


REVIEW

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People's migrations and plants for food: a review for fostering sustainability

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Abstract

Human movements via migrations facilitate the transport of plants and knowledge. Migrations were always present in our human history, but conflicts and environmental changes are contributing to the increase in people's movements to and from different parts of the world. In this literature review, our focus is on the ethnobotany of food plants and migrations, and the adaptations following this process. We analyzed 58 studies dealing with human migrations and food plants, including both internal migrations and international ones, over a wide period from several centuries to the present but with the predominance of migrations since the second half of the twentieth century. Most studies reported migrations between countries or regions (80%) in which people search for better economic opportunities. Other reasons for migrations were refugees, mandatory displacements, and slavery. The studies included cultivated plants, gathered plants (foraged), and food plants purchased on markets or obtained via exchanges or importation. We discuss the identitarian role of food plants in the processes of maintenance, abandonment, replacement, and incorporation of plants; although the evidences of abandonment are the most difficult to track. After the migration, the maintenance of a food identity will depend on several variables, including how important it is to keep a distinct identity, the plant resources available, the people's agency of the plant resources, and also the reasons for each migratory movement. Finally, we discuss the implications of this ethnobotanical knowledge and practices related to food plants for sustainability.

Keywords Ethnobotany, Traditional ecological knowledge, Local ecological knowledge, TEK, LEK, Ethnoecology, Movement, Diaspora, Food plant, Edible plant

Plain English Summary

Throughout history, people moving from one place to another have played an important role in transporting plants and knowledge worldwide. Recently, the increase in global conflicts and environmental changes has led to more people moving to different places. Our literature review focuses on the relationship between migrations and food plants, and how people adapt to new environments. We analyzed 58 studies covering different periods, with an emphasis on migrations since the 1950s. Most of the studies looked at migrations between countries or regions, driven by the search for better economic opportunities. Other reasons for migration included refugees, forced displacements, and slavery. The food plants in these studies could be cultivated, gathered from the wild, bought at markets, or acquired through trade or exchanges. Food plants are important in shaping cultural identity and migrations can affect the maintenance, abandonment, replacement, and incorporation of these plants. However, it is challenging

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to track evidence of plant abandonment. After migrating, the ability to maintain a food identity associated with specific plants depends on factors like the importance of keeping a distinct identity, the availability of plant resources, people's access to these resources, and the reasons behind the migration. Finally, we discuss the implications of this knowledge about food plants and related practices for sustainability.

Background

To a greater or lesser extent, migration has always been a phenomenon throughout human history. Besides allowing us to occupy some of the most remote areas of the globe, human migration also transports knowledge, habits, and plants; and migrants adjust and adapt to new circumstances and settings. If, since our prehistory, this relationship between migrating people and food plants primarily ensured our survival [1], contemporary mass migrations have taken on new dimensions in which food plants have strong ties to people's own identities [2–5]. Food serves as a source of nutrition and sustenance but also as a trigger of comfort, evoking memories of "food from home" and a reminder of identity about who we are and where we came from [6, 7].

Today, numbers about people's migrations reached expressive levels. According to UNHCR [8] 89.3 million people—including refugees, internally displaced people, and asylum seekers—were forcibly displaced at the end of 2021. Following the war in Ukraine, estimates for 2022 raise the number of forcibly displaced people to 100 million, or more than 1% of the world's population [8]. Although international migration flows have remained almost stable in the first decades of the twenty-first century [9], global forced migration rates remained high [8], and some major changes are also expected after the pandemic [10]. In addition, three-quarters of the countries experiencing food security crises had the highest rates ever recorded of internally displaced people because of conflicts, violence, and natural disasters [11].

Migration often contributes to the formation of plural and multicultural societies, which are characterized by the coexistence of several cultural and ethnic groups within a single geographic area. These relations between migrants and host societies can be approached by studies on the acculturation process, focusing on the adaptations of migrants. For example, in a classic acculturation model, Berry [12] suggests four potential acculturation strategies: assimilation, integration, separation, and marginalization. When aiming at the plants as a specific component of these processes, ethnobotany contributes to understanding how people adapt after migrations.

Medeiros et al. [13] approached the issue of migrations and plants proposing different adaptive strategies of migrants for medicinal plants: abandonment, replacement, and maintenance. However, while these authors

[13] emphasized the medicinal role of plants, the adaptive processes for food plants can be somewhat different due to the identitarian role of foods. Thus, in this study, we change the focus from medicinal plants to food plants, based on a literature review about the ethnobotany of food plants and migrations. We are directing our attention to contexts where a given cultural group is moving to another cultural/environmental setting, and when discussing adaptations, food plants have been considered in this review as a proxy for foods, being aware however that foods and food systems represent much larger phenomena and arenas. We discuss the state of the art of the literature on this subject, considering the general patterns that emerge in this debate and the processes that must not be generalized. Among the different profiles of migrations [14], our review is focused on the migrations between and within countries, facilitated or not by agreements between states, including refugees and forced migrations, but excluding seasonal migrations without this context (e.g., pastoralists).

Methods

We did a literature review based on the standards of the PRISMA checklist [15] to verify the minimum quality criteria in systematic reviews. We used the Scopus Elsevier database, searching in the fields Title, Abstract or Keywords the following key: (TITLE-ABS-KEY ((ethnobotany OR ethnoecology OR "local knowledge" OR "local ecological knowledge" OR "LEK" OR "traditional knowledge" OR "traditional ecological knowledge" OR "TEK") AND (migrant OR migration OR refugee OR movement OR diaspora) AND (plant) AND (food)), and with no year limit (Fig. 1). Although we use the keywords only in English, few articles in other languages were also retrieved when there was an abstract in English. We used both TEK and LEK and simply "local knowledge" since there is no consensus in the worldwide usage of these concepts, which sometimes can be used interchangeably but in other instances refer to different historical processes in the knowledge dynamics.

We first examined each title and abstract of these studies to remove those clearly out of our focus. We then examined the full text of the remaining studies, according to the following eligibility criteria: a) our main focus is when a given human group moved to another cultural or environmental context, thus we

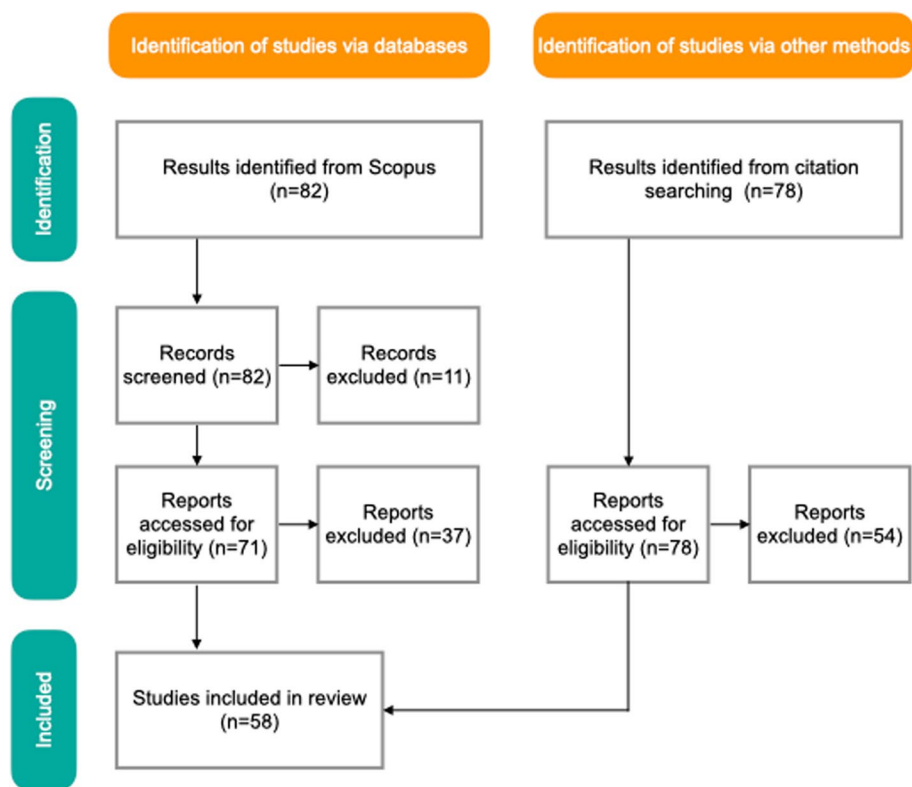


Fig. 1 Flow diagram for the literature review. modified from Page et al. 2021 [15]

