# Digestive plants in a Mapuche community of the Patagonian steppe: multidimensional variables that affect their knowledge and use

Soledad Molares, María Laura Ciampagna and Ana Ladio

**Correspondence**

**Soledad Molares[1,*], María Laura Ciampagna[2] and Ana Ladio[3]**

[1]CIEMEP, Universidad Nacional de La Patagonia San Juan Bosco-CONICET, Roca 780, CP 9200 Esquel, Chubut, Argentina, smolares@gmail.com.
[2]División Arqueología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata-CONICET, Av. 122 y 60 s/n, CP 1900 La Plata, Buenos Aires, Argentina, mlciampagna@gmail.com.
[3]INIBIOMA, Universidad Nacional del Comahue-CONICET, Quintral 1250, CP 8400 San Carlos de Bariloche, Río Negro, Argentina, ahladio@gmail.com.

[*]Corresponding Author: smolares@gmail.com

**Ethnobotany Research and Applications 25:17 (2023)** - http://dx.doi.org/10.32859/era.25.17.1-19
Manuscript received: 28/10/2022 – Revised manuscript received: 22/02/2023 - Published: 23/02/2023

## Research

## Abstract

*Background:* In a rural Mapuche community of the Patagonian steppe (Chubut, Argentina), we analyzed how the use and popularity of digestive plants are affected by their aroma, the presence of dual medicinal-edible uses, their digestive versatility, biogeographical origin and accessibility.

*Methods:* Free listing and in-depth interviews were conducted with 25 collaborators, complemented with participant observation and walks in the field. Quantitative indices, non-parametric methods (Binomial and Chi-square tests, $p$ < 0, 05) and generalized linear models (GLM, Omnibus test, $p$ < 0, 05) were performed.

*Results*: Local collaborators use 61 digestive plants, including a similar number of native and exotic species. Most are used for only one type of digestive use, are very accessible and have aroma. There are as many species with dual use as without dual use. Exotic species generally have more aroma than native ones. Only exotic species are highly accessible. Species with dual uses are mainly used as condiments. Digestive-only species could or could not have aroma. The popularity of species is only affected by their digestive versatility and aroma, mainly for exotic ones.

*Conclusions:* Local pharmacopoeia reflects aspects that account for its cultural resilience, including a high richness of native and exotic digestive plants, many of which are used for specific ailments. The species have been selected from the joint evaluation of biophysical and sociocultural variables that influence their knowledge and forms of use. These variables and perceptions would also allow diversification in response to changes, forming part of a bio-cultural legacy unique to Patagonia.

*Keywords:* Mapuche medicinal flora, Patagonia, popularity, cultural resilience.

## Background

Traditional medicinal floras are composed of families and species that have not been selected at random, but from complex biophysical and sociocultural bases (Leonti *et al.* 2003). According to Silva Santos *et al.* (2018) this process includes two general phenomena:the introduction of species to a local medical system and the differential use of those species. In the first case, research focuses on determining the reasons why a species is or is not medicinal, whereas in the second it focuses on the factors or drivers that influence its popularity or consensus of use. Studies interested in this topic considered some of the following explanatory factors:organoleptic perceptions (mainly aroma and taste) (Leonti *et al.* 2002; Molares & Ladio 2009a, Medeiros *et al.* 2015), duality of medicinal-food uses (Etkin & Ross 1982, Chamorro & Ladio 2020), environmental accessibility (Lucena *et al.* 2012), therapeutic versatility (Kujawska & Pieroni 2015), and biogeographical origin of the species as part of the history of use of local flora (Valussi 2012; Rahman *et al.* 2016, Gaoue *et al.* 2017, Silva Santos *et al.* 2018, Almeida Caetano *et al.* 2020, Leonti *et al.* 2020).

According to different authors, the organoleptic properties of plants and the cultural perceptions associated with them could be one of the most important factors in the selection and uses of medicinal plants (Casagrande 2000, Shepard 2004, Molares & Ladio 2015). This might be due to the fact that aroma and taste would function as chemosensory clues about medicinal virtues (Pieroni *et al.* 2002, Leonti 2003, Medeiros *et al.* 2013), as alerts about their toxic potential and/or as mnemonic resources to remember the specific uses and recommended doses according to a patient's age and state of severity (Molares & Ladio 2009a, 2014). All this could be especially evident when dealing with very distinctive smells and tastes (aromas and tastes of *Lamiaceae* or *Chenopodiaceae*, among others) and/or common ailments, such as digestive, respiratory and musculoskeletal diseases (Medeiros *et al.* 2015, Molares & Ladio 2015). They also constitute a key feature of the prototypical species of each category of medicinal use (Molares & Ladio 2014).

In particular, a relationship has been found between the prevention and treatment of digestive ailments and the use of plants whose aroma, bitterness and astringency are prominent attributes (Molares & Ladio 2009a, Geck *et al.* 2017). The presence of alkaloids, saponins, flavonoids, glycosides, terpenoids and/or phenols could be responsible for such organoleptic characteristics and also for their varied digestive properties (Pieroni *et al.* 2005, Molares & Ladio 2009a, Choudhury *et al.* 2015). Note that this low phytochemical specificity required by the inhabitants would favor the management of digestive ailments in households, given that in general it would not imply specific knowledge, restricted to healers or other local specialists (Bacigalupo 2001).

However, the diversity of phytochemicals with similar aroma and taste questions whether these attributes alone can explain the selection of plants for different therapeutic functions. Instead, it is possible that aromas and tastes are indirectly responsible for the selection of medicinal plants, for example, through the perception of their effectiveness (Dos Santos *et al.* 2021), and/or that they function in combination with other biocultural attributes (Geck *et al.* 2017).

In addition, previous works by Pieroni and Torry (2007) stated the importance of taste in determining the edible nature of medicinal plants, pointing to the presence of dual medicinal food uses as another plant attribute to consider. The overlap and categorization of plants as food and medicine in a range of contexts has been highlighted in ethnopharmacological research (Etkin & Ross 1982, Pieroni & Price 2006, Jennings *et al.* 2015, Kujawska & Pieroni 2015, Chamorro & Ladio 2020). Many digestive species are also employed as food flavoring, condiments and preservatives or are ingredients in popular beverages (mate, tea, etc.) due to their outstanding aroma and taste qualities (Pieroni *et al.* 2002, Carović-Stanko *et al.* 2016). In other cases, they are considered healthy foods and are included in salads, soups and other local recipes (Pieroni *et al.* 2002, Cambie & Ferguson 2003). In general terms, the use of digestive plants as foods, especially in traditional communities, depends on the context of use and the forms of preparation (Etkin 1996).

On the other hand, therapeutic versatility, understood as the average number of medicinal uses that a community assigns to a given species, is usually positively related to its popularity or consensus of use, especially when it assumes moderate to high values (Richieri *et al.* 2013, Rossi-Santos *et al.* 2018). This quality could be related to the diversity of biomolecules or health promoting compounds that plants and their different parts possess (Brandt *et al.* 2004) as well as to a greater environmental accessibility of the species, which would provide more opportunities to know, experiment and test their diverse properties (Thomas *et al.* 2009, Ullah *et al.* 2014).

Environmental accessibility is also considered an explanatory factor for popularity (Voeks 2004, Albuquerque 2006, Thomas *et al.* 2009). This category is understood as a physical distance from a home or community to the place where a plant grows, but could also be extended in terms of seasonality, abundance and price, as well as access to markets, gardens or natural areas where plants are found (Albuquerque 2006, Sõukand & Kalle 2010).

Another prominent factor is the biogeographic origin of species (Gaoue *et al.* 2017, Leonti *et al.* 2020). In Patagonia, 60% of the 500 recognized medicinal species are native. In general, all categories of ailments are treated with native and exotic species, although the native ones tend to present higher consensus values than the exotic ones. The native species are obtained mainly by gathering in rural environments, and the exotic ones in anthropogenic environments or they are purchased. This suggests the coexistence of ancestral and foreign knowledge accumulated over time. Although there is a tendency towards less use of native species in the region, which is not observed for exotic ones (Molares & Ladio 2009b). According to Kujawska and Pieroni (2015), most Eurasian food crops and associated weeds were introduced during the 17th century in America. They were available as food and medicinal resources for at least 400 years, a time during which migrant, indigenous and mestizo communities interacted with them. This scenario was also reproduced in Patagonia, where exotic plants are vital resources for rural and urban inhabitants in the region (Molares & Ladio 2009b, Chamorro & Ladio 2020). These plants arrived on the continent with a wealth of associated knowledge, which was resignified and recreated in the new enclaves of cultural appropriation. In this process, they may have gained uses and become more versatile. This gained versatility would be an attribute constructed during their history of global and local use (Leonti *et al.* 2020). Some authors even propose that versatility is greater for introduced species than for native ones (Kujawska & Pieroni 2015, Hart *et al.* 2017, Rossi-Santos *et al.* 2018). In Patagonia, a study on the Mapuche pharmacopoeia of the Subantarctic forest demonstrated the high versatility and cultural importance of exotic digestive species, some of which are recognized worldwide, such as *Artemisia absinthium*, *Mentha* spp. and *Matricaria chamomilla* (Molares & Ladio 2009a). From another perspective, the diversification hypothesis proposes that the incorporation of exotic plants in local floras could be an enriching strategy, since they would provide bioactive compounds that are absent or scarce among native options (Alencar *et al.* 2010, 2014). However, other approaches propose that the differential palatability between native and exotic species could justify the preference for the latter, which have a more pleasant taste than native species (Albuquerque 2006, Molares & Ladio 2015).

