró* pepper	ISA (2018)
Arawak	*Koowheiwaaphi*	*Bunda de saúva* pepper	ISA (2018)
Arawak	*Kopitte*	*Cebolão* fruit pepper	ISA (2018)
Arawak	*Kowaidathe*	*Castanha* fruit pepper	ISA (2018)
Arawak	*Maako*	Brown pepper	ISA (2018)
Arawak	*Madzawithe*	*Jurubeba* pepper	ISA (2018)
Arawak	*Maipanali*	*Tapioca de inhambu* pepper	ISA (2018)
Arawak	*Makoweiithi*	*Urutau* eye pepper	ISA (2018)
Arawak	*Maroli Hitako*	Small toucan pepper	ISA (2018)
Arawak	*Peerihitako*	*Bico de gavião* pepper	ISA (2018)
Arawak	*Peritsota*	*Unha de gavião* pepper	ISA (2018)
Arawak	*Phito-Hiwida*	*Cabeça de grilo* pepper	ISA (2018)
Arawak	*Pirikitothe*	*Olho de periquito* pepper	ISA (2018)

Arawak	*Pomenhiri*	Fragrant pepper	ISA (2018)
Arawak	*Ttalattalane*	Mild and flat Pepper	ISA (2018)
Arawak	*Wiitshia*	*Pipira* pepper	ISA (2018)
Arawak (Resígaro)	*Ahatsi*	Pepper	Wavrin (1951)
Arikapu	*Tɔrɔtə*	Pepper	Ribeiro (2008)
Baniwa	*Áatti*	Pepper	Ramirez (2001)
Baniwa	*Dzaaka-náapa*	Pepper	Ramirez (2001)
Baniwa	*Katóoto*	Large and hot pepper	Ramirez (2001)
Baniwa	*Korhitáko*	Pepper	Ramirez (2001)
Baniwa	*Mítsa*	Toasted pepper	Ramirez (2001)
Baniwa	*Wítshia*	Pepper	Ramirez (2001)
Jê	*Bàri'y*	Pepper	Salanova & Ottawa (2010)
Ka`apór	*Ky`i*	Pepper	Caldas (2009)
Kinikinau	*Teeti*	Pepper	Souza (2008)
Kwazá	*Hade*	Pepper	Manso (2012)
Old Tupi	*Kyynha*	Pepper	Carvalho (1987)
Sateré-Mawé	*Musé*	Pepper	Miquiles & Castro (2022)
Terena	*Teti*	Pepper	Silva (2013)
Timbira	*P`yrhy*	Pepper	Amado (2005)
Tucana	*Biá*	Pepper	Giacone (1939)
Tupi (tembé-ténêtéhar)	*Kiiy*	Pepper	Boudin (1978)
Tupi (tembé-ténêtéhar)	*Tay*	Pepper	Boudin (1978)
Tupi (tembé-ténêtéhar)	*Tay ta-z-ahi*	Hot pepper	Boudin (1978)
Tupi (tembé-ténêtéhar)	*Taypuku*	Long pepper	Boudin (1978)
Tupi (tembé-ténêtéhar)	*Taz-apu'a'i*	*Periquito* pepper	Boudin (1978)
Warazu do guaporé	*Tái*	Pepper	Ramirez *et al.* (2017)
Waurá	*Aipiu'na*	Pepper	Richards (1973)
Waurá	*Kata'muti*	Pepper	Richards (1973)
Waurá	*Aisa'palu*	Pepper	Richards (1973)
Wayana	*Asi*	Pepper	Camargo (2008)

The most recent IBGE census that recorded Indigenous languages took place in 2010 and identified 274 languages spoken by individuals belonging to 305 different ethnic groups (IBGE 2012). Thus, although the records of words designating peppers in Indigenous languages may appear significant, they may be minimal when considering the total number of Indigenous languages in Brazil. However, caution must be taken not to overestimate the number of landraces known by

Indigenous communities, since some languages may be variations of the same language or some ethnic groups may be subgroups or segments of the same ethnic group. Therefore, there is an eminent need for further linguistic and anthropological studies.

In addition to the food, medicinal, and transcendental uses of *Capsicum* genetic resources, as discussed in Section 3, there is historical evidence of the importance of its fruits and seeds in systems of exchange and trade in remote regions. Abbeville (1874) reported that Indigenous Peoples from the state of Maranhão, Northeast Brazil, traded pepper fruits for tools such as axes and sickles. In the state of Roraima, in northern Brazil, Nascimento Filho *et al.* (2007) documented interethnic trade involving *jiquitaia* (dried and ground chili pepper) and noted that this commercial practice has been carried out for several centuries. These historical exchanges allowed for the expansion of crossbreeding, giving rise to new varieties that helped expand usages and enriched agrobiodiversity (Barbosa *et al.* 2010; ISA 2018).