included studies focused on migrations, being past or contemporary movements, but we excluded seasonal transitory migrations which are part of the livelihood of several human groups (e.g. pastoralists); b) for the geographic scale, we included both internal migrations (within a given country) and inter-countries; c) although we considered the gradient between food uses and medicinal uses of plants, we include studies which have focused on food plant uses (studies with only medicinal uses were excluded, but studies about migrations and food habits/dishes with enough details about the plant ingredients were included); d) to avoid duplicity of information, we excluded revisions when they were clearly based on the same data already published; we also excluded articles examining a given data set which was already published by the same author(s).

For this set of included studies, we did a snowball literature sampling [16], checking for the cited articles in each study adherent to our inclusion criteria. For the snowball literature, we first analyzed the titles of the cited articles. For those that could meet our objectives, we examined the full text according to the inclusion criteria explained above. All databases were consulted in April 2023. Screening of the publications for inclusion

or exclusion was done manually by the first author and checked by the other authors (Fig. 1).

The following descriptive data were extracted from each publication: (1) What is the focus of the study on food plants (strictly on food plants; food and medicinal plants; plants with several uses, including food; homegardens; food plants as ingredients; one single plant with food uses); (2) What is the people’s agency on the plants: the studies could focus on cultivated plants for food, on plants gathered for food (foraged), on plants purchased from markets (or brought from other areas by third parties, e.g., with no direct management agency of the person who migrated), or in a combination of these three strategies of obtaining the food plants; (3) In each study, the group who migrated; (4) Source and target areas of the migratory movement (we used the country names and geographic regions according to UN Statistics Division [17]), adding the data if the migration was within a country; (5) When the migration occurred, or the time frame of each study; (6) The main reasons provoking the migration, classified into broad categories (economic opportunity, mandatory relocation, slavery, refugees, remaining from past migrations, or a combination of those reasons). For migrant people in a given place for

more than 150 years, we considered them as remaining from past migrations, except in the case of the massive movement of enslaved people from Africa to the Americas. Slave traffic ended about 150 years ago [18], but still left widespread marks of inequality within many current societies.

In addition to the descriptive data, since we are dealing with very diverse time frames, socio-ecological contexts, and also with studies with different objectives, for each study we categorized the adaptations on plant use and knowledge after migrations in three broad and non-exclusive domains: (a) the adaptations restricted to management practices; (b) the adaptations on the knowledge about plants (when the study reported changes in knowledge about plants, but do not specify any given plant species related to these changes in knowledge); and (c) the adaptations related to the plant species used as food, e.g. when the study mentioned the change in plant species used as food due to migration, which were always linked to changes in knowledge about plants.

Then, when considering the adaptations related to plant species, we tried to find examples of maintenance, replacement, abandonment, or incorporation in each study, including innovations adopted by migrants. We also retrieved other qualitative, relevant information and drivers of change in the knowledge about plant use. All data was organized in spreadsheets for qualitative data analysis. For a graphic representation of the articles and sources used we built a circular dendrogram with Rawgraphs [19] and to show the migration flows we built a Sankey graph with Sankeymatic [20].

Results

How migrations and food plants are being studied

A total of 58 studies were selected and included in this review (Fig. 1), published from 1994 to February 2023, all written in English except one (in Spanish [21]). About two-thirds of them (67%) were published in the last decade. The most used vehicles for publicizing the results were the journals *Economic Botany* and *Journal of Ethnobiology and Ethnomedicine* (each journal with 17% of the studies), *Human Ecology* (7%), *Plants* (5%), *Ecology of Food and Nutrition*, *Ethnobotany Research & Applications*, and *Phytotherapy Research* (3% each). Another 19 journals were used once, and 7% of the studies were published as book chapters (Fig. 2). The detailed set of studies and data retrieved is available in Additional File 1.

The main focus of 36% of the studies was food plants, with a remarkable contribution of articles focusing on plants with food and medicinal uses (26%). Plant uses in general (including other uses besides food and medicine) were approached by 19% of the studies, and plants from homegardens, 10%. Three studies (5%) focused on

only one species, and we also included two studies (3%) focused on foods and migrants, but which had enough details to individualize plant ingredients among the food preparations.

Most studies (91%) used interviews for data collection, with different strategies of sampling and with different degrees of detailing. Seven percent of the studies also did inventories in homegardens [3, 22–24], and 3% also surveyed local [1] or larger markets [25]. Two studies used secondary sources (3% [26, 27]). Other methods used were dietary studies checking for frequency of consumption [28], a questionnaire for a diabetes study [29], and the author's expertise [30].

The studies reported migrations occurred several centuries ago and present generation migrations. Migrations that occurred several centuries ago could have kept testimonies of the source areas when those migrants remained relatively isolated in the target area, or the case of the African enslaved people trade due to the massive scale along the time and in the number of people affected. Most migrations reported in the reviewed studies, however, occurred since the second half of the twentieth century (Fig. 3).

We could identify 76 flows of migration (Fig. 4), considering that one study could report more than one flow from one source area to a target area (e.g., when a study investigated several groups who migrated to a given place) or more than one reason for these migrations. Internal migrations accounted for 20% of the migrations flows and are represented mainly by rural to urban migrations in the American and Asian continents, driven by the search for better economic opportunities. Most studies reported movements between countries (80%), driven mainly by the search for better economic opportunities, supported or not by government policies.

The movements between countries could be between contiguous countries or in the same geographic region (37%). Movements between different continents accounted for 43%. The representation of some migration could have inflated by this latter percentage flows when one study reported more than one migration flow, such as those from the African continent to the American continent [26–27; yet it only partially reflects the massive and violent migration due to slavery).

About 15% of migration flows were of refugees, including war refugees [28, 31] and refugees after the beginning of an authoritarian government [32]. For another 15% of the studied migrations, the movement occurred more than 150 years ago. However, the group remained relatively isolated until recently [33–35], as in several Southern European studies. Mandatory relocations accounted for 3% of the migration flows. They could have been supported by long-term governmental policies [36] or