The above evidence shows the multidimensionality of factors that can influence the selection and use of medicinal plants. In the present work, we test for the first time this premise based on a case study in a rural Mapuche community situated in the steppe of Argentine Patagonia. Our hypotheses indicate that the selection of digestive species is associated with:1- digestive versatility and plant origin; 2- the presence of aroma, taste and plant origin; 3- the presence of edible properties and aromatic attributes; 4- accessibility, plant origin and digestive versatility. And our predictions indicate that:1a- most popular digestive plants are exotic; 1-b most popular digestive plants are the most versatile; 1c- exotic plants are more versatile than native ones. 2a- The highest richness of digestive species will correspond to plants with aroma and taste; 2b- most popular plants are aromatic; 2c- exotic species are more aromatic than native ones. 3a- The highest proportion of plants used as digestives will be dual; 3b- most popular plants are dual; 3c- dual species are more aromatic than digestive-only ones. 4a- Most digestive species are very accessible; 4b- most popular digestive plants are the most accessible; 4c- popular exotic plants are more accessible than native ones.

## Materials and Methods

### Study area and population

The study area is located in the community of Gualjaina (42°4'S and 70°32'W), Chubut province, approximately 90 km from the nearest city, Esquel (Fig. 1). The climate is cold temperate, with strong winds from the West throughout the year. Average annual rainfall is close to 119 mm, and the average annual temperature is 11.7 ºC (Mereb 1990, Tell *et al.* 1997). The community is circumscribed by the Lepá and Gualjaina rivers, which together with several intermittent streams and springs supply water for human and animal consumption and small-scale agriculture (Morales *et al.* 2020). The geomorphology of northwestern Chubut corresponds to the Central or Precordilleran Environment. The predominant vegetation is a gramino-shrub steppe, with **coirón** (*Festuca* sp.), **pasto hilo** (*Poa lanuginosa* Poir.), **neneo** (*Azorella prolifera* (Cav.) G. M. Plunkett & A. N. Nicolas), **uña de gato** (*Nassauvia axillaris* D.Don), **calafate** (*Berberis microphylla* G.Forst), and **barba de chivo** (*Retanilla patagonica* (Speg.) Tortosa), among others, and small riverside groves dominated by **sauces** (*Salix* spp.) and **álamos** (*Populus* spp.), with scarce presence of **sauce criollo** (*Salix humboldtiana* Willd.). Exotic species such as **ajenco** (*Artemisia absinthium* L.), **cardos** (*Carduus* spp.) and **diente de león** (*Taraxacum officinale* F.H.Wigg.), among others, predominate near houses (Correa 1998).

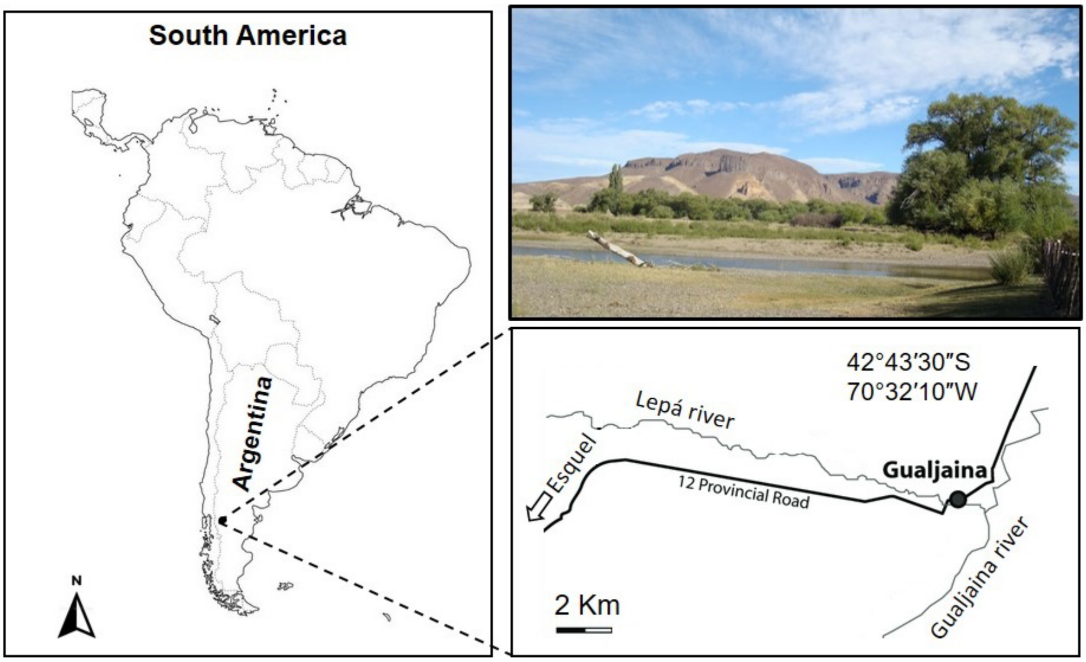


Figure 1. Map of the study area in Gualjaina, Patagonia, Argentina (Modified from Morales *et al.* 2020).

Their population is 1183, which represents approximately 0.2 % of the total Province of Chubut (https://www.argentina.gob.ar/chubut). People from this community live in a relatively isolated form and need to draw many difficult environmental and social conditions. The main factors affecting their lifestyle are desertification processes, social inequality, and the failure of development models and public policies, among others. Inhabitants are Mapuche and mestizo people. The main economic activity is sheep and goat raising and, to a lesser extent, peridomestic horticulture. A small proportion of the population works in local stores, are laborers in the construction industry or are state employees (Morales *et al.* 2017, 2020). The native language is Mapuzungun (mapu = land and zungun = to speak); however, it is currently only spoken by a small portion of the population (less than 20%) who are bilingual elderly or young neo-speakers, whereas the rest speak only Spanish. In general, inhabitants have a subsistence standard of living, with limited access to basic services such as potable water, electricity, gas, sewage, etc. Attention in the official health centers is limited to maternal and childcare, treatment of common diseases and injuries, patients' referral to the highest complexity hospital located in the city of Esquel and supply of some essential medicines (Morales *et al.* 2020).

This community constitutes an interesting case study due to its rural conditions, the distance from urban centers and the strong attachment of people to their customs of origin and survival, including the use of medicinal plants. After various participatory meetings, the residents have expressed to us their interest in the research topic. At the same time, we have a deep bonds of trust with the families, these were built and reviewed in the territory during previous research projects.

**Methodology**

Prior informed consent was initially requested from the communal chief (lonko, in mapuzungun) and from each collaborator in accordance with the code of ethics of the International Society for Ethnobiology (ISE 2006) and the recommendations established at the United Nations Conference on Sustainable Development based on the protection of traditional knowledge and the recognition of intellectual property rights (Rio+20 2012). This study was also conducted according to the ethics guidelines of Nagoya Protocol (Argentinian National Law N° 27246). Before the interviews, we explained the general objective of the research and clarified that their identities would be preserved. We continued with the interview only if the collaborator agreed to participate in the survey. Therefore, all collaborators orally confirmed free and informed consent prior to data collection. No other specific additional procedure was mandatory for this kind of study in our country in the date of this research.

The sampling was nonprobabilistic and purposive, and involved the participation of 25 collaborators, herders of small herds, firewood collectors and users of medicinal plants. From number 15 onwards the sample became saturated, and the incorporation of new cases tended to repeat the information (Mejía Navarrete 2000, Martínez

2017). Each informant was visited on average four times from the summer of 2011 to the summer of 2015. Collaborators were men (13%) and women (87%), born and raised in the community of Gualjaina. The average age was 57 years old (min. 25, max. 85). In the rural communities of Patagonia, women are recognized as the most relevant social agents in the intra- and intergenerational transmission of medicinal knowledge (Ladio 2021). In our case study, this is reflected in the prevalence of women interviewed.

Semi-structured and in-depth interviews were conducted in Spanish, complemented with participant observation and walks in the field with the collaborators (Albuquerque *et al.* 2014). First, data related to general population, cultural and socioeconomic conditions were recorded. Then, a free listing of digestive species used for the treatment and prevention of diseases and/or symptoms located in the digestive tract (masticatory apparatus, esophagus, stomach, small intestine, large intestine, rectum and anus) was requested (Molares & Ladio 2009a, Neamsuvan *et al.* 2012). In addition, ailments related to the pancreas, liver and gallbladder were included, as they also play a role in the digestion process (Molares & Ladio 2009a). The different emic subcategories of digestive use (e.g., digestive, laxative, antidiarrheal, empacho, etc.) were registered. For each species, we recorded its location in the landscape, whether it is cultivated, purchased or collected around houses, grazing sites, riverbanks, or other environments. We also inquired about the edible use of digestive species, whether they are used as condiments or as ingredients in local dishes, their forms of preparation and the presence of aroma and taste characteristics considered for their recognition and selection.

Herbarium material was collected and deposited as a control at the Centro de Investigación Esquel de Montaña y Estepa Patagónica (CIEMEP). Scientific names of digestive plants were updated using the World Flora Online (http://worldfloraonline.org).

**Data analysis**

The total richness of digestive species was determined, and the popularity (numerical variable) of each species was estimated by the consensus of use (CU = *N° of informants mentioning the species s/total N° of informants*100*). The therapeutic versatility index was partially modified for this study in order to test the hypothesis considered and was estimated by calculating *the total number of subcategories of digestive uses based on emic point of view* (rather than broader categories of medicinal uses) *mentioned for the species s/total N° of informants* (Digestive Versatility= DV, numerical variable) (Molares & Ladio 2009, 2012, Almeida Caetano *et al.* 2020).