Rêgo et al. (2012) emphasize that the Amazon Region is an important center of diversity for *Capsicum*, and that during the last decade it has undergone significant genetic erosion due to intense anthropogenic pressure. In recent decades, local pepper landraces in Brazil have been replaced by commercial crops, which have contributed to reducing pepper variability. In this regard, there are few data available on the *in situ*/on farm conservation status of plant genetic resources of *Capsicum* in Brazil. The hypothesis is that it is carried out throughout the national territory by farmers from traditional communities.

For example, according to Pereira *et al.* (2017), farmers from Quilombola communities in the state of Amapá, in northern Brazil, cultivate approximately 20 landraces of *Capsicum* peppers, and many also act indirectly as seed guardians. The authors also observed that conservation and cultivation activities are concentrated in the hands of women in the community, as is the dissemination of ethnobotanical knowledge, which is shared between mothers and daughters in their daily interactions.

Another traditional community, the Baniwa people, maintains small agricultural plots that constitute important sites for the diversification and *in situ*/on farm conservation of *Capsicum* genetic resources. A survey conducted by the Instituto Socioambiental (2018) identified 78 chili pepper landraces, predominantly belonging to *C. chinense* and *C. frutescens*, cultivated across 40 communities located within a transboundary territory spanning Brazil, Colombia, and Venezuela. For the Baniwa, *Capsicum* genetic resources are regarded as a form of intergenerational heritage. According to their cosmology, the ancestor of each Baniwa group received a specific variety of pepper, which is considered sacred and is transmitted primarily through female lineages, circulating from woman to woman (ISA 2018). Furthermore, cultural accounts from different Indigenous villages in the Amazon report that the cultivation, processing, and distribution of chili peppers within the village and surrounding areas are carried out exclusively by women, either individually or collectively. These women are locally referred to as "*pimenteiras*" (Nascimento Filho *et al.* 2007).

One intriguing narrative of *in situ* conservation of *Capsicum* genetic resources involves the worship of a wild pepper that grows naturally in the mountain ranges of Roraima. This species is *C. chinense*, and for the local Indigenous Peoples these peppers are cultivated in their fields by the "*Curupira*" or "*Ataí-taí*" (a Brazilian mythological figure, known for his backward-facing feet and hair that pulses with fire, considered a guardian of the forests for playing tricks to intimidate and scare away forest invaders). Due to this mystical belief, the pepper receives the symbolic name of "*Pimenta do Curupira*" ("*Curupira* pepper" in English) or simply "*pimi'ró*" ("small pepper" in the Macuxi language) (Nascimento Filho *et al.* 2007).

When it comes to *ex situ* conservation, between the 48 accepted species of *Capsicum* (Barboza *et al.* 2022), 32 are registered in Brazilian herbaria and 17 in genebanks (Table 2). A total of 10,118 records of wild and domesticated landraces of *Capsicum* sp. were found in Brazilian herbaria (GBIF 2025), and 5,092 records of accessions in genebanks (Embrapa 2025). Such *ex situ* conservation strategies are recognized for enabling the maintenance of biodiversity and serving as repositories of genetic resources (Fernandes *et al.* 2025).

Although the enrichment of genebanks with traditional landraces has been noteworthy over the past decade, several challenges still require attention. According to Pádua *et al.* (2022), the main gap lies in the incomplete geographic coverage of several genera. The authors argue that strengthening collaboration among genebanks, research institutions, and conservation units is of paramount importance.

Table 2. Records of *Capsicum* L. species in Brazilian herbaria and genebanks.