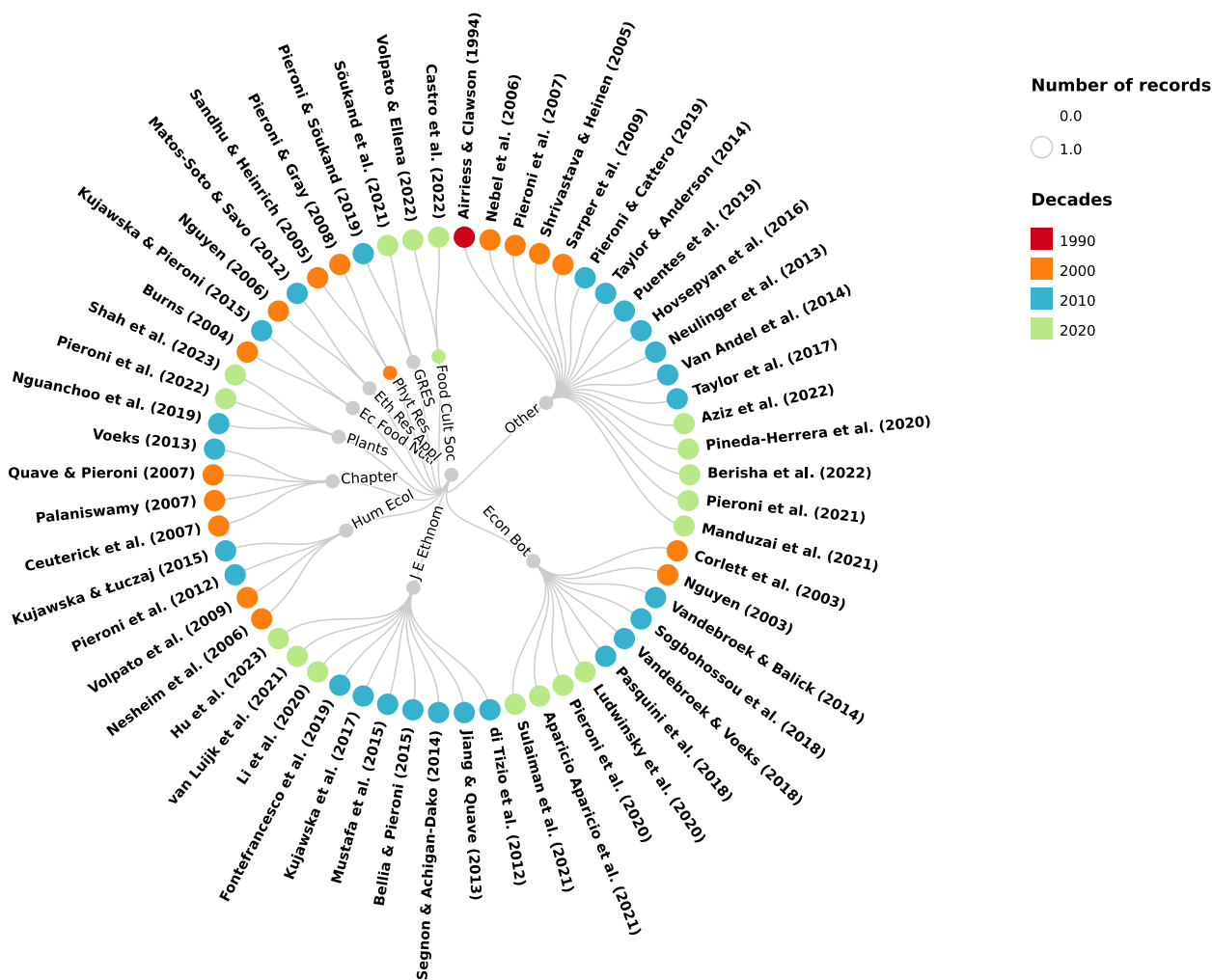


Fig. 2 Selected articles, main sources used for publication, and decades of publication ($N=58$ studies reviewed). Econ Bot = Economic Botany, J E Ethnomed = Journal of Ethnobiology and Ethnomedicine, Hum Ecol = Human Ecology, Chapter = book chapter, Ecol Food Nutr = Ecology of Food and Nutrition, Ethnobot Res Appl = Ethnobotany Research and Applications, Phytoter Res = Phytotherapy Research, Genet res Crop Evol = Genetic Resources and Crop Evolution, Food Cult Soc = Food, Culture & Society

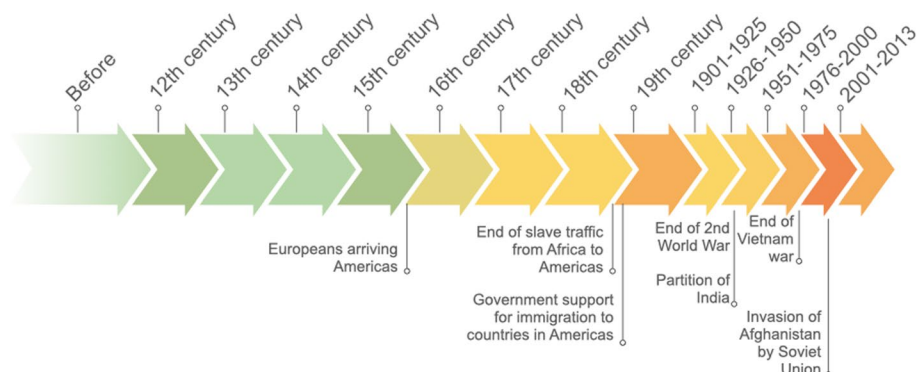


Fig. 3 When the studied migrations occurred ($N=58$ studies reviewed). Lighter green: two studies; darker orange: 28 studies. One study could consider several migratory waves or longer time spans

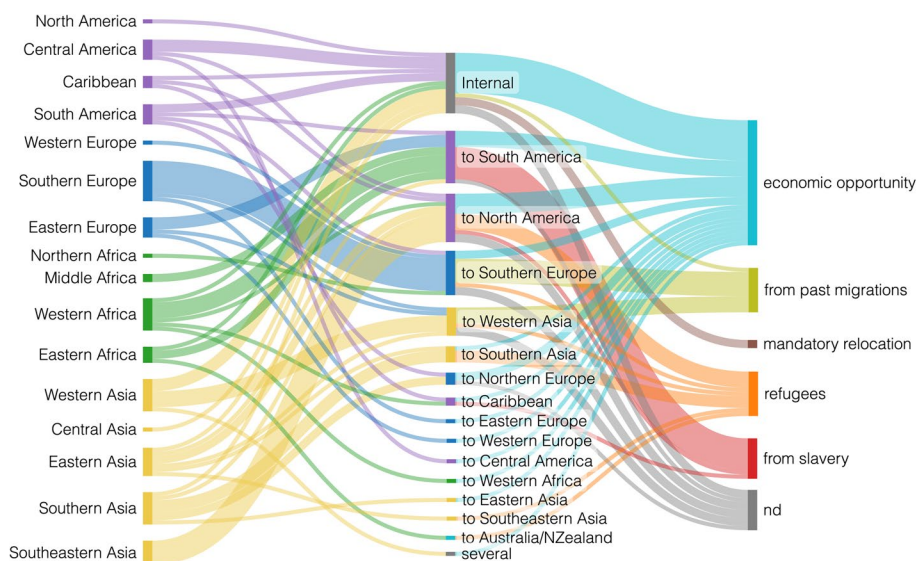


Fig. 4 Flows and main reasons for migration, between major world regions (N=58 studies reviewed). One study could report more than one flow (total 76 flows), nd=no data available

occurred in more violent processes [37]. For 13% of the migration flows, we could not identify the main reason for the migration.

Migration effects on plant management, knowledge, and use

Regarding the people’s agency on the plants, in 12% of the studies, people used plant foods cultivated by themselves. For example, for people in relocated villages in Southern China, frequent cultivated species include staples as *Zea mays* L. and *Ipomoea batatas* (L.) Lam., main vegetables such as *Capsicum annuum* L. and *Solanum melongena* L., and fruits such as *Morus alba* L. and *Eryobotrya japonica* (Thunb.) Lindl. [36]. In arid and semi-arid regions from Benin, people who did internal migrations cultivate vegetables such as *Abelmoschus esculentus* (L.) Moench., *Corchorus olitorius* L., *S. macrocarpon* L., *Vernonia amygdalina* Delile; fruits (e.g. *Citrus sinensis* (L.) Osbeck, *Mangifera indica* L., *Psidium guajava* L.); cereals (e.g. *Oryza sativa* L., *Sorghum bicolor* (L.) Moench., *Z. mays* L.); pulses (e.g. *Arachis hypogaea* L., *Glycine max* L., *Vigna unguiculata* (L.) Walp.); and roots and tubers (e.g. *Colocasia esculenta* (L.) Schott., *Dioscorea* spp., *I. batatas* Lam., *Manihot esculenta* Crantz) [28]. Twenty-nine percent of the studies included gathered plants (foraged), for which the management action is not direct (Fig. 5), such as the gathering of *Apteranthes tuberculata* (N.E.Br.) Meve and Liede, *Mentha longifolia* (L.) L., *Withania coagulans* (Stocks) Dunal, and *Zygochillum indicum* (Burm.f.) Christenh. and Byng among Afghan refugees in Pakistan [31]; and, among multiethnic

migrants in Guatemala, the fruits of *Chamaedorea tepelilote* Liebm. in Mart., *Pouteria sapota* (Jacq.) H.E.Moore & Stearn, *Piper auritum* Kunth, and *Dialium guianense* (Aubl.) Sandwith [38]. In 12% of the studies, people depended on markets, exchanges, or plants brought from other places, with no management action over the plants. Examples are several species bought in ethnic markets by Chinese and Taiwanese in USA [39], and in Bolivian markets among internal migrants in Argentina [40]. In 34% of the studies, the plants used for food were obtained in a combination of these actions (cultivated and gathered 19%; cultivated and markets 7%; cultivated, gathered and markets 9%), and in 7% we could not determine the people’s agency on the plants. Migration can lead to adaptations in how people relate to the plants used for food, on different levels, and based on people’s agency of the plant component (Fig. 5).