Based on Morales *et al.* (2017) species were classified according to their accessibility (categorical variable):1- Not very accessible species (low):This category includes species that are not very abundant and/or are present in environments located 3-4 km or more from homes, in places where hills and ravines with intricate bushes predominate. Collaborators usually move on foot before 3-4 km, further they usually require a horse, truck or other vehicle. 2- Moderately accessible species (moderate): They are present in environments located at an intermediate distance or situation to those defined in the previous category and the following one. Considering the expanded herbal landscape concept defined by Sõukand and Kalle (2010), this category includes purchased species with the highest monetary cost. 3- Very accessible species (high):These are common species, abundant and/or present in anthropogenic environments (around houses, corrals, sheds, farms, roadsides, etc.), where ruderal grasses and shrubs predominate. Species of low monetary cost are included.

During interviews, when asking about the aroma and taste of plants, the interlocutors always smelled the plants to remember their aroma or put their hands to their noses as a reflex action. Aroma were often not lexically differentiated of taste by the interlocutors, that is, they were mentioned indistinctly, and in most cases no taste categorization was evident, except for some species that register more therapeutic virtues in addition to its use as a digestive, or outstanding culinary values. Therefore, data on the intensity or other descriptions of the aroma and/or taste of the species were not statistically tested. According to Amat and Vincent (2003), smell and taste are anatomically and physiologically related and, theoretically, only a few compounds could be authentically separated by specialists in a laboratory. This separation between taste and aroma seems to be more a theoretical construct of Western thought than a cultural or biological attitude (Brett & Heinrich 1998, Hurrell *et al.* 2008, Molares 2010). Following Pieroni *et al.* (2002):"This recalls one of the major limits of the analysis of folk taxonomies:not everything can be categorized, and not all categories can be linguistically labelled". Taking this into account and the data we were able to collect, we chose in this first approach to classify the species only as aromatic or non-aromatic (binary variable). In this manner when the collaborators affirmed "this plant does have" aroma and/or taste, the value of the variable was one (1). In contrast, the value was zero (0) when affirmed "this plant does not have" aroma and/or taste "it just smells like **yuyo** (grass)".

According to their biogeographic origin (binary variable), species were classified as native or exotic to the Patagonian territory (Zuloaga *et al.* 2008). Then, the duality (numerical variable) of medicinal-food uses of each species was estimated with the formula DUC*s* = *∑DUCis/N*, where DUC*is* = *Nº of uses mentioned by informant i for species s* (possible values:1 = The species is used exclusively as a digestive, and 2 = The species is also used as food) and N = *Total number of informants that cite species s*. DUC*s* can assume values between 1 and 2 (1 ≤ DUC*s* ≤ 2).

Pearson's skewness coefficient (Ap), which measures the deviation from symmetry expressed as the difference between the mean and median with respect to the standard deviation, was calculated to analyze the behavior of popularity and digestive versatility. If Ap < 0, the distribution has a negative skewness, that is, the mean is smaller than the mode. If Ap = 0, the distribution is symmetric. If Ap > 0, the distribution has a positive skewness, since the mean is larger than the mode. Considering that the data does not follow a normal distribution, non-parametric binomial tests were used to test the null hypothesis that plant richness is equally distributed among categories (predictions 2a, 3a and 3c), and the Chi-square test was used to analyze prediction 4a. To test the remaining predictions, we built eight generalized linear models (GLM), based on a multinomial probability distribution and a cumulative logit link function. These models were found significant (Omnibus test, Chi-square test, $p < 0,05$). Details of the models and estimates are described in supplementary material.

## Results

**Richness, popularity and biogeographical origin of digestive species**

Participants mentioned a total of 61 digestive species, many of these are used in infusion, decoction and to a lesser extent are ingested as part of local dishes (*Oryza sativa*, *Triticum aestivum*, *Allium* spp., etc).

The popularity of the species presents an asymmetric curve (asymmetry coefficient Ap = 1.96). It can be observed that the average value of popularity is relatively low, 21.64% ± 19.7 (Fig. 2). Most of the species (n = 42) are below this value, that is, they are not very popular; the remaining species (19) present values that fluctuate between 26.7% and 93.3%, being the most popular:*Acantholippia seriphioides* (**tomillo del campo** 93. 3%), *Dysphania ambrosioides* (**paico** 86.6%), *Tanacetum balsamita* (**boldo** 73.3%), *Buddleja araucana* (**pañil** 66.6%) and *Schinus johnstonii* (**molle** 53.3%) (Table 1). In contrast to prediction 1a, it was found that biogeographic origin does not affect popularity; native (26 species, 42.6% of total) and exotic (35 species, 57.4% of total) digestive species are used equally (GLM, $p > 0.05$).

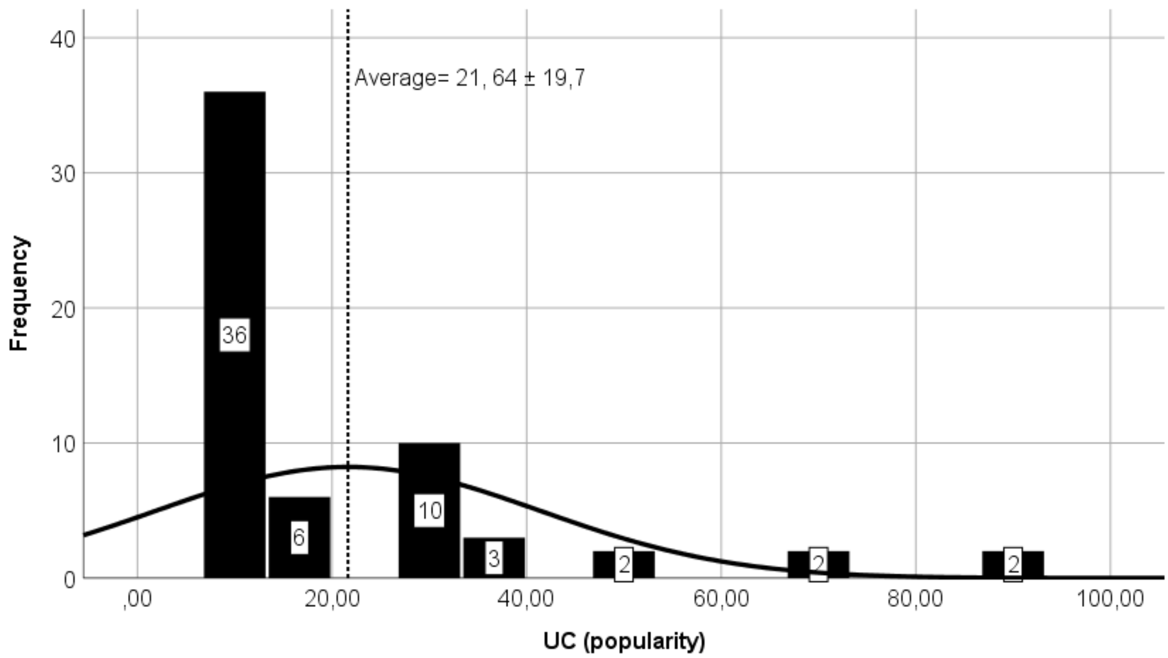


Figure 2. Popularity curve of digestive species in the community of Gualjaina, Patagonia, Argentina. Reference: the vertical dotted line indicates the average value for the variable.

**Digestive versatility, popularity and biogeographical origin of species**

Digestive species are mainly used as "bajativas" (aids digestion) (53.5% of the records), analgesics (14.4%) and against "empacho" (cluster of symptoms that include stomach pain, loss of appetite, constipation or diarrhea, vomiting, heartburn, gas, weakness, headache, etc. whose etiology is normally of the supernatural order) (10.10%). To a lesser extent, they are used as antacids, antidiarrheals, hepatics, laxatives, to "take the cold out of the stomach" and antispasmodics (Table 1).

Most of the species used have low digestive versatility values, that is, collaborators mostly use species that have only one or a few therapeutic actions. Digestive versatility presents an asymmetric curve (asymmetry coefficient Ap = 4.32), with an average value of 0.26 ± 0.35. Only two species (*Berberis microphylla* and *Acantholippia seriphioides*) have values of DV ≥ 1 (Table 1, Fig. 3).

Table 1. Digestive species from Gualjaina community (Patagonia, Argentina) and its biophysical and socio-cultural attributes. Abbreviations: DUC, Dual use; UC, Popularity; DV, Digestive versatility.

