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ANALYSIS **Open Access**

Botanical Ethnoknowledge Index: a new quantitative assessment method for cross-cultural analysis

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Abstract

The scientific accuracy of ethnobotanical study has significantly grown in the past decades due to the adoption of quantitative methods, mainly represented by indices. These quantitative approaches can provide data amenable to hypothesis testing, statistical validation, and comparative analysis. Plenty of indices are applied nowadays in ethnobotany. However, none of the previously developed indices have argued for comparing general ethnobotanical knowledge between two or more human groups. Hence, this study seeks to cover this methodological gap and proposes a novel index that will provide ethnobotanists with a tangible number representing the general ethnobotanical knowledge of a specific human group. The proposed index will enable researchers in the field to compare ethnobotanical knowledge of two or more ethnic/ religious/ cultural groups; it will also be possible to conduct a comparison within the same group, such as comparing two distanced time periods, genders, and/or age groups. The index complexly employs several factors that can be critical when assessing ethnobotanical knowledge (e.g. total number of species reported by all participants in a particular group, mean number of species reported per participant in a particular group, and mean number of citations per species in a particular group). The index is designed to be mainly used in ethnobotany; however, it is also usable in ethnobiology and may be applicable in other studies related to traditional knowledge assessment.

Science highlights

- The study proposes an index that will enable researchers to compare ethnobotanical knowledge of two, or more, human groups.
- The proposed index is also applicable when conducting intra-group comparisons on gender, age, and temporal basis.
- The index complexly employs several factors that can be critical when assessing ethnobotanical knowledge.

Keywords BEI, Cross-cultural comparison, Ethnobiology, Ethnobotany, Intra-group comparison, Quantitative analysis, Traditional knowledge

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Introduction

Ethnobotany, the study of interactions between people and plants, has gotten greater attention in recent decades due to its critical role in developing novel crops and medicines and highlighting human biocultural heritage [1]. The interest of ethnobotanists extends to a wide range of the people–plants relationship, from the medicinal use of plants to food use and from the use as material to plants employment in rituals [2]. Ethnobotanists also focus on the cultural significance of plant use, and most often, they attempt to compare ethnobotanical knowledge between several human groups [3–5]. Currently, dozens of journals publish ethnobotanical studies, while there were only a few journals in the past decades [6]. Due to its interdisciplinary character, ethnobotany has changed its definition, objectives, and methodology since Harshberger introduced it in 1896; it currently encompasses many scientific fields, including botany, ecology, and anthropology [7]. These disciplines provide a variety of research possibilities since they employ distinct paradigms and methodologies. Phillips [8] argues that the scientific accuracy of ethnobotanical studies has significantly grown in the past decades due to the adoption of quantitative methods; quantitative indices mainly represent those methods.

One of the most significant endeavours in ethnobotany, according to Martin [9], is the quantitative assessment of the handling and use of botanical resources. Hence, the objectives of ethnobotanical researchers are very different when applying quantitative indices. Until recently, quantitative data analysis gave ethnobotany a subjective and descriptive character in inventories of useful plants; however, this analysis gradually became less subjective and more experimental [6]. Methodological tools have been developed to respond to questions about the interrelation between people and plants, both qualitatively and quantitatively. Despite introducing many ethnobotanical indices, a large proportion of ethnobotanical papers remained heavily dependent on qualitative analysis and building narrative conclusions without robust statistical support, which was criticized by Heinrich et al. [10].

Phillips [8] studied 41 documents published between 1966 and 1994. This review examined the methods used in ethnobotanical research to address the different uses and importance of plant species for communities. The study of Phillips [8] confirmed that quantitative approaches are highly beneficial for the academic study of ethnobotany. Similarly, Albuquerque [11] analysed the evolution of the use of the term "quantitative ethnobotany" and found that this approach generally contributed to methodological advances in ethnobotany. Moreover, this approach gives the science of ethnobotany a significant impact on biological conservation by providing implications and insight into the importance of different vegetation types for humans and the effect of anthropogenic pressure on these environments. Another similar study was also carried out by Hoffman & Gallaher [12], using the term relative cultural importance (RCI) to refer to some of the data analysis techniques used by Phillips [8] and others. The relative cultural importance (RCI) indices, such as the "use values" which was developed by Prance et al. [16], are applied in ethnobotany to calculate a value for each folk or biological plant taxon. These approaches can provide data suitable for hypothesis testing, statistical validation, and comparative analysis [12].

Despite the fact that quantification allowed ethnobotanical researchers to assess people's knowledge of plant resources and incorporate the perspective of a large number of informants [13], some criticisms of using indices have been demonstrated by few scientists. Gaoue et al. [14] argued that despite improvements, recent ethnobotanical research has overemphasized the use of quantitative ethnobotany indices and statistical methods borrowed from ecology, yet underemphasized the development and integration of a strong theoretical foundation. Leonti [15] sees that the use of ethnobotanical indices in some contexts is not helpful, as the case in ethnopharmacology, because important factors influencing plant use, such as the availability of pharmaceutical drugs or the severity of diseases covered by the use categories are not considered in such indices. Besides, Leonti [15] argues that the cultural value and importance of plants in general, and more specifically, of medicinal plants and botanical drugs cannot be summed up by numbers.