From a broader perspective, adaptations in management practices were present in 11% of the studies, and this proportion was more expressive among studies in which people cultivated the food plants they used (Fig. 5, orange bars). For example, in Assam (India) homegardens [41], people who migrate from rural areas of India and Bangladesh and Nepal do not have disadvantages due to a lack of local ecological knowledge due to the intensive use of available land. In Vietnamese gardens in New Orleans (US), management adaptations reflected changes from subsistence to commercial-oriented gardens [3]. On the other side, in Chicago (US), Taiwanese and Chinese migrants are relying more on available markets than on garden plants in this urban area [39]. However,

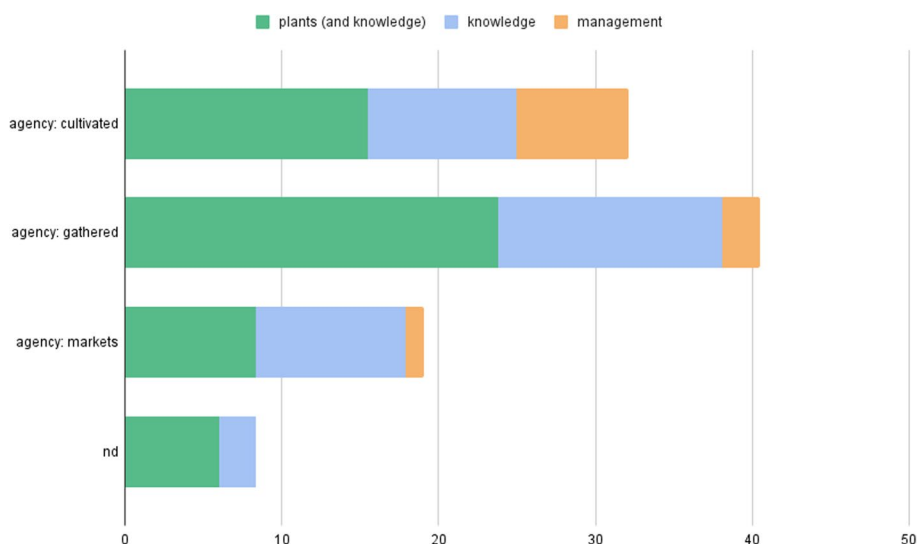


Fig. 5 People’s agency on food plants, and changes in management practices, knowledge, and plants used. Data in percentage for a total of 84 occurrences of agency types in 58 studies reviewed

management and knowledge cannot be separated, and higher management knowledge can be adaptively advantageous for people who migrate to another area but keep using specific plant resources, such as in the case of the spider plant in Benin [42].

Examples of adaptations in the level of plant knowledge (Fig. 5, blue bars), but not mentioning plant species in particular, were observed in 37% of the studies, with a slightly higher proportion for those studies in which the plant resources were gathered/foraged (14 studies) when contrasted to cultivated (10 studies) or obtained in markets or through exchanges (10 studies). In some cases, migration does not seem to affect plant knowledge, such as in the circular migrations in Mexico [43] and among migrant and non-migrant students in a coastal urban area in Brazil [44].

The maintenance of knowledge about food plants can be part of the very objectives of a given study, in a way to reinforce a distinctive feature of migrant’s identity within the matrix of other socio-cultural identities, such as in the case of studies with Chinese in Buenos Aires [25], or Paraguayans in Argentina [45], and this notion can be reinforced by their perceptions of keeping traditions even when some loss is observed among younger generations (e.g., Sikhs in London [46]). This maintenance happens in different degrees depending on how migrants were attached to their original identity, such as among Albanians and Moroccans who migrate to Italy [47]. For people from Pakistan and India in northern England, the idea of migrants losing their traditions is also questioned, since ethnic food traditions are one of the cultural traits most resistant to modernization and adaptation in the host

country [48]. Among people from Dominican Republic in New York (US), food traditions are symbolic representations of their identity [49], and in Armenia; the "plants of the mountains" were sent to familiars who migrated recently to European countries as a distinctive characteristic of Armenian [50]. In Germany, the uses and preparations of food plants related to German-Russian migrant identity are maintained [51].

The incorporation of plant food knowledge was reported for circular migration in the Mexican Huasteca region [21], and although people who migrated were the youngest in age, they recognized more plants and more uses than those who never left the community. In Hawaii, more plant uses among Vietnamese migrants when compared to people in Vietnam [52]. In Benin, internal migrations contributed to a higher species richness, due to a more favorable target environment [53].

The loss or abandonment of plant knowledge after migrations were observed among younger generations of migrants from Poland in Brazil [54], from Vietnam in Hawaii and the US [52], and from Pakistan and India in the UK [48]. Also, in the UK, in London, migrants from Latin America keep using few functional foods, and they reported barriers to using plants, such as lack of time and a different language [55]. Incorporation into the surrounding plant food habits, indicative of loss of original knowledge, was reported in different time frames: after centuries since their migration, Greeks in Italy lost many of the original features of their wild vegetable-based folk cuisine [33]. Similar phenomena were observed after complex migrations of different groups in Kosovo [56] and for wild plant foraging among Sarikoli people

who migrated from Xinjiang to Pakistan [32]. In Tajikistan, the forced relocation could be the reason for plant knowledge loss among the Yaghnobi people [37]. For a recent migration in a multiethnic returnee community in Guatemala, people who recently settled in the area could not have enough time to learn about the identification of forest species, which can result in the collective loss of knowledge [38].

Migration effects on the set of plants species used as food

For 52% of the studies ($n=44$) we observed adaptations on the use of plant species—which are obviously always also related to plant knowledge—and these adaptations were most frequent for gathered plants (24 studies) than for cultivated (15 studies) or obtained in markets or via exchanges (8 studies).

Among all the 44 studies which mentioned adaptations in food plant species, maintenance in the use of plants appears as a way to keep cultural memories, or in different degrees, with an identitarian role [1, 29, 40, 57], which can be present in the way some plant ingredients were prepared [58]. This maintenance is also evidenced in the names attributed to plant species, such in Suriname [26] for West and Central African names (Ewe, Fon, Bantu-Kikongo, and Akan) given to plants of African origin and for some American plants introduced in Africa before the slave traffic.

The maintenance in the use of plants for foods can be related to a few species or for several plants, even when other adaptation processes are in place, such as incorporation, replacement, or loss (see examples in Table 1).

Abandonment and replacement are the most difficult adaptations to track in adaptations of migrants. In some cases, the migration time was too far to have good testimonies of abandonment [64], in others the authors suspect abandonment but with no strong evidence to define which plants were abandoned precisely. For example, a considerable amount of African knowledge was probably lost in Suriname after the African diaspora [26]. In Italy, Slavic people probably abandoned 38 plant species [65], but there are limitations to ensuring the occurrence of this process. Afghan refugees in Pakistan remembered at least 15 plants due to past use in Afghanistan, after four decades of living in a new environment; and yet they could not identify precisely, two taxa could be *Polygonum* sp. and *Allium rosenbachianum* Regel [73].