| Species/Family | Vernacular name | Uses | Origin | Edible | Aroma | Access | DUCs | UC | DV |
|---|---|---|---|---|---|---|---|---|---|
| *Acantholippia seriphioides* (A.Gray) Moldenke/ Verbenaceae | **Tomillo de campo** | antacid, digestive, against stomach pain, antidiarrheal, mild purgative | na | x | x | low | 1.6 | 93.3 | 1.07 |
| *Adesmia boronioides* Hook.f./ Fabaceae | **Paramela** | digestive, against stomach pain | na | x | x | low | 2 | 26.7 | 0.27 |
| *Allium sativum* L./ Amaryllidaceae | **Ajo** | analgesic | ex | x | x | high | 2 | 6.7 | 0.07 |
| *Anarthrophyllum strigulipetalum* Sorarú/ Fabaceae | **Puel neneo** | digestive | na | | | low | 1 | 6.7 | 0.07 |
| *Apium prostratum* Labill. ex Vent./ Apiaceae | **Apio del campo** | digestive, against stomach pain | na | x | x | low | 2 | 6.7 | 0.07 |
| *Aristotelia chilensis* Stuntz/ Elaeocarpaceae | **Make** | digestive, against stomach pain | na | x | | low | 2 | 13.3 | 0.13 |
| *Artemisia abrotanum* L./ Asteraceae | **Eter, Buen viejo** | digestive, against stomach pain, hepatic | ex | | x | high | 1 | 33.3 | 0.4 |
| *Artemisia absinthium* L./ Asteraceae | **Ajenco** | digestive | ex | | x | high | 1 | 33.3 | 0.33 |
| *Azorella prolifera* (Cav.) G.M.Plunkett & A.N.Nicolas/ Apiaceae | **Neneo** | analgesic | na | | x | high | 1 | 13.3 | 0.13 |
| *Baccharis sagittalis* DC./ Asteraceae | **Carqueja** | against stomach pain, empacho | na | | x | low | 1 | 13.3 | 0.13 |
| *Baccharis salicifolia* (Ruiz & Pav.) Pers./ Asteraceae | **Chilca** | astringent, hepatic, digestive, laxative, empacho | na | | | moderate | 1 | 13.3 | 0.33 |
| *Berberis microphylla* G.Forst./ Berberidaceae | **Calafate** | astringent, hepatic, digestive, laxative | na | x | | moderate | 2 | 46.7 | 2.4 |
| *Brassica* sp.?/ Brassicaceae | **Nabo de campo** | digestive | ex | x | x | high | 2 | 13.3 | 0.13 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Buddleja araucana* Phil./ Scrophulariaceae | **Pañil** | antispasmodic, hepatic, antidiarrheal, empacho, digestive, stomachache | na | x | | low | 1.7 | 66.7 | 0.73 |
| *Camellia sinensis* (L.) Kuntze/ Theaceae | **Té verde, té de winka** | digestive | ex | x | x | high | 2 | 13.3 | 0.13 |
| *Carduus* spp.?/ Asteraceae | **Cardo** | hepatic | ex | x | | high | 2 | 6.7 | 0.07 |
| *Centaurium cachanlahuen* B.L.Rob./ Gentianaceae | **Cachanlagua** | digestive | na | | | moderate | 1 | 6.7 | 0.07 |
| *Chenopodium album* L./ Amaranthaceae | **Quingüilla** | digestive | ex | x | | high | 2 | 6.7 | 0.07 |
| *Citrus limon* (L.) Osbeck/ Rutaceae | **Limón** | calm stomach pain | ex | x | x | moderate | 2 | 6.7 | 0.07 |
| *Clinopodium darwinii* Kuntze/ Lamiaceae | **Té pampa** | calm stomach pain | na | | x | low | 1 | 13.3 | 0.13 |
| *Dysphania ambrosioides* (L.) Mosyakin & Clemants/ Amaranthaceae | **Paico** | calm stomach pain, digestive, empacho | na | x | x | high | 1.2 | 86.7 | 0.87 |
| *Dysphania multifida* (L.) Mosyakin & Clemants/ Amaranthaceae | **Paico hembra** | digestive, empacho | ex | | x | high | 1 | 20 | 0.2 |
| *Equisetum bogotense* Kunth/ Equisetaceae | **Cola de caballo** | digestive | na | | | moderate | 1 | 20 | 0.2 |
| *Fabiana imbricata* Ruiz & Pav./ Solanaceae | **Palo piche** | digestive | na | | x | moderate | 1 | 20 | 0.2 |
| *Pseudognaphalium* sp. /Asteraceae | **Sanjuancito** | calm stomach pain | na | | | moderate | 1 | 6.7 | 0.07 |
| *Gunnera tinctoria* (Molina) Mirb./ Gunneraceae | **Nalca** | digestive | na | x | x | low | 2 | 13.3 | 0.13 |
| *Limonium brasiliense* Kuntze/ Plumbaginaceae | **Guaicurú** | digestive | na | | | low | 1 | 13.3 | 0.13 |
| *Malus domestica* (Suckow) Borkh./ Rosaceae | **Manzana** | digestive, mild purgative | ex | x | | high | 2 | 13.3 | 0.13 |
| *Matricaria chamomilla* L./Asteraceae | **Manzanilla** | digestive, calm stomach pain | ex | x | x | high | 2 | 20 | 0.2 |
| *Medicago sativa* L./ Fabaceae | **Alfa** | digestive | ex | x | | high | 2 | 13.3 | 0.13 |
| *Melissa officinalis* L./Lamiaceae | **Torongil** | digestive, calm stomach pain, empacho | ex | x | x | high | 1.3 | 26.7 | 0.33 |
| *Mentha suaveolens* Ehrh./ Lamiaceae | **Menta** | digestive | ex | | x | high | 1 | 6.7 | 0.07 |
| *Mentha x piperita* L./ Lamiaceae | **Menta peperina** | digestive, empacho, hepatic | ex | x | x | high | 1.7 | 40 | 0.4 |
| *Mentha pulegium* L./ Lamiaceae | **Poleo, Menta chiquita** | digestive, calm stomach pain, empacho | ex | x | x | high | 2 | 20 | 0.2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Mentha x rotundifolia* (L.) Huds./ Lamiaceae | **Menta, Yerba buena** | digestive, calm stomach pain, empacho | ex | x | x | high | 1.5 | 40 | 0.4 |
| *Mentha suaveolens* Ehrh./ Lamiaceae | **Menta chilena** | antidiarrheal, digestive | ex | | x | high | 1 | 26.7 | 0.33 |
| Mix of commercial species | **Cachamay** | calm stomach pain | ex | x | x | high | 1 | 6.7 | 0.07 |
| Mix of woody species | **Ceniza** | empacho, laxative | na | | | high | 1 | 13.3 | 0.13 |
| *Nasturtium officinale* R.Br./ Brassicaceae | **Berro** | digestive | ex | x | x | low | 2 | 40 | 0.4 |
| *Origanum vulgare* L./ Lamiaceae | **Orégano** | digestive | ex | x | x | high | 2 | 6.7 | 0.06 |
| *Oryza sativa* L./ Poaceae | **Arroz** | antidiarrheal | ex | x | | high | 2 | 6.7 | 0.06 |
| *Oxalis adenophylla* Gillies/ Oxalidaceae | **Culle** | digestive | na | x | x | low | 2 | 6.7 | 0.06 |
| *Prunus cerasus* L./ Rosaceae | **Guinda** | laxative | ex | x | x | high | 2 | 33.3 | 0.33 |
| *Quercus* sp./ Fagaceae | **Corcho** | laxative | ex | | | low | 1 | 6.7 | 0.06 |
| *Ribes rubrum* L./ Grossulariaceae | **Grosella** | digestive | ex | x | x | high | 2 | 6.7 | 0.06 |
| *Rosa rubiginosa* L./ Rosaceae | **Rosa mosqueta** | digestive | | x | x | high | 2 | 13.3 | 0.13 |
| *Rosmarinus officinalis* L./ Lamiaceae | **Romero** | digestive | ex | x | x | high | 1 | 13.3 | 0.13 |
| *Rumex crispus* L./ Polygonaceae | **Romaza, Lengua de vaca** | antidiarrheal, calm stomach pain | ex | x | | high | 1.2 | 33.3 | 0.33 |
| *Ruta chalepensis* L./ Rutaceae | **Ruda** | digestive, calm stomach pain | ex | | x | high | 1 | 33.3 | 0.33 |
| *Salvia officinalis* L./ Lamiaceae | **Salvia** | digestive | ex | x | x | high | 2 | 6.7 | 0.06 |
| *Sambucus nigra* L./ Viburnaceae | **Sauco** | calm stomach pain | ex | x | x | high | 2 | 6.7 | 0.06 |
| *Sanicula graveolens* Poepp. ex DC./ Apiaceae | **Cilantro** | digestive | na | x | x | low | 2 | 6.7 | 0.06 |
| *Schinus johnstonii* F.A.Barkley/ Anacardiaceae | **Molle** | digestive, calm stomach pain, empacho, analgesic | na | x | x | moderate | 1.9 | 53.3 | 0.6 |
| *Schinus patagonica* (Phil.) I.M.Johnst. ex Cabrera/ Anacardiaceae | **Laura** | laxative | na | | x | low | 1 | 6.7 | 0.06 |
| *Senecio* sp./ Asteraceae | **Mata dolor** | digestive | na | | x | high | 1 | 6.7 | 0.06 |
| *Tanacetum balsamita* L./ Asteraceae | **Boldo** | antidiarrheal, digestive, calm stomach pain, empacho | ex | x | x | high | 1.1 | 73.3 | 0.73 |
| *Tanacetum vulgare* L./ Asteraceae | **Ajenco verde** | digestive | ex | | x | high | 1 | 13.3 | 0.13 |
| *Taraxacum officinale* F.H.Wigg./ Asteraceae | **Chicoria** | digestive | ex | x | x | high | 2 | 33.3 | 0.33 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Triticum aestivum* L./ Poaceae | **Trigo** | antidiarrheal, empacho | ex | x | | high | 2 | 13.3 | 0.13 |
| *Valeriana carnosa* Sm./ Caprifoliaceae | **Ñamkulawen** | digestive, calm stomach pain | na | | x | low | 1 | 33.3 | 0.33 |
| *Rhodophiala gilliesiana (Herb.)*/ Amaryllidaceae | **Cañiñim** | digestive | na | x | x | low | 2 | 20 | 0.2 |