Specie/variety	Herbaria	Genebanks
[1]*Capsicum* L.	1,714	1,421
[2]*Capsicum annuum* L.	466	110
[2]*Capsicum annuum* L. var. *annuum*	53	662
[3]*Capsicum annuum* L. var. *glabriusculum* (Dunal) Heiser & Pickersgill	97	27
[3]*Capsicum baccatum* L.	798	130
[3]*Capsicum baccatum* L. var. *baccatum*	243	26
[2]*Capsicum baccatum* L. var. *pendulum* (Willd.) Eshbaugh	537	219
Capsicum baccatum L. var. *umbilicatum* (Vell.) Hunz. & Barboza	7	
[3]*Capsicum caatingae* Barboza & Agra	304	
[3]*Capsicum campylopodium* Sendtn.	275	1
[3]*Capsicum carassense* Barboza & Bianch.	17	
[4]*Capsicum chacoense* Hunz.		2
[5]*Capsicum chinense* Jacq.	1,566	1,104
[3]*Capsicum coccineum* (Rusby) Hunz.	45	
[3]*Capsicum cornutum* (Hiern) Hunz.	129	
[4]*Capsicum eximium* Hunz.	1	
[3]*Capsicum flexuosum* Sendtn.	963	4
[3]*Capsicum friburgense* Barboza & Bianch.	23	
[5]*Capsicum frutescens* L.	804	252
[4]*Capsicum galapagoense* Hunz.		1
Capsicum hookerianum (Miers) Kuntze	1	
[3]*Capsicum hunzikerianum* Barboza & Bianch.	35	
[4]*Capsicum lanceolatum* (Greenm.) C.V. Morton & Standl.		1
[3]*Capsicum longidentatum* Agra & Barboza	66	
[4]*Capsicum lycianthoides* Bitter	1	
[3]*Capsicum minutiflorum* (Rusby) Hunz.	18	
[3]*Capsicum mirabile* Mart.	299	1
Capsicum muticum (Sendtn.) Barboza	21	
[3]*Capsicum parvifolium* Sendtn.	364	1
[3]*Capsicum pereirae* Barboza & Bianch.	94	
[2]*Capsicum pubescens* Ruiz & Pav.	3	22
[3]*Capsicum rabenii* Sendtn.	403	21
[3]*Capsicum recurvatum* Witasek	311	
[4]*Capsicum rhomboideum* (Dunal) Kuntze	4	
[3]*Capsicum schottianum* Sendtn.	181	
[3]*Capsicum villosum* Sendtn.	240	
Total	**10,118**	**5,092**

According to Rio de Janeiro Botanical Garden (2025): [1]Data not specified at the species level; [2]Species of cultivated origin; [3]Species native to Brazil; [4]Species not native to Brazil; [5]Species considered naturalized in Brazil.

Furthermore, the need to integrate pepper landraces cultivated by Indigenous and Quilombola Peoples into *ex situ* conservation strategies has been discussed for decades, as highlighted by Barbosa *et al.* (2002), who observed the considerable ecological and economic potential of wild peppers cultivated by Indigenous Peoples in the Amazon, given their distinct forms and flavors. Similarly, Del Ré & Feijó (2024) argue that Indigenous and Quilombola communities require effective state protection to safeguard their genetic resources and ensure their food security and sovereignty. However, these landraces cultivated by Indigenous and Quilombola Peoples remain insufficiently represented in Brazilian herbaria and genebanks, as demonstrated in Figure 4.