Table 2 shows examples of possible abandonments of plants used for food after the migration. In contrasting environments, the lack of availability of some species is directly related to their abandonment, such as in the probable case of mushrooms among Polish migrants in Argentina [62] and some plant ingredients for Andean migrants in lowland Argentina [56]. The abandonment

of foraging practices [31, 35] also contributed to the abandonment of plants, as well as the acculturation process, which is not exclusive to migrant groups as observed in a multicultural context in Georgia [74].

In the literature, we found a few examples of replacements of plant food species after migrations (Table 3). Replacement is associated with the incorporation of new species, which in a dynamic process can occur both with a linkage to the identitarian role of plant foods or dishes made with plant ingredients, or through the food delocalization and homogenization with the surrounding socio-cultural environment.

Parallel with replacement, when people substitute plant species as ingredients or as foods, other incorporations are an expected adaptive process after people migrate, when different species are available in the source environment. For example, in Kenya, after rural to urban migration, people substituted wild leafy vegetables with cheap cabbage and kale; staples (yam, arrowroots, and sweet potatoes) with rice and potatoes; and millet and sorghum with maize; but they also added plants (e.g. *Vigna subterranea* (L.) Verdc.) to create new recipes [68].

Other examples of incorporation were observed in Pakistan, where Afghan refugees incorporated the use of plants from Pakistan, and local Pakistaners (Pathan) only used plants from Pakistan [31]. In Italy, Greeks probably incorporated several species primarily used regionally over the centuries (e.g. *Chrysanthemum segetum* L., *Urospermum picroides* (L.) Scop. ex F.W.Schmidt, *Lotus edulis* L.) [64]. In Romania, Venetian migrants incorporated *Humulus lupulus* L. use into their baking traditions [58]. Hmong people who migrated to the US incorporated the cultivation of *Capsicum annuum* L., *Coriandrum sativum* L., *Mentha spicata* L., *Momordica charantia* L., *Ocimum basilicum* L., *Phaseolus vulgaris* L., *Allium chinense* G.Don, *Polygonum odoratum* Lour., and *Cucurbita pepo* L. [22]. Medog people who migrate from Bhutan to Tibet slowly incorporated introduced species such as *Eleusine coracana* Gaertn., *Sorghum bicolor* (L.) Moench, *Zea mays* L., and *Prunus persica* (L.) Batsch, along trade routes [75]. In this sense, the adaptive enrichment of plant food repertoire among migrants, both through maintenance and incorporation is an advantage for food security [23].

The incorporation of industrialized food was also mentioned by several authors. For example, this phenomenon is reported in Argentina for migrants from the highlands to the lowlands [40], and in Australia for women refugees from Somalia who replaced traditional bread with ready-baked ones [28]. However, in this last case, women also incorporated the consumption of vegetables and fruits not consumed in Somalia [28].

Table 1 Examples of maintenance in the use of plant foods after migration; references are in brackets

Species	Context
<i>Cucumis sativus</i> L. <i>Zea mays</i> L. <i>Hydrocotyle javanica</i> Thunb. <i>Polygonum</i> aff. <i>cymosum</i> Trevir.	For Hmong from Vietnam in the US [22]
<i>Piper nigrum</i> L. <i>Capsicum annuum</i> L. <i>Allium sativum</i> L. <i>Allium cepa</i> var. <i>cepa</i>	For Vietnamese in the US [59]
<i>Capsicum</i> spp. <i>Porophyllum ruderale</i> (Jacq.) Cass. <i>Dysphania ambrosioides</i> (L.) Mosyakin & Clemants <i>Piper auritum</i> Kunth <i>Amaranthus</i> sp. <i>Chenopodium album</i> L.	For cultivated plants in Mexican homegardens in the US [24]
<i>Momordica charantia</i> L. <i>Benincasa hispida</i> (Thunb.) Cogn.	For cultivated plants in Chinese homegardens in the US [24]
<i>Artemisia absinthium</i> L.	For Haitians in Cuba, even with difficulties associated with cultivation [60]
<i>Cajanus cajan</i> (L.) Millsp. <i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai <i>Cucumis melo</i> L. <i>Dioscorea alata</i> L. <i>Hibiscus sabdariffa</i> L. <i>Sesamum indicum</i> L. <i>Tamarindus indica</i> L.	Plants associated with the African diaspora in Colombia [61]
<i>Abelmoschus esculentus</i> (L.) Moench <i>Amaranthus viridis</i> L.	After African diaspora in tropical America [27]
<i>Sonchus oleraceus</i> L. <i>Allium cepa</i> L. <i>Allium sativum</i> L. <i>Anethum graveolens</i> L. <i>Brassica oleracea</i> L. <i>Citrus limon</i> (L.) Osbeck <i>Cucurbita</i> spp. <i>Daucus carota</i> L. <i>Linum usitatissimum</i> L. <i>Mentha x piperita</i> L. <i>Petroselinum crispum</i> (Mill.) Fuss <i>Piper nigrum</i> L. <i>Prunus domestica</i> L. <i>Solanum tuberosum</i> L. <i>Camellia sinensis</i> (L.) Kuntze <i>Coffea arabica</i> L.	For Polish migrants in Argentina, as the only species known from their country of origin [62] For Polish migrants in Argentina [63]
<i>Reseda alba</i> L.	For Greeks in Italy [64]
<i>Tamus communis</i> L.	For Slavic people in Italy, use of shoots in sauces and pasta [65]
<i>Papaver rhoeas</i> L. <i>Vicia faba</i> L. <i>Cichorium intybus</i> L. <i>Synapsis</i> spp. <i>Scolymus hispanicus</i> L.	For Albanians in Italy, who use these species for unique Albanian dishes [66]
<i>Zea mays</i> L. <i>Annona muricata</i> L. <i>Mangifera indica</i> L. <i>Capsicum baccatum</i> var. <i>pendulum</i> (Willd.) Eshbaugh <i>Solanum tuberosum</i> L. <i>Peumus boldus</i> Molina <i>Linum usitatissimum</i> L. <i>Hordeum vulgare</i> L. <i>Ruta graveolens</i> L. <i>Matricaria chamomilla</i> L. <i>Uncaria tomentosa</i> (Willd. ex Schult.) DC. <i>Mentha x piperita</i> L.	For Peruvians in Italy; maintaining the importation of some species which can be found in Italy and some mixtures [67]

Table 1 (continued)