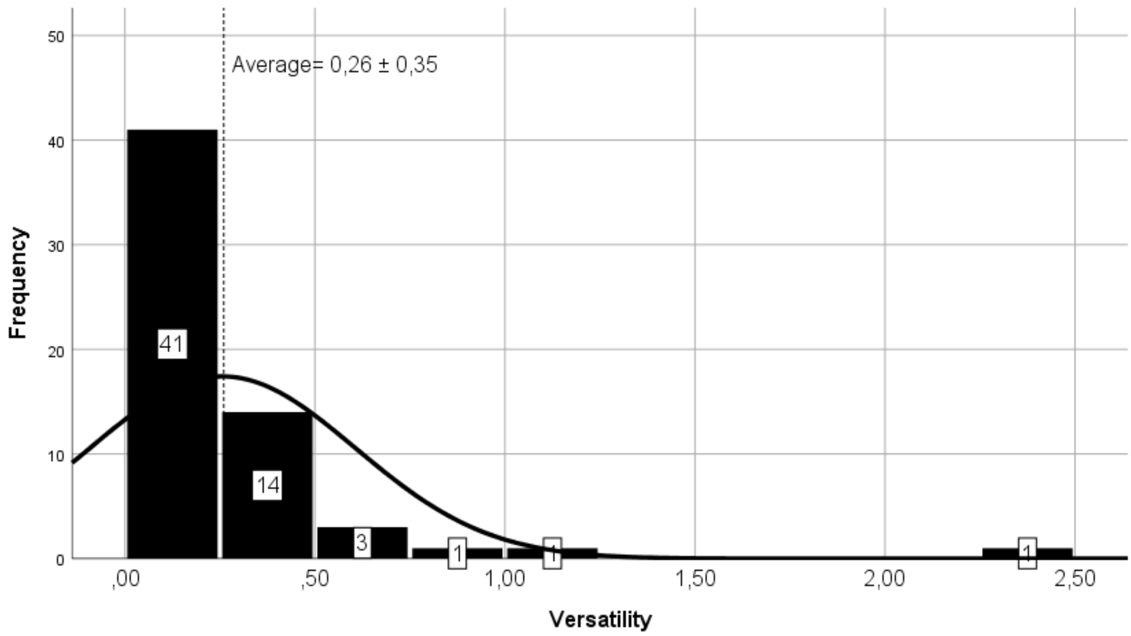


Figure 3. Digestive versatility curve of digestive species from the community of Gualjaina, Patagonia, Argentina. Reference: the vertical dotted line indicates the average value for the variable.

In agreement with prediction 1b, digestive versatility varies positively with the popularity of species (positive beta) (GLM, $p < 0.05$). In contrast to prediction 1c, biogeographic origin does not affect digestive versatility; native and exotic species are equally versatile (GLM, $p > 0.05$).

**Aromaticity, popularity and biogeographical origin of digestive species**

In agreement with prediction 2a, most of the digestive species (75.4%) have aroma according to the collaborators' perception (Binomial Test, $p < 0.05$). The remaining species smell like **yuyo** (grass, weed). In contrast to prediction 2b, aromatic plants are not more popular than nonaromatic plants (GLM, $p > 0.05$). In accordance with prediction 2c, most exotic plants have aroma (GLM, $p < 0.05$).

We found that a few species could be described in detail by their aroma:*Oxalis adenophylla* (sour or tart leaves), *Valeriana carnosa* and *Azorella prolifera* (bitter roots), *Gunnera tinctorea* and *Limonium brasiliense* (harsh, dry or tea-like roots), *Mentha* spp. (candy-like or sweet leaves) and *Schinus* spp. (scented branches), while other species simply "scented". Regarding intensity, "strong aroma", such as those of *Artemisia absinthium*, and mild aroma, such as those of *Nasturtium officinale*, were mentioned. In general, "very bitter," "strong," "repugnant" and "harsh" plants are used in low doses and in the treatment of ailments in adults, whereas "mild" "sweet" and "sour" plants can be used in larger quantities and/or to treat children.

**Duality of uses, popularity and aroma of digestive species**

In contrast to prediction 3a, inhabitants use in equal proportion plants with dual medicinal food uses (60%, n = 37) and digestive plants without dual uses (40%, n = 24) (Binomial test, $p > 0.05$). In contrast to prediction 3b, popularity is not affected by the duality of plant uses (GLM, $p > 0.05$). On the other hand, in agreement with prediction 3c, species with duality of uses have mostly aroma and taste (binomial test, $p < 0.05$), whereas exclusively digestive species could or could not have these attributes (binomial test, $p > 0.05$).

In general, digestive species consumed in the food context are used to taste "mate" (traditional infusion of *Ilex paraguariensis*) (e.g., *Acantholippia seriphioides*, *Buddleja araucana*), prepared as an infusion to give closure to a meal (e.g., *Camellia sinensis*, *Matricaria chamomilla*), used as an ingredient in salads (e.g., *Nasturtium officinale*, *Taraxacum officinale*) or as a fruit (e.g., *Berberis microphylla*, *Prunus cerasus*). A special case is the resin of **molle** (*Schinus johnstonii*), which is consumed as chewing gum.

**Accessibility, popularity and biogeographical origin of digestive species**

According to prediction 4a, most of the digestive species cited are very accessible (59% of the total) ($X^2$, $p < 0.05$), obtained by purchase, cultivation and/or collection in environments close to homes (e.g., *Matricaria chamomilla*, *Artemisia absinthium*, *Dysphania ambrosioides*) (Table 1). Twenty-eight percent of the species are not very accessible because they are found more than 3 km from homes, are not very abundant and/or are difficult to find (e.g., *Acantholippia seriphioides*, *Buddleja araucana*). The remaining 13% of the species are moderately accessible (e.g., *Berberis microphylla*, *Equisetum bogotense*), including species that are in decline according to the collaborators' opinion (*Schinus johnstonii*). However, in contrast to hypothesis 4b, popularity is not affected by accessibility (GLM, $p > 0.05$).

On the other hand, the accessibility of digestive plants differs with biogeographic origin. Native plants are negatively associated with high accessibility, whereas exotic plants are positively associated with high accessibility, which agrees with prediction 4c (GLM, $p < 0.05$). There are no significant differences between native and exotic species in relation to medium and low accessibility, that is, they are used equally (GLM, $p > 0.05$).

## Discussion

**Richness, popularity and biogeographical origin of digestive species**

The recorded richness of 61 species is lower than that documented in a previous study conducted in another Mapuche community in the sub-Antarctic forest (75 species, Molares & Ladio 2009a), which could be related to the greater biodiversity and structural complexity of the forest environment than the arid area where Gualjaina community is settled. Considering both study cases, and following Albuquerque and Oliveira (2007), the high richness of plants used for the same purpose may suggest that the Mapuche medical system possesses utilitarian redundancy as a significant cultural attribute, that is, that different species can be used for the treatment of the same ailment. This, in turn, may have implications for resilience, given its effect on the maintenance of the functions of the local medical system, that is, if one resource ceases to exist locally, another could replace it. Therefore, redundancy enhances medical system function because those components that appear redundant at one point in time become important when some environmental change occurs. The key here is that when change occurs, that always happens, the redundancies in digestive plants allow for continued functioning and provisioning health for the Mapuche people.

In terms of popularity, the vast majority of species show low values, meaning that there is little agreement among local collaborators on the main digestive species of the local flora, except for *Acantholippia seriphioides*, *Dysphania ambrosioides*, *Buddleja araucana* and *Schinus johnstonii* and the exotic *Tanacetum balsamita*, which have already been highlighted in the Mapuche pharmacopoeia, even for ailments other than gastrointestinal ones (Molares & Ladio 2009b, 2012, 2014). This indicates that utilization is concentrated in a few species, and the reasons for their preference need to be studied in more depth. It has even been suggested that redundant species remaining in the absence of a preferred species would only be utilized as long as they offer utilitarian returns close to that of the lost species, such as perceived efficacy and accessibility (Albuquerque *et al.* 2020).

The popularity of native species is similar to that of exotic ones. In contrast, a review study of Mapuche pharmacopoeia in the last century found that native species were the most popular (Molares & Ladio 2009b). Although we need to go deeper in this sense, we consider that the presence of exotic species in regional flora for at least 150-200 years has gradually contributed to this result. Added to this are the local repercussions of the global boom in the use of naturist therapeutic options, which extensively promote the use of exotic species such as *Origanum vulgare*, *Mentha piperita*, *Camellia sinensis*, *Rosmarinus officinalis*, and *Matricaria chamomila*. Many of these exotic species are widely known globally for uses other than digestive, for example *Rosmarinus officinalis* is known for its sedative, sudorific, antispasmodic and antirheumatic properties (Pochettino 2015). In this sense, the diversification of plants used as digestives can also be influenced by other types of medicinal uses not considered in this contribution. Many of these exotic species have been resignified and are currently used according to the peculiarities of the Mapuche medical system, including perceptions about their effectiveness and the appropriate dosages to treat each disease, even those of symbolic and cultural etiology (Molares & Ladio 2014, 2015). This hybrid corpus of native and exotic plants could be part of process of diversification, extending the repertoire of digestive species and offering greater flexibility to local medical systems and/or filling gaps left by native species (Alencar *et al.* 2010, Hart *et al.* 2017, Medeiros *et al.* 2017). Even so, the effects of public health policies that suggests the exclusive use of biomedicines, the inaccessibility of some traditional environments, the migration of young people to cities, as well as the advancement of the Market, could tend to homogenize the local medical system (i.e. the abandonment of native resources and their replacement by exotics ones) (to read of biocultural homogenization in Mapuche knowledge see Barreau *et al.* 2019). This is an aspect that did not emerge from our field data now but will have to be monitored going forward.