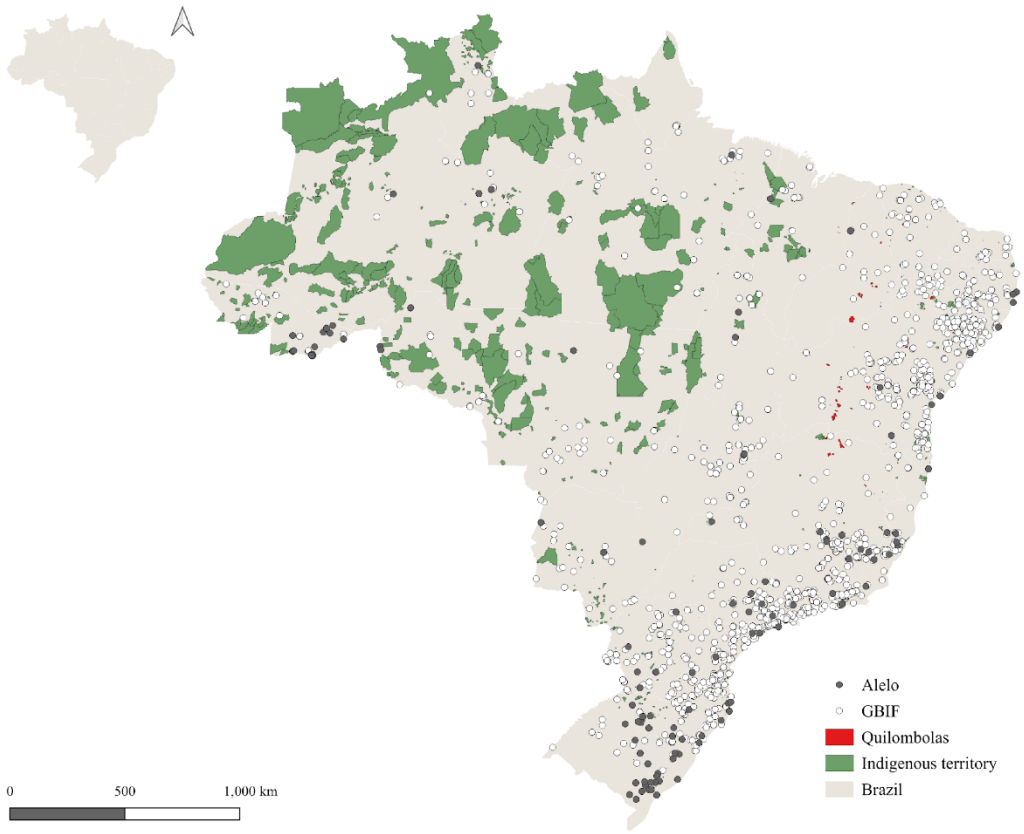

Figure 4. Collection points for specimens deposited in herbaria (extracted from the Global Biodiversity Information Facility - GBIF) or as accessions in germplasm banks (obtained from the AleloVegetal database), overlapping Indigenous and Quilombola lands officially demarcated in Brazil.

The spatial analysis revealed a limited overlap between *ex situ* conservation efforts and Indigenous and Quilombola territories, suggesting that current conservation strategies do not fully capture the diversity maintained *in situ* by traditional communities. From a biocultural perspective, the findings of this study highlight that traditional communities are not only users of biodiversity, but active agents in its conservation and diversification. The underrepresentation of these territories in formal conservation systems points to structural and institutional barriers that need to be addressed to develop more inclusive and effective strategies.

The lack of representation may directly reflect the bureaucratic barriers embedded in Brazilian environmental legislation, which often discourages research and conservation initiatives in Indigenous and Quilombola territories. Law 13,123/2015 regulates access to genetic heritage, and under its provisions, collecting biological material requires authorization from the Genetic Heritage Management Council (CGEN), registration in SisGen, community consent, and benefit-sharing arrangements (Brazil 2015). In the case of Indigenous and Quilombola communities, the process also involves additional institutions, such as Funai and Incra, respectively. This extensive bureaucracy acts as a significant obstacle, perpetuating the invisibility of *Capsicum* landraces historically cultivated by these communities. Another problem faced by Indigenous and Quilombola communities in Brazil, which ultimately underestimates the results of this study, is the obstacle to the official demarcation of their territories. For example, the latest update of geospatial data from INCRA indicated the presence of demarcated Quilombola territories only in the Northeast region (Figure 5), which is far below the reality (Almeida & Nascimento 2022).

In the face of threats to biodiversity, *ex situ* conservation of genetic resources contributes to mitigating gene erosion. When a landrace becomes extinct, the associated cultural habits are lost, such as food uses, cultivation methods, conservation strategies, and other ways of uses (Del Ré & Feijó 2024; Sudré *et al.* 2025). Thus, the lack of representation of traditional landraces can generate irreversible implications for the communities in which they are cultivated, compromising food security, medicinal treatments, and religious and ritualistic traditions.