Species	Context
<i>Tanacetum vulgare</i> L. <i>Veronica allionii</i> Vill.	For Waldensian communities in Italy, which can have contributed to the cultural spread of the use of recreational teas from British and Northern/Central European customs [34]
<i>Foeniculum vulgare</i> Mill <i>Thymus capitatus</i> (L.) Hoffmanns. & Link <i>Mentha spicata</i> L.	Overlap with Arabic names for Maronites of Cyprus [35]
<i>Amaranthus hybridus</i> L. <i>Ananas comosus</i> (L.) Merr. <i>Arachis hypogaea</i> L. <i>Basella alba</i> L. <i>Bidens pilosa</i> L. <i>Cajanus cajan</i> (L.) Millsp. <i>Catha edulis</i> (Vahl) Forssk. ex Endl. <i>Cleome gynandra</i> L. <i>Colocasia esculenta</i> L. (Schott) <i>Corchorus olitorius</i> L. <i>Crotalaria brevidens</i> Benth. <i>Cucurbita ficifolia</i> Wall. <i>Cucurbita moschata</i> Duchesne <i>Dioscorea bulbifera</i> L. <i>Dovyalis abyssinica</i> (A.Rich.) Warb. <i>Eleusine coracana</i> (L.) Gaertn. <i>Erucastrum arabicum</i> Fisch. and C.A.Mey. <i>Galinsoga parviflora</i> Cav. <i>Ipomoea batatas</i> (L.) Lam. <i>Lablab purpureus</i> (L.) Sweet <i>Launaea cornuta</i> (Hochst. Ex Oliv. and Hiern) C. Jeffrey <i>Mangifera indica</i> Wall <i>Manihot esculenta</i> Crantz <i>Medicago sativa</i> L. <i>Mondia whitei</i> (Hook. f.) Skeels <i>Musa acuminata</i> Colla <i>Pennisetum glaucum</i> L. <i>Persea americana</i> Mill. <i>Portulaca oleracea</i> L. <i>Saccharum officinarum</i> L. <i>Sesamum</i> sp. <i>Solanum nigrum</i> complex <i>Solanum tuberosum</i> L. <i>Sorghum bicolor</i> (L.) Moench <i>Symphytum uplandicum</i> Nyman <i>Urtica massaiica</i> Mildbr <i>Vigna subterranea</i> (L.) Verdc. <i>Vigna unguiculata</i> (L.) Walp.	Species related to rural–urban transfers of people of eight ethnic groups: Kikuyu, Luo, Luhya, Kisii, Maasai, Kamba, Sabaot, and Turkana in an urban setting in Kenya [68]
<i>Mentha aquatica</i> L. <i>Chenopodium album</i> ssp. <i>album</i> <i>Polygonum cognatum</i> Meisn. <i>Portulaca oleracea</i> L.	Internal migrants in Turkey, who keep names and uses of food plants [69]
<i>Rumex acetosella</i> L. <i>Prunus spinosa</i> L. <i>Armoracia rusticana</i> G.Gaertn., B.Mey. & Schreb. <i>Crataegus</i> spp. <i>Viburnum opulus</i> L.	For Molokans (international refugees) in Azerbaijan [70]
<i>Fagus</i> sp. <i>Viburnum</i> sp. <i>Amaranthus</i> sp. <i>Armoracia</i> sp. <i>Humulus</i> sp. <i>Urospermum</i> spp.	Wild food plants used exclusively by Molokans in Armenia when compared to other groups in the same region (Armenians, Greeks, Yazdis) [71]
<i>Tradescantia zebrina</i> Bosse <i>Talinum fruticosum</i> (L.) Juss.	For Hmong from China in Thailand [72]

Table 1 (continued)

Species	Context
<i>Chenopodium</i> sp. <i>Lepidium</i> sp. <i>Lamium</i> sp. <i>Malva</i> sp. <i>Medicago</i> sp. <i>Portulaca</i> sp. <i>Rumex</i> sp. <i>Stellaria</i> sp.	For Afghan refugees in Pakistan, mainly plants found in anthropogenic environments [73]
<i>Agasyllis latifolia</i> (M. Bieb.) Boiss. <i>Anthriscus sylvestris</i> (L.) Hoffm <i>Heracleum</i> spp.	For Bats from Ingushetia and Chechnya in Georgia, possibly related to their pastoralist traditions [74]

Table 2 Examples of abandonment in the use of plant foods after migration; references are in brackets

Species	Context
<i>Momordica cochinchinensis</i> (Lour.) Spreng. <i>Pandanus amaryllifolius</i> Roxb. ex Lindl.	For Vietnamese in the US, the use of these species was substituted by food colorants [59]
<i>Rubus</i> sp. <i>Vaccinium</i> sp. <i>Sambucus</i> sp.	For Polish migrants in Argentina, probably due to the unavailability of these fruits native to the source area of the migrants [63]
<i>Corchorus olitorius</i> L. <i>Solanum macrocarpon</i> L. <i>Celosia argentea</i> L. <i>Gynandropsis gynandra</i> (L.) Briq.	After the African diaspora in tropical America, some of these species are only occasionally consumed [27]
<i>Blighia sapida</i> K.D. Koenig <i>Amaranthus dubius</i> Mart ex Thell. <i>Portulaca oleracea</i> L.	For food plants associated with the African diaspora in Colombia. Additionally, the use of <i>Abescolmus esculentus</i> and <i>Brassica oleracea</i> were declining [61]
<i>Erythoxylon coca</i> Lam. <i>Plantago linearis</i> Kunth	For Peruvians in Italy; due to the impossibility of cultivation and rarity [67]

Table 3 Examples of replacement in the use of plant foods after migration; references are in brackets

Species	Context
<i>Coriandrum sativum</i> L. and <i>Ocimum basilicum</i> L. replacing <i>Persicaria odorata</i> (Lour.) Soják	For Vietnamese in the US [59]
<i>Sorghum bicolor</i> (L.) Moench replacing <i>Saccharum officinarum</i> L.	For Hmong from Vietnam in the US; <i>S. bicolor</i> in the source area was not cultivated as food) [22]
<i>Artemisia abrotanum</i> L. and <i>Origanum majorana</i> L. replacing <i>Artemisia absinthium</i> L.	Species used for <i>tifey</i> , a traditional Haitian drink, for Haitians in Cuba, replaced due to similar morphology [60]
<i>Rumex paraguayensis</i> D. Parodi <i>Oxalis debilis</i> Kunth <i>Rubus rosifolius</i> Sm. <i>Rubus sellowii</i> Cham. & Schltld. replacing taxa from the same genus	For Polish migrants in Argentina [62]
<i>Oryza</i> sp. replacing <i>Chenopodium quinoa</i> Willd.	For people from highlands Andean Argentina who migrated to the lowlands, but also in the source area [40]
<i>Sedum</i> sp. and <i>Talinum</i> sp. replacing closely related taxa	For Hmong from China in Thailand [72]

Resistance to incorporating or replacing food plants appeared in some cases. For example, a few ethnobotanical uses from Italian traditions have been incorporated into Peruvian customs [67]. For Puerto Ricans in the US, at least for the first generation of migrants, different yam crops were not interchangeable with the original ones [1].

Discussion

Research efforts about food plants and migrations have increased in the last decade, and although our focus is on ethnobotany, these efforts encompass diverse approaches due to the intersection of other areas of knowledge such as nutrition and cultural studies. The literature retrieved

was predominantly in English, and we recognize the limitation of using only keywords in English (which resulted in the final inclusion of only one reference in a language different from English [21]). Additionally, several different approaches to the theme migrations and food expand this debate beyond the academic field of ethnobotany, for example through the studies focused on nutrition (e.g. [28]) and health [76], food and identity (e.g. [4, 77, 78]), or even through artistic initiatives (e.g. [79]).

In the ethnobotanical scope, several studies in migrants' ethnobiology have addressed the crucial role of "edibles medicines" [80], or plants consumed for their attributed attitude to counteract illness and improve general wellbeing ([66, 80, 81], among others). This overlap between food and medicinal plants in the host country, where often access to public health services is fair, has been indicated also as a possible reason explaining the apparent contradiction that urban migrants do sometimes use more plants than their counterparts in the countries of origin [82].

Studies in this subject focused on a wide time frame with the predominance of migrant movements since the second half of the twentieth century. Large-scale migrations and globalization are closely intertwined [14, 83], and this period corresponds to the second wave of globalization and economic integration, which is still ongoing [84].

Most migratory movements were between countries, and 20% were within the same country (internal migrations). The main target regions of these migrations were North America and Southern Europe (driven by the search for economic opportunities) and South America (considering the massive forced movement of people from Africa during slavery). The reasons for moving from one place to another can be multifactorial and multilayered and involve more or less agency or voluntariness [12, 85, 86] of the person who migrates. From one extreme, slavery is the most awful and violent reason, in which people did not have a choice about their movements. In such a violent process, even if the presence of some species on both sides of the Atlantic before the slave traffic could have facilitated a "relatively seamless ethnobotanical transition" [30], we must not ignore the dramatic consequences of this violent process, including the consequences of the abrupt food transition on the ethnobotanical repertoires of plants used for food, influencing the adaptation of these populations to the new environment.