There are plenty of indices that are applied nowadays in ethnobotany. These indices were categorized by Hoffman & Gallaher [12] into four main categories:

1. Uses totalled, which is a simple sum of all known uses for each species.
2. Subjective Allocation: such as, Use Value [16]; and Index of Cultural Significance [17].
3. Informant Consensus (informant Tally): such as, Corrected Fidelity Level [18]; Species Use Value for one informant, and Species Use Value for one species across all informants [19].
4. Informant Consensus (Informant Score): such as, the Informant Score Method [20]; and Choice Value [21].

In addition to these categories, other indices are currently applied in ethnobotany such as Jaccard Similarity Index, which assess the overlap percentage in number of used species between cultural groups [22].

However, none of the developed indices, so far, has approached the assessment of overall/general ethnobotanical knowledge of a human group. Hence, this study seeks to cover this methodological gap and aims to provide a new tool to quantitatively assess ethnobotanical knowledge richness, particularly when comparing the general ethnobotanical knowledge between two, or more, human groups, as well as when conducting intra-group comparisons on gender, age, and temporal basis.

A new index: Botanical Ethnoknowledge Index (BEI)

The newly developed index, named the "Botanical Ethnoknowledge Index" and abbreviated as "BEI", complexly combines several crucial factors related to ethnobotanical knowledge. It is built on the total number of plant species reported by all participants in a particular group, the mean number of plant species reported per participant in a particular group, the mean number of citations per species in a particular group, the number of participants from the particular group, and the total number of species reported by all compared groups in the study. The higher value of BEI represents richer ethnobotanical knowledge.

The BEI is presented in the following formula:

$$\mathrm{BEI} = \left(\frac{\mathrm{ms}}{\mathrm{Sg}} + \frac{\mathrm{mc}}{N}\right) * \frac{\mathrm{Sg}}{\mathrm{St}}$$

Or in line format as:

$$\mathrm{BEI} = [(\mathrm{ms}/\mathrm{Sg}) + (\mathrm{mc}/N)] * \mathrm{Sg}/\mathrm{St}$$

BEI: Botanical Ethnoknowledge Index. ms: mean number of species reported per participant in a particular group. Sg: total number of species reported by all participants in a particular group. mc: mean number of citations per species in a particular group. *N*: number of participants in the particular group. St: total number of species reported by all compared groups in the study.

The index values will range between 0 (but never equals) and 2 (equals or smaller). Higher values of BEI represent a higher level of ethnobotanical knowledge of a particular group. However, values falling between 1 and 2 are possible but expected to occur less often, particularly when a group has unique ethnobotanical knowledge relative to other compared groups. If researchers are interested to investigate more the statistical significance between the index values, further statistical tests such as t-tests or ANOVA can be employed.

The index assesses and calculates the complex relationship between several factors related to ethnobiological/ethnobotanical knowledge of a particular group and opens a window to compare it with other groups with similar ecological conditions and flora.

The first part of the equation (ms/Sg) captures the contribution of every participant in the targeted group to the overall knowledge of their group. This is represented by the mean number of species reported per participant relative to the total number of species reported by all participants in the relevant group. The number of species reported per participant is a quantitative indication of ethnobotanical knowledge and its richness among the relevant group, and it has been employed in several contexts in a few indices [12].

The second part of the equation (mc/*N*) captures the spread of ethnobotanical knowledge (the known/used species) among the relevant group. The mean number of citations per species (mc) relative to the number of participants in the same group serves as a general indication of the participants' agreement ratio on used species. This part of the equation aligns with the concept of Frequency of Citation, which has been employed in different contexts in several indices such as choice value [21], relative frequency of citation [23], and corrected fidelity level [18].

The third part of the equation (Sg/St) scales the result of the previous parts by comparing the total number of species reported by all participants in the relevant group to the total number of species reported by all studied groups. The total number of reported species in a particular group (Sg) is a clear indication of the diversity and richness of ethnobotanical knowledge, and it has been reported as such in numerous ethnobotanical studies [3, 24, 25]. This part of the equation/index effectively gives a relative weight of comparison.

The above-presented index is designed to compare groups with similar sample sizes. However, in order to overcome this limitation when comparing groups with different sample sizes, the index value can be relatively corrected by multiplying it with a coefficient as follows:

$$F = N\ \mathrm{mean}/\left(N\ \mathrm{mean} + \sqrt{N}\ \mathrm{min}\right)$$

F: correcting factor. *N* mean*:* mean number of participants among all compared groups. $\sqrt{N}$ min*:* square root of the number of participants in the smallest group.

The principle behind this correcting factor is to adjust sample size variations; however, avoiding such variations by comparing similar sample sizes would