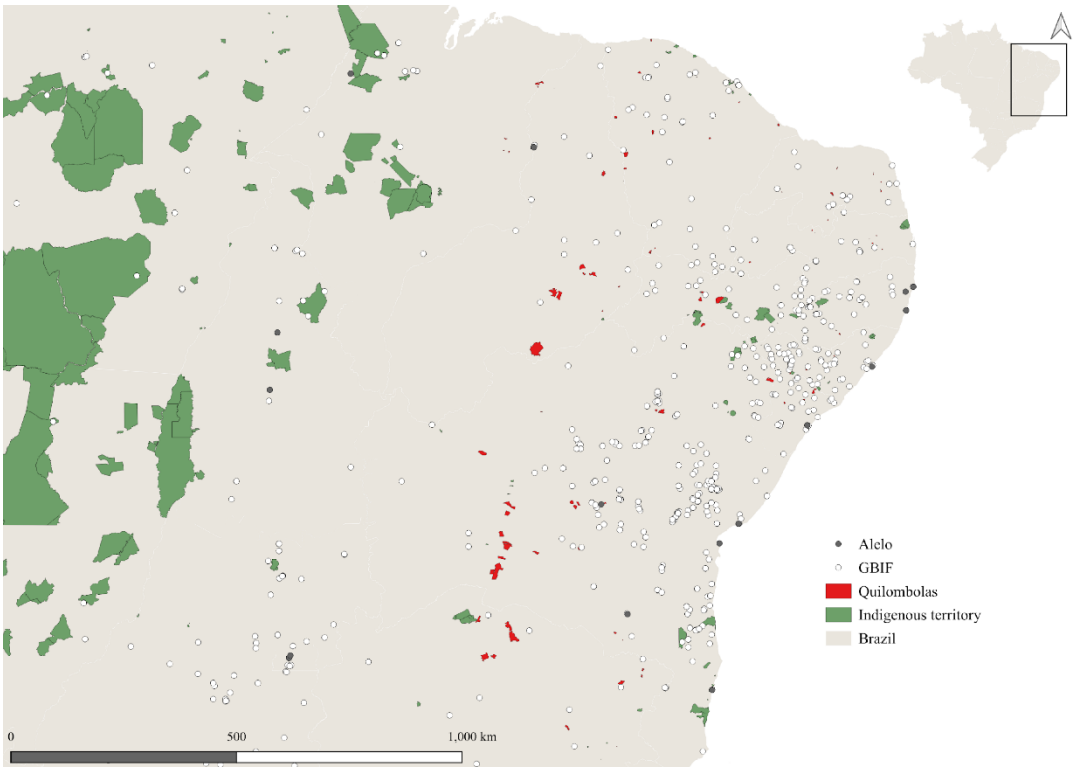

Figure 5. Collection points for specimens deposited in herbaria (extracted from the Global Biodiversity Information Facility - GBIF) or as accessions in germplasm banks (obtained from the AleloVegetal database), overlapping Indigenous and Quilombola lands officially demarcated in the northeastern region of Brazil.

Conclusion

This study demonstrates that *Capsicum* peppers in Brazil are associated with a wide range of uses, closely linked to local traditions and the diversity of domesticated landraces across regions. Within the Brazilian context, Indigenous and Quilombola Peoples use numerous *Capsicum* landraces, which, in addition to serving as food, hold deep cultural, medicinal, and religious meaning. Although this review focuses on documented uses, the evidence suggests that Indigenous and Quilombola practices contribute to the maintenance and transformation of *Capsicum* diversity through actions such as selective harvesting, seed exchange, and cultivation in homegardens and agricultural plots. These practices reflect a continuum of human-plant interactions, rather than discrete categories of wild versus domesticated.

The presence of specific *Capsicum* landraces is closely tied to the integration of language, knowledge, and practice within Indigenous and Quilombola communities. Local names and narratives expressed in native languages encode ecological and culinary knowledge, guiding management, selection, cultivation, harvesting and use. These linguistic and cultural frameworks are inseparable from everyday practices locally situated in each territory that actively contribute to the conservation of *Capsicum* landraces. When these interconnected systems remain intact, they enable the *in situ* maintenance of *Capsicum* diversity and reinforce the role of peppers as living components of biocultural heritage. However, due to the country's vast size and cultural diversity, comprehensive and consolidated ethnobotanical investigations remain notably insufficient. The limited existing documentation indicates that these plants have always been an integral part of local cultures.

Germplasm conservation has traditionally been undertaken by the communities themselves, ensuring the maintenance of *Capsicum* landraces *in situ*. Therefore, it is essential to broaden *ex situ* conservation, as done by Embrapa, while simultaneously incorporating strategies that support and respect *in situ* conservation, strengthening the active participation of Indigenous and Quilombola communities in preserving their agrobiodiversity and traditional knowledge.

Declarations

List of abbreviations: Not applicable

Ethics approval and legal compliance: This study complies with Brazilian Law 13.123/2015 and Decree 8.772/2016. As it involves indirect use of associated traditional knowledge through secondary data sources, the activity was registered in SisGen under number A1366EB.
Consent for publication: Not applicable
Availability of data and materials: Not applicable
Competing interests: Not applicable
Funding: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Conselho Nacional de Desenvolvimento Científico e Tecnológico
Author contributions: J.G.C. and C.F.M.L. collected the data, analyzed, and wrote the text. D.R.V. elaborated the GIS analysis and helped with discussion. A.A.M. and R.L.B. supervised the research and collaborated on the final version.

Acknowledgements

This material was produced through funds from Capes (Process 88887.150239/2025-00 and 88881.982701/2024-01) and CNPq (Processes 309602/2025-4 and 167137/2018-2).

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