Mandatory relocations guided by governmental policies can be as traumatic as situations of war refugees, in which people lose their places with no possibility of choice. These traumatic processes can contribute to the loss of knowledge of original plant resources used for food

due to limited mobility to gather wild plant foods and a limited possibility to keep in contact with familiars in the original area and receive plants and seeds from abroad [31, 37]. Yet in some situations, refugees can migrate to other places due to war or political regimes, with some degree of agency when they can choose where to go and can keep their ties with their source area, also keeping the exchanges of plant foods and knowledge [67, 68]. Combined with these forced migrations, different socio-economic scenarios (driven by hunger, unemployment, environmental changes, and others) can lead to migration. These economic migrations can be supported by governments, such as in the massive migrations from Europe to North and South America encouraged by the governments in the late 19th and early twentieth century, or can involve a higher risk of the person who chooses to pursue an economic alternative, including illegal migrations. In these situations, migrants' adaptations in the use of food plants will vary depending on the context, and on the intensity of people's agency on their plant resources; yet the identitarian role of food certainly plays an important role in the ethnobotanical repertoires.

Migrations within the same country included circular migrations studied in countries of Central America and movements from rural to urban areas in South America and Africa. The small percentage of studies on internal migrations (20%) indicates a gap in the knowledge about these processes related to knowledge and use of food plants. We expected to find more ethnobotanical data on rural-to-urban migrations, yet these studies can focus on other processes and not migration itself. Several authors have been stressing the urban ethnobotany as an insightful approach [82, 87], yet the majority of the studies are centered on medicinal plants and rural-urban migrations [88]. Hence the role of food plants transported by migrants to urban environments remains understudied.

Migration is a fertile topic in the debate on acculturation [12, 89–91]. In our review, beyond situations where there was a movement of people with a distinct cultural identity into a context of a different dominant group, there were also situations of contested regions with historical multicultural occupations (e.g. several studies in Eastern Europe and Western Asia [35, 56], or with the creation of new political borders imposing different arrangements of the dominant groups [92, 93], which could also have consequences for how people relate with their own identity and with their knowledge and use of food plants. Other complex trajectories of migrations involve historical migrations in which there is more than one "target" area, such as in the case of circular migrations in Guatemala and Mexico [23, 43] or German/Russian migration [51]. Along these historical trajectories, people keep adapting

to new environments by incorporating knowledge and use of new plant species native to these environments [38] or introduced by other groups [75].

We observed different strategies for accessing food plant resources (gathering, cultivation, purchasing in markets, or obtaining through external exchanges), and the adaptations in the use of plant foods after migration will be mediated by these strategies. For example, if the target environment is markedly different from the source environment, we could expect less availability of known native plants (except for widely distributed species), contrasting conditions for cultivation, and less availability of habitual plant foods in the markets. The dependence on markets will be affected by their availability, in which ethnic food markets in large urban centers play an important role in enabling access to food plants related to multicultural identities [39, 40]. On the other hand, dependency on markets reduces the user autonomy on the plant resources, as observed in studies where foraging is being replaced by market purchasing [73]. Although the reduced autonomy of markets, autonomy in the plant access is favored by strong network connections with source areas [40, 68].

Revisiting the adaptive strategies of migrants for medicinal plants [13], we found much more examples of maintenance in the use of food plants than of replacement, incorporation, and loss. However, for plants used as food, the emphasis on the cultural identity of the migrant group as being different from the dominant group creates a headfirst bias in this interpretation due to the identitarian role of foods. For example, several studies tried to find distinctive plants used as food by groups previously identified with a given migrant identity. Maintenance in the use of food plants, plants as specific ingredients, flavors, and recipes related to one's identity, represents one way to keep ties with the source area. Thus we highlight the importance of focusing not only on the use but on the preparations of plant foods in traditional dishes [40, 94]. The rare instances of replacement are mostly concerned with changing the plant components while keeping a traditional dish or recipe (Table 3). The incorporation of plants is necessary for replacement, but migrant settlements serve as active innovation laboratories [68]. Sensory aspects of food can trigger the migrants' memory in terms of identity [6]; in this regard, incorporation can occur through the absorption of new plants with similar flavors to the ones in traditional dishes or completely unusual ones, through novel meals and eating practices. Thus, migrants can increase their ethnobotanical repertoires due to the maintenance and incorporation of plants.

Specific information on the loss or abandonment of plant foods used before migration is perhaps the most challenging data to track since it requires baseline information or cross-cultural comparative studies with source areas, which are all subjected to other contemporary drivers of change. Lack of the plant resource (such as in the case of wild foods foraged in the source area), lack of cultivation conditions, changing livelihoods in a new area, and hardships of migration with different degrees of traumatic experiences, pile up with generalized phenomena such as the nutritional transition [95], the growing occurrence of food deserts [96] and food homogenization [97], which are directly related to food insecurity and loss of food sovereignty [98].

In some reported cases, migration did not affect the knowledge of food plants. These cases were related to internal or circular migrations, with a relatively smaller contrast between migrants and the dominant group [43, 44], but the loss of knowledge on plant foods was also reported, especially among younger generations [48, 52, 65].

A conceptual model from social sciences on cultural changes resulting from migrations [12, 89] proposes different outcomes depending on the interaction tendency of the migrant group and their degree of cultural conservatism [12]. In this model, the main outcomes are (a) integration (when cultural identity is maintained and there are positive relations with the host society); (b) assimilation (when only positive relations with the host society are important and migrants adopted the dominant culture); (c) separation (when cultural heritage is maintained but with social segregation); and (d) marginalization (with social segregation and loss of original identity, which can occur through exclusion or individualism) [12, 90, 99]. Based on this model, we summarize the possible outcomes related to the ethnobotany of plant foods after migrations (Fig. 6), considering also the availability of the original plant resources and the people's agency on the plant.

In the best outcome (integration, Fig. 6 top right square), ethnobotanical repertoires on food plants can persist and adapt, depending on the possibility to keep cultivation practices, on similar environments in target areas, and on the availability of ethnic markets and maintenance of network exchanges with source areas. Due to the identitarian role of foods, the loss of ethnobotanical knowledge of food plants highly depends on the degree of cultural conservatism. Thus, variables such as a similar floristic composition between the source and the target area of migration, or an easy link to the place of origin through importation, ethnic markets, or cultivation, do not assure that replacement or abandonment would not occur, as expected in the case of medicinal plants [13].