**Versatility, popularity and biogeographical origin of digestive species**

The most popular species are those with the greatest digestive versatility. This observed relationship coincides with what has been found in other communities of the Argentine Patagonia, in which the most valued medicinal species are those that cover a broad spectrum of ailments (Richieri *et al.* 2013, Molares & Ladio 2014). This quality could be especially valued "as a reassurance," considering that the symptoms or etiologies of these ailments are usually not very specific. In addition, multipurpose species tend to be more conserved, transported during migrations and shared than nonversatile ones. Thus, this hypothesis predicts that people are more likely to retain knowledge, use and access to a plant that has a greater number of applications for humans (Gaoue *et al.* 2017). However, most of the digestives used are not very versatile, showing a broad repertoire of species that combat specific ailments that should also be conserved in the local medical system.

Digestive versatility does not vary with the biogeographic origin of digestive species. These results do not support the premises reported by Alencar *et al.* (2014), because in this system native species offer varied alternatives of use that are not less than those provided by exotic plants. However, our results agree with the case study in Brazil conducted by Rossi-Santos *et al.* (2018), since native and exotic medicinal species had similar therapeutic versatility. Although our findings cannot be extrapolated to other medicinal uses, we can agree that perhaps species of exotic origin are being tested, but knowledge of those plants has not yet been validated and extended in the community (Alencar *et al.* 2014), so further study efforts are needed on this topic.

**Aroma, popularity and biogeographical origin of digestive species**

Most digestive plants have aroma, in accordance with previous studies in the region (Molares & Ladio 2009a) and in other places in the world (Silva Santos *et al.* 2018). Many of these species have essential oils (*Acantholippia seriphioides*, *Adesmia boronioides*, *Allium* spp., *Apium prostratrum*, etc.), these constitute the most prominent biological reasons for using them as digestive plants, because the terpene compounds of essential oils act as antimicrobial, antispasmodic, anti-inflammatory, etc. (Koyama *et al.* 2020). On the other hand, Gilca & Barbulesco (2015) indicate that in arid areas the secondary plant metabolism pathways could be favored towards the production of aromatic compounds, as an adaptive strategy for the control of desiccation and insolation. Thus, a greater presence of aroma and taste could be closely related to the chemical repertoire of the local flora. However, this aspect is not related with their plant popularity in the community. In addition, exotic digestive plants are more aromatic than native ones. Even if some aromatic natives are of the most popular species, such as *Acantholippia seriphioides* and *Dysphania ambrosioides*. These preliminary results suggest a relationship between aroma, medicinal uses and local chemical ecology. Further studies are needed to deepen this aspect.

**Duality of uses popularity and aroma of digestive spices**

Duality -or nonduality- of uses is related to the presence of aroma. Although it was not possible to test the importance of the intensity of the aromas in this regard, we found clues that in a bitterness gradient, the milder and more pleasant-tasting species tend to have dual uses (e.g., *Adesmia boronioides*, *Matricaria chamomilla*, *Apium prostratum*, *Origanum vulgare*) or be digestive only (e.g., *Centaurium cachanlahuen*, *Equisetum bogotense*); and that, at the other extreme, the most strongly bitter or stinking species are exclusively digestive (e.g., *Ruta chalepensis*, *Valeriana carnosa*, *Artemisia absinthium*). Concomitantly, Etkin and Ross (1982) pointed out that astringency, pungency and bitterness, when mild, are attributes valued both for their digestive and condiment properties. Studies focused on food plants have suggested that people tend to reject foods with a strongly bitter taste and prefer those with a sweet or insipid taste due to an association between bitter taste and toxic compounds such as terpenes and alkaloids, among others (Glendinnin 1994). In other words, there is a relationship between the perception and evaluation of intensities (strong and/or very bitter or odorous plants) and the adjustment of doses according to the concentration of active ingredients, which can be an important heuristic tool to prevent intoxication (Dos Santos *et al.* 2021). However, the consumption of bitter or moderately bitter plants in many cultures around the world is possible through detoxification processes and/or in low quantities (Pieroni *et al.* 2002, Pieroni & Torry 2007).

On the other hand, the results obtained indicate that the duality of uses does not affect the popularity of digestive species. This is striking considering that ethnobotanical and phytochemical antecedents reveal that the use of wild edible plants by rural Patagonian populations diversifies diet and offers a variety of minerals and micronutrients, playing a crucial role in the prevention of chronic diseases (Barreau *et al.* 2019, Chamorro & Ladio 2020). Possibly, unlike the growing revaluation experienced by Mapuche herbalism, wild edible plants are suffering a process of abandonment, affecting their dual use (Chamorro & Ladio 2019). Added to this is the gradual abandonment of organoleptic perceptions in the processes of experimentation of flora with medicinal potential. In a previous work, Molares and Ladio (2008) report on intra- and intercommunity taboos that limit the transmission of organoleptic knowledge to a few people (elders, healers). This is significant when considering that it is from the experimentation of medicinal plants that some of them are later incorporated as food, although other studies suggest the opposite (Bennett & Prance 2000, Etkin & Ross 1994).

**Accessibility, popularity and biogeographical origin of digestive species**

Most digestive species are very accessible, which agrees with what has been pointed out by other authors (Voeks 2004, Albuquerque 2006, Thomas *et al.* 2009). Exotic species are particularly accessible, being found in domestic and peridomestic sites (Molares & Ladio 2012, 2014, 2015, Chamorro & Ladio 2020). These are more accessible than native species due to different factors, including the retreat of native flora palatable to livestock, and because they can be cultivated and/or purchased. Their greater accessibility reduces uncertainty and allows their availability throughout the year, even in winter when it is not always possible to go out to look for them due to the harshness of the climate.

Case studies analyzed by Case *et al.* (2005) and discussed in Alencar *et al.* (2014) mention the correlation between reduced accessibility of native plants and loss of knowledge about them. Nevertheless, and in agreement with other authors (Albuquerque 2006, Trindade *et al.* 2015, Gonçalves *et al*, 2016, Jimenez Escobar *et al.* 2021), native species of low abundance or low accessibility can still be highly valued, due to their effectiveness and other factors that retain them in local memory (for example *Acantholippia seriphioides*, see Molares & Ladio 2014), showing the importance of the cultural legacy of some native plants.

## Conclusions

The use of digestive plants is linked to a multidimensionality of variables (aroma, dual medicinal-edible uses, digestive versatility, biogeographical origin and accessibility) that differentially affect their use patterns. Native and exotic plants are part of the local medical system in a complementary way. This reflects the coexistence of an ethnomedicine with Mapuche and European roots, suggesting processes of exchange and resignification to adjust them to local particularities. Although our results support some of the propositions of the diversification theory (Alencar *et al.* 2014), they also reflect local particularities that possibly stem from the regional historical and colonial process experienced by Patagonian communities. Thus, the local pharmacopoeia reflects a process of cultural resilience, including a set of diverse plants that are generally used for only one type of digestive use, but that overall provide a wide spectrum of digestive applications, being exotic plants the most accessible in family life.

In this way, the analysis of the popularity of the plants used reflected complex patterns, in which the greatest versatility and the presence of aroma are crucial for inhabitants, mainly for exotic ones. However, many species used without these attributes are also important. The species described here are part of the bio-cultural legacy of the region. Around half of the species are also used as digestive and health foods (have dual digestive-food uses), forming part of both the material and symbolic life of the considered Patagonian community, contributing to food security and household health.

Analyzing the multidimensionality of factors that influence the use of medicinal plants can also provide clues about their vulnerability. For example, about the importance for this community of the conservation of home orchards and wild areas near homes, which are at risk given the increasing water limitations in the steppe due to global socio-environmental change that make it difficult to sustain them. This highlights the irreplaceability of these spaces for people to cultivate, experience and evaluate plants, according to their own environmental and organoleptic perceptions inseparably linked to their cosmology. This process of diversification of species and learning is key for this system of knowledge, which has so far shown itself to be resilient, to be able to meet the new challenges of the future.

## Declarations

***List of abbreviations:*** CIEMEP= Centro de Investigación Esquel de Montaña y Estepa Patagónica; ININBIOMA= Instituto de Investigaciones en Biodiversidad y Medioambiente; CONICET= Consejo Nacional de Investigaciones Científicas y Técnicas; ISE= International Society for Ethnobiology; GLM= General linear model; CU= consensus of use; DV= Digestive versatility; DUCs= Duality of medicinal-food uses ; AP= Pearson's skewness coefficient; Na= native; Ex= exotic; etc.= among other things; e.g.= for example; i.e.= that is; N°= number

***Ethics approval and consent to participate:*** This study was conducted according to the ethics guidelines of the International Society for Ethnobiology Code of Ethics and Nagoya Protocol (Argentinian National Law N.°27246). All collaborators agreed orally to participate in the survey and confirmed free and informed consent prior to data collection.

***Consent for publication:*** Not applicable.

***Availability of data and materials:*** The data used to support the findings of this study are available from the corresponding author upon reasonable request.

***Competing interests:*** The authors have no conflicts of interest to declare.

***Funding:*** This investigation was supported by the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and ANPCyT (Agencia Nacional de Promoción Científica y Tecnológica -PICT-2018--03395).

## Acknowledgements

Special thanks are due to the inhabitants of Gualjaina for their willingness to collaborate in this study. This investigation was supported by the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) of Argentina and ANPCyT (Agencia Nacional de Promoción Científica y Tecnológica -PICT-2018-03395).

## Literature Cited

Albuquerque UP. 2006. Re-examining hypotheses concerning the use and knowledge of medicinal plants: a study in the Caatinga vegetation of NE Brail. Journal of Ethnobiology and Ethnomedicine 2:30.

Albuquerque UP, De Oliveira RF. 2007. Is the use-impact on native Caatinga species in Brazil reduced by the high species richness of medicinal plants? Journal of Ethnopharmacology 113:156-170.

Albuquerque UP, Alves Ramos M, Paiva de Lucena RF, Alencar NL. 2014. Methods and techniques used to collect ethnobiological data. In:Albuquerque UP, Fernandes Cruz da Cunha LV, Paiva de Lucena RF, Nóbrega Alves RR. (eds.). Methods and techniques in ethnobiology and ethnoecology. Humana Press, New York, Pp. 15-37.

Albuquerque UP, Borba do Nascimento AL, Machado de Freitas Lins Neto E, Santoro Rosa F, Taboada Soldati G, Moreno Brito de Moura J, Medeiros Jacob MC, Muñiz de Medeiros P, Santos Gonçalves PH, Heriques da Silva R, Soares Ferreira Junior W. 2020. Breve introdução à etnobiologia evolutiva. 1. ed. Nupeea, Recife, Brasil.

Alencar NL, Araújo TAS, Amorim ELC, Albuquerque UP. 2010. The inclusion and election of medicinal plants in traditional pharmacopoeias-evidence in support of the diversification hypothesis. Economic Botany 64:68-79.

Alencar NL, Santoro Rosa F, Alburquerque UP. 2014. What is the role of exotic medicinal plants in local medical systems? A study from the perspective of utilitarian redundancy. Revista Brasileira Farmacognosia 24:506-515.

Almeida Caetano R, Albuquerque UP, Medeiros PM. 2020. What are the drivers of popularity and versatility of medicinal plants in local medical systems? Acta Botánica Brasilica 34(2):256-265.

Amat JM, Vincent JD. 2003. Una nueva fisiología del gusto. RBA Libros, Barcelona, España.

Bacigalupo AM. 2001. La Voz del Kultrun en la Modernidad:Tradición y Cambio en la Terapéutica de Siete Machi. Editorial Universidad Católica, Santiago, Chile.

Barreau A, Tomás Ibarra J, Wyndham FS, Kozak RA. 2019. Shifts in Mapuche Food Systems in Southern Andean Forest Landscapes: Historical Processes and Current Trends of Biocultural Homogenization. Mountain Research and Development 39 (1):12-23.

Bennett BC, Prance GT. 2000. Introduced plants in the indigenous pharmacopoeia of Northern South America. Economic Botany 54 (1):90-120.

Brandt K, Christensen L, Hansen-Møller J, Hansen S, Haraldsdottir J, Jespersen L, Purup S, Kharazmi A, Barkholt V, Frøkiær H, Kobæk-Larsen M. 2004. Health promoting compounds in vegetables and fruits. Trends in Food Science and Technology 15(7-8):384-393.

Brett JA, Heinrich M. 1998. Culture, perception and the environment:The role of chemosensory perception. Angewandte Botanik 72:67-69.

Cambie RC, Ferguson LR. 2003. Potential functional foods in the traditional Maori diet. Mutation Research 523-524:109-117.

Carović-Stanko K, Petek M, Grdiša M, Pintar J, Bedeković D, Ćustić MH, Satovic Z. 2016. Medicinal Plants of the Family Lamiaceae as Functional Foods-a Review. Czech Journal of Food Science 34 (5):377-390.

Casagrande DG. 2000. Human Taste and Cognition in Tzeltal Maya Medicinal Plant Use. Journal of Ecological Anthropology 4:57-69.

Case RJ, Pauli GF, Soejarto DD. 2005. Factors in maintaining indigenous knowledge among ethnic communities of Manus Island. Economic Botany 59:356-365.

Chamorro M, Ladio A. 2020. Native and exotic plants with edible fleshy fruits utilized in Patagonia and their role as sources of local functional foods. BMC Complementary Medicine and Therapies 20 (155):1-16

Chamorro MF, Ladio A. 2019. Patagonian berries: a source of wellbeing. In:Bermejo EH, Pochettino ML, Herrera Molina F, Labarca Y, Tarifa García F. (eds.). CultIVA: Red Iberoamericana de Cultivos Infrautilizados y Marginados con Valor Agroalimentario. CYTED. Editorial Lola, Buenos Aires, Argentina (Accessed 30/3/2020).

Choudhury PR, Choudhury MD, Ningthoujam SS, Mitra A, Nath D, Talukdar AD. 2015. Plant utilization against digestive system disorder in Southern Assam, India. Journal of Ethnopharmacology 175:192-197.

Correa MN. 1998. Flora Patagónica. Parte I. Colección Científica del INTA, Buenos Aires, Argentina.

Reinaldo RCPS, Santoro FR, Albuquerque UP, Muñiz de Medeiros P. 2021. Taste and chemical composition as drives for utilitarian redundancy and equivalence: a case study in local medical systems in Northeastern Brazil. Journal of Ethnobiology and Medicine 18 (4).

Etkin N, Ross P. 1994. Pharmacologic implications of "wild" plants and Hausa diet. In: Etkin NL. (Ed.). Eating on the wild side, the pharmacologic, ecologic, and social implications of using noncultigens. The University of Arizona Press, Tucson, London, Pp. 85-101.

Etkin NL. 1996. Ethnopharmacology: the Conjunction of Medical Ethnopgraphy and the Biology of the Therapeutic Action. In:Sargent TM, Johsnson CF. (Eds.). Medical Anthropology: a handbook of Theory and Method. Revised Edition. Praeger Publishers, New York, Estados Unidos, Pp. 151-164.

Etkin NL, Ross PJ. 1982. Food as medicine and medicine as food: an adaptative framework for the interpretation of plant utilization among the Hausa of northern Nigeria. Social Science and Medicine 16(17):1559-1573.

Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC, McMillen H. 2017. Theories and Major Hypotheses in Ethnobotany. Economic Botany 71(3):269-287.

Geck MS, Stefano Cabras L, Casu A, Reyes García J, Leonti M. 2017. The taste of heat: how humoral qualities act as a cultural filter for chemosensory properties guiding herbal medicine. Journal of Ethnopharmacology 198:499-515.

Gilca M, Barbulescu A. 2015. Taste of medicinal plants: a potential tool in predicting ethnopharmacological activities? Journal of Ethnopharmacology 174:464-473.

Glenndinning JI. 1994. Is the bitter rejection response always adaptive? Physiology and Behavior 56 (6):1217-1227.

Gonçalves PHS, Albuquerque UP, Medeiros PM. 2016. The most commonly available woody plant species are the most useful for human populations:a meta-analysis. Ecological Applications 26(7):2238-2253.

Hart G., Gaoue OG, de la Torre L, Navarrete H, Muriel, P, Macía, MJ, Balslev, H, León-Yánez S, Jørgensen, P, Cameron Duffy, D. 2017. Availability, diversification and versatility explain human selection of introduced plants in Ecuadorian traditional medicine. PLoS ONE 12(9), e0184369.

Hurrell JA, Ulibarri EA, Delucchi, G, Pochettino, ML. 2008. Plantas aromáticas condimenticias. Biota Rioplatense XIII, Editorial LOLA, Buenos Aires, Argentina.

ISE (International Society of Ethnobiology). 2006. Code of Ethics. http://www.ethnobiology.net/code-of-ethics (Accessed 24/10/2021).

Jennings HM, Merrell J, Thompson JL, Heinrich M. 2015. Food or medicine? The food-medicine interface in households in Sylhet. Journal of Ethnopharmacology 167:97-104.

Jimenez Escobar DN, Dumecq MB, Morales D, Ladio A. 2021. Cross-scale analysis of diversification in fuelwood use in three contrasting ecoregions of Argentina (Chaco, Pampa and Patagonia):the role of exotic species in subsistence. Ethnobiology and Conservation 10:33.

Koyama S, Heinbockel T. 2020. The Effects of essential oils and terpenes in relation to their routes of intake and application. International Journal of Molecular Science 21:2-36.

Kujawska M, Pieroni A. 2015. Plants used as food and medicine by Polish migrants in Misiones, Argentina. Ecology of Food and Nutrition 54:255-279.

Ladio AH. 2021. Mujeres rurales en el sostenimiento de la soberanía alimentaria y los equívocos patriarcales en los estudios etnobiológicos del norte de la Patagonia. Ethnoscientia 6(2):1-19.

Leonti M, Casu L, de Oliver Martins DT, Rodrigues E, Benítez G. 2020. Ecological Theories and Major Hypotheses in Ethnobotany: Their Relevance for Ethnopharmacology and Pharmacognosy in the Context of Historical Data. Revista Brasilera de Farmacognosia 30:451-466.

Leonti M, Ramirez F, Sticher O, Heinrich M. 2003. Medicinal Flora of the Popoluca, México: A botanical systematical perspective. Economic Botany 57(2):218-230.

Leonti M, Sticher O, Heinrich M. 2002. Medicinal plants of the Popoluca, México: Organoleptic properties as indigenous selection criteria. Journal of Ethnopharmacology 81:307-315.

Lucena RFP, Medeiros PM, Araújo EL, Chaves Alves GC, Albuquerque UP. 2012. The ecological apparency hypothesis and the importance of useful plants in rural communities from Northeastern Brazil: an assessment based on use value. Journal of Environmental Management 96(1):106-115.

Martínez LM. 2017. Muestra cualitativa. Una propuesta integradora. Investigación Cualitativa en Ciencias Sociales 3:180-190.

Medeiros PM, Ferreira JWS, Ramos MA, Silva TC, Ladio AH, Albuquerque UP. 2017. Why do people use exotic plants in their local medical systems? A systematic review based on Brazilian local communities. PLoS ONE 12(9), e0185358.