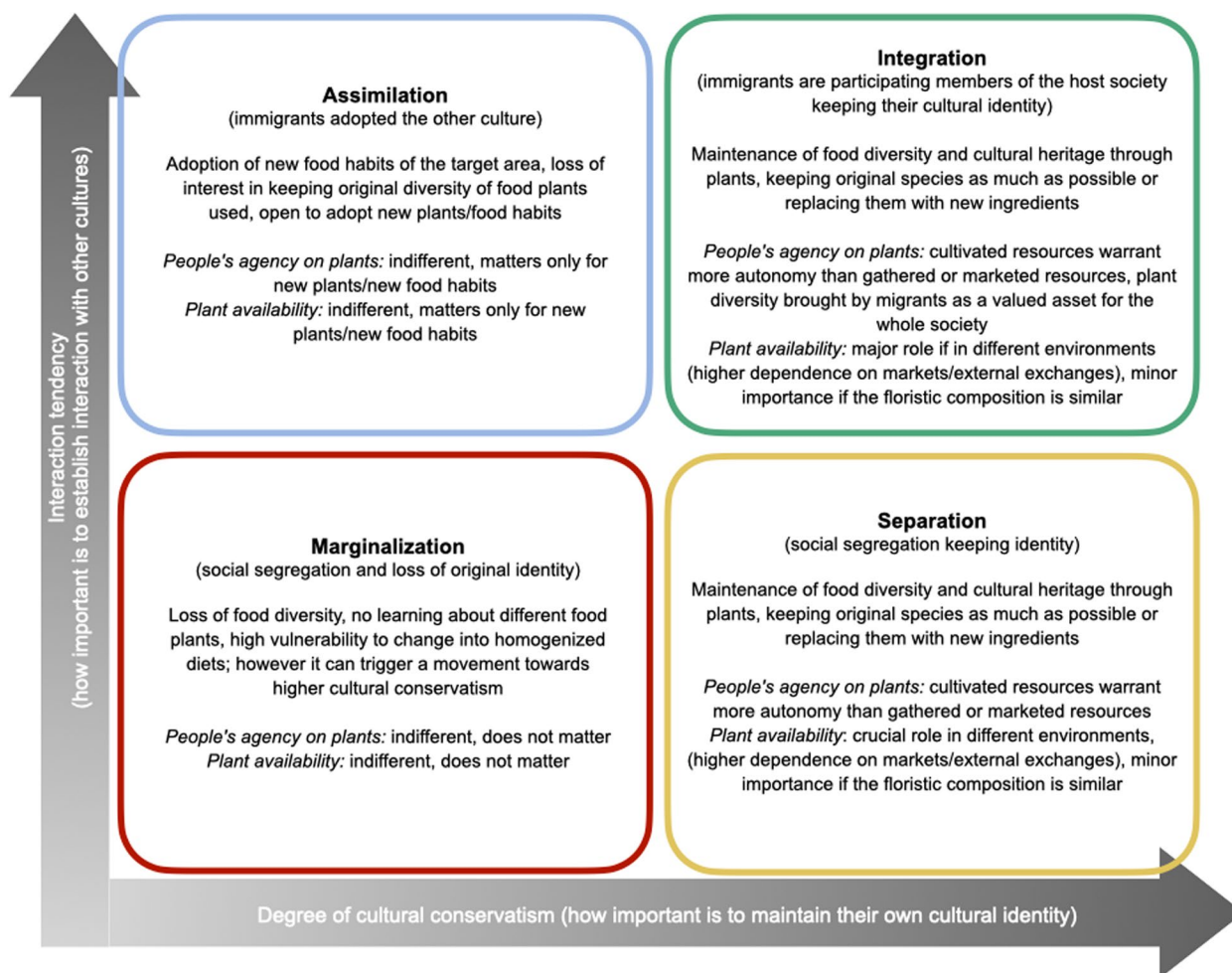


Fig. 6 Major outcomes related to the ethnobotany of plant foods after migrations. Based on Berry (1997) [12] and Erten et al. (2018) [89]

In the worst outcome (marginalization, Fig. 6 bottom left), the ethnobotanical repertoire can be heavily threatened at first. This also suggests a high susceptibility to food insecurity when considered in the context of food homogenization and nutritional transition due to the increasing availability of ultra-processed foods [95]. However, it can also trigger a process of strengthening identities and moving towards a higher cultural conservatism, when traditional knowledge is resilient.

As a conceptual model, it simplifies reality, and one should avoid the risk of generalizing the model for any given situation. Other variables that must be taken into account are, for example, the need or desire to save time and labor to cultivate, gather, or prepare plants for food, which can be important for migrants searching for new economic opportunities and working long hours [55], or may not be significant variables [28]. Alternatively, other important variables can be the role of the religious practices embedded in cultural conservatism [100, 101], the

relation to a distinct language or dialect [102, 103], the time since the migration occurred, or after how many generations an identity is kept vibrant. Finally, the identification of strategies such as biculturalism tends to replace acculturation approaches [91], and this implies a reconsideration of the processes of assimilation and marginalization.

Since our review is based on a diversity of approaches, we assume the existence of intricate biases in our results. First, as mentioned before, studies on food plants and migrations could be biased by the very nature of searching for discontinuities in plant use in multicultural societies. As many literature reviews consider indexed sources, our results are also subject to the biases of academic scientific production [104]. The results found are also expected to be biased by the research groups studying the ethnobotany of plant foods, their country/region affiliations, and by particular goals and profiles of these groups. Finally, since migrations and the use of plants for

food is a phenomenon intertwined with the evolution of humans, in a much broader temporal sense we could consider other migrations in an archaeological time [105], but we did not find studies that related them to adaptations to food plants, based on our sampling criteria.

Migrants' food plants and a more sustainable Earth

Local and traditional ecological knowledge associated with plants is connected to several sustainable development objectives, such as those related to poverty, health and wellbeing, responsible consumption and production, climate action, life on land, and partnerships [106]. When focusing on food plants and migrations, this bio-cultural legacy can also serve as an important foundation for regional sustainable food systems [71]. The theme food, identity and migrations receives contributions and insights from a wide range of approaches (see for example [2, 4, 14, 28, 77–79]), which together can help us tackle the interdisciplinary challenges of sustainability.

The celebration of migrants' food could concretely foster sustainability and cohesion in several ways: a. Embracing diversity and inclusivity: food plants are an integral part of culture and celebrating the food of different cultures could help to break down barriers and promote understanding between people from different backgrounds; b. Promoting cultural exchange: people could learn about the history and traditions behind the food, the ingredients used, and the cooking techniques [47, 75]. This can help to broaden people's horizons and promote a sense of curiosity and openness towards other cultures; c. Supporting local economies: Many migrants bring with them unique culinary skills and knowledge that can be leveraged to create new gastronomic businesses and job opportunities [1, 25]. This can help to boost local economies and create more vibrant communities; d. Further fostering social networks: Food can be a powerful way to bring people together and create a sense of community [40, 68]. Dining together, people could connect with others who share a common interest and build meaningful relationships; e. Contributing to amplifying agrobiodiversity: for the case of cultivated plants, agrobiodiversity can be improved in multicultural contexts, favoring in situ conservation of diverse plant genetic resources [36, 53]; f. Strengthening food sovereignty: By respecting diversity and inclusivity, migrants' foods can assist governance movements related to autonomy and collective efforts for the improvement of food systems [40, 71].

Overall, celebrating migrants' food plants could help to foster several dimensions of sustainability and can contribute to social cohesion, by promoting diversity and cultural exchange, supporting local economies, building

social networks, contributing to agrobiodiversity conservation, and food sovereignty.

Conclusions

Ethnobotany, specifically focusing on the study of food plants and emphasizing the role of contextualized knowledge and practices, plays a significant role in understanding and connecting various pressing issues on food security and food sovereignty. The way the dynamic relationships between people and plants change after moving from one place to another depends strongly on how attached this group of people is to their original cultural identity and the permeability and support of the dominant society in the target area to the arrival of these newcomers. It also highly depends on the conditions surrounding arrival, the level of the traumatization, and if the needed support is received in the host country. In the general picture, diverse cultural identities have the potential to create pockets of biodiversity, when people use and manage plants for various purposes with various intensities and consistency, notably food plants.

Food plants can be elements of comfort for people in distress due to migration, including traumatic situations, but also uneasiness about being a long-lived place of identity. On the plant side, migrations can contribute to landscape transformations via agrobiodiversity increase, and ultimately to biodiversity conservation when native useful plants are part of multicultural food repertoires. Within this scope, we suggest more efforts to understand the dynamics of food plant adaptation in internal migrations, including rural-to-urban and rural-to-rural movements. Adaptive processes including replacement but also abandonment have been understudied, as well as the disappearance of plant knowledge. Eventually, future studies will need to clarify if and how marginalization processes can accelerate the loss or resilience of unique ethnobotanical repertoires. Regarding sustainability, by embracing and celebrating the food of different cultures, transported by current or past migratory displacements, more inclusive and vibrant communities could be enhanced, and also be better equipped to face the challenges of the future.

Supplementary Information

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Additional file 1.

Authors' contributions

NH designed the work and lead the review; AP, RS, NP, JP, RHL, and MCG made substantial contributions to the conception of the work and interpretation of data. All authors read and approved the final manuscript.

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Availability of data and materials

All data is included as supplementary materials.

Declarations

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