Medeiros PM, Ladio AH, Albuquerque UP. 2013. Patterns of medicinal plant use by inhabitants of Brazilian urban and rural areas: a macroscale investigation based on available literature. Journal of Ethnopharmacology 150:729-46.

Medeiros PM, Pinto BLS, Nascimento VT. 2015. Can organoleptic properties explain the differential use of medicinal plants? Evidence from Northeastern Brazil. Journal of Ethnopharmacology 159:43-48.

Mejía Navarrete J. 2000. El muestreo en la investigación cualitativa. Investigaciones sociales 5:165-180.

Mereb M. 1990. Caracterización climatológica de los valles superior y medio del río Chubut. Dirección general de estudios y proyectos. Hidrometeorológico principal. Provincia del Chubut: Ministerio de economía, obras y servicios públicos.

Molares S. 2010. Flora medicinal aromática de la Patagonia:características anatómicas y propiedades organolépticas utilizadas en el reconocimiento por parte de la terapéutica popular. Phd thesis. Centro Regional Universitario Bariloche. Universidad Nacional del Comahue, Argentina.

Molares S, Ladio AH, 2008. Plantas medicinales en una comunidad Mapuche del NO de la Patagonia Argentina:clasificación y percepciones organolépticas relacionadas con su valoración. BLACPMA 7(3):149-155.

Molares S, Ladio AH. 2009a. Chemosensory perception and medicinal plants for digestive ailments in a Mapuche community in NW Patagonia, Argentina. Journal of Ethnopharmacology 123:397-406.

Molares S, Ladio AH. 2009b. Ethnobotanical review of the Mapuche medicinal flora: Use patterns on a regional scale. Journal of Ethnopharmacology 122 (2):251- 260.

Molares S, Ladio AH. 2012. Mapuche perceptions of Andean *Nothofagus* forests and their medicinal plants:a case study from a rural community in Patagonia, Argentina. Biodiversity and Conservation 21:1079-1093.

Molares S, Ladio AH. 2014. Medicinal plants in the cultural landscape of a Mapuche-Tehuelche community in arid Argentine Patagonia:an eco-sensorial approach. Journal of Ethnobiology 10:61.

Molares S, Ladio AH. 2015. Complejos vegetales comestibles y medicinales en la Patagonia Argentina: sus componentes y posibles procesos asociados. BLACPMA 14 (3):237-250.

Morales D, Molares S, Ladio A. 2017. Firewood resource management in different landscapes in NW Patagonia. Frontiers in Ecology and Evolution 5:1-13.

Morales D, Molares S, Epele L, Ladio A, Manzo P, Alday G. 2020. An interdisciplinary approach to perception of water quality for human consumption in a Mapuche community of arid Patagonia, Argentina. Science of the Total Environment 720:137508.

Neamsuvan O, Tuwaemaengae T, Bensulong F, Asae A, Mosamae K. 2012. A survey of folk remedies for gastrointestinal tract diseases from Thailand's three southern border provinces. Journal of Ethnopharmacology 144:11-21.

Pieroni A, Nebel S, Quave C, Münz H, Heinrich M. 2002. Ethnopharmacology of liakra: traditional weedy vegetables of the Arbëreshëof the Vulture area in southern Italy. Journal of Ethnopharmacology 81:165-185.

Pieroni A, Nebel S, Santoro RF, Heinrich M. 2005. Food for two seasons: Culinary uses of non-cultivated local vegetables and mushrooms in a south Italian village. International Journal of Food Sciences and Nutrition 56 (4):245-272.

Pieroni A, Price LL. (Eds.). 2006. Eating and Healing: Traditional Food as Medicine. Haworth Press, Food Products Press, Binghamton, New York, Estados Unidos.

Pieroni A, Torry B. 2007. Does the taste matter? Taste and medicinal perceptions associated with five selected herbal drugs among three ethnic groups in West Yorkshire, Northern England. Journal of Ethnobiology 3:21.

Pochettino ML. 2015. Botánica Económica. Las plantas interpretadas según tiempo, espacio y cultura. Sociedad Argentina de Botánica. Buenos Aires, Argentina.

Rahman IU, Ijaz F, Afzal A, Iqbal Z, Ali N, Khan S.M. 2016. Contributions to the phytotherapies of digestive disorders:Traditional knowledge and cultural drivers of Manoor Valley, Northern Pakistan. Journal of Ethnopharmacology 192:30-52.

Richeri M, Ladio AH, Beeskow AM. 2013. Conocimiento tradicional y autosuficiencia: la herbolaria rural en la Meseta Central del Chubut (Argentina). BLACPMA 12 (1):44-58.

Rossi-Santos B, Oliveira Jacintho J, Milliken W, Teixeira Braga Messias MC. 2018. The Role of Exotic Species in Traditional Pharmacopeias of the Cerrado:a Case Study in Southeast Brazil. Economic Botany 72(1):38-55.

Shepard GH. 2004. A Sensory ecology of medicinal plant therapy in two amazonian societies. American Anthropology 106 (2):252-266.

Silva Santos C, Novais Barros F, de Paula M, Rando J, Teixeira do Nascimento V, Medeiros PM. 2018. What matters when prioritizing a medicinal plant? A study of local criteria for their differential use. Acta Botanica Brasilica 32(2):297-302.

Sõukand R, Kalle R. 2010. Herbal landscape: the perception of the landscape as a source of medicinal plants. Trames 14:207-226.

Tell G, Izagarre I, Quintana RD. 1997. Flora y fauna patagónicas. Editorial Caleuche, San Carlos de Bariloche, Argentina.

Thomas E, Vandebroek I, Van Damme P, Goetghebeur P, Douterlungne D, Sanca S, Arrazola S. 2009. The relation between accessibility, diversity and indigenous valuation of vegetation in the Bolivian Andes. Journal of Arid Environments 73(9):854-861.

Trindade OlMR, Jardim JG, Casas A, Guerra NM, Lucena PRF. 2015. Availability and Use of Woody Plant Resources in Two Areas of Caatinga in Northeastern Brazil. Ethnobotany, Research and Application 14:313-330.

Ullah S, Khan MR, Shah NA, Shah SA, Majida M, Farooq MA. 2014. Ethno- medicinal plant use value in the Lakki Marwat District of Pakistan. Journal of Ethnopharmacology 158:412-422.

Valussi M. 2012. Functional foods with digestion-enhancing properties. International Journal of Food Science and Nutrition 63 (1):82-89.

Voeks RA. 2004. Disturbance Pharmacopoeias: Medicine and Myth from the Humid Tropics. Annals of the Association of American Geography 94 (4):868-888.

Zuloaga FO, Morrone O, Belgrano MJ. (Eds.). 2008. Catálogo de las Plantas Vasculares del Cono Sur. (Argentina, Sur de Brasil, Chile, Paraguay y Uruguay). Monographs in Systematic Botany from the Missouri Botanical 107:i-xcvi:1-3348.

Supplementary material. Summary of results considering our predictions. Particularly, summary of the parameters of the GLM estimates for the six models used. Wald is the chi-square that tests the null hypothesis, df = degrees of freedom, Sig = level of significance, ∗significant results in the model at 0.05.

| Prediction | Model/ test | Factor | Wald chi-square | Sig |
|---|---|---|---|---|
| 1(a) Most popular digestive plants are exotic | GLM<br>*Distribution: Multinomial*<br>*Link: Acum. logit*<br>*Dependent variable: UC* | Biogeographic Origin | 0.20 | p = 0.887 |
| 1(b) Most popular digestive plants are the most versatile | GLM<br>*Distribution: Normal*<br>*Link: Identity*<br>*Dependent variable: UC* | Digestive Versatility | 4.493 | p < 0.05 * |
| 1(c) Exotic plants are more versatile than native ones | GLM<br>*Distribution: Binomial*<br>*Link: Logit*<br>*Dependent variable: Biogeographic Origin* | Digestive Versatility | 2.89 | p = 0.09 |
| 2(a) The highest richness of digestive species will correspond to plants with aroma | Binomial | Plants with aroma vs. without aroma | | p < 0.05* |
| 2(b) Most popular plants are aromatic | GLM<br>*Distribution: Tweedie*<br>*Link: Logarithmic*<br>*Dependent variable: UC* | Aromaticity | 1.25 | p = 0.26 |
| 2(c) Exotic species are more aromatic than native ones. | GLM<br>*Distribution: Binomial*<br>*Link: Logit*<br>*Dependent variable: Biogeographic Origin* | Aromacity<br>Non aromatic x native.<br>Beta: 1.3 | 4.606 | p = 0.03* |
| 3(a) The highest proportion of plants used as digestives will be dual | Binomial | Dual plants vs. non dual plants | | p = 0.125 |
| 3 (b) Most popular plants are dual | GLM<br>*Distribution: Normal*<br>*Link: Identity*<br>*Dependent variable: Biogeographic Origin* | Duality | 0.34 | p = 0.56 |
| 3 (c) Dual species are more aromatic than digestive-only ones | Binomial | Dual aromatic plants vs. dual non aromatic plants | | p < 0.05* |
| 4 (a) Most digestive species are very accessible | $X^2$= 20.1, gl. 2 | Frequency of accessibility categories | | p < 0.05* |
| 4(b) Most popular digestive plants are the most accessible | GLM<br>*Distribution: Multinomial*<br>*Link: Acum. logit Dependent variable: UC* | Accessibility | 0.068 | p =0.66 |
| 4 (c) Popular exotic plants are more accessible than native ones. | GLM<br>*Distribution: Binomial*<br>*Link: Logit*<br>*Dependent variable: Biogeographic Origin* | Accessibility<br>Very accessible species x native. Beta: -4.02 | 25.12 | p < 0.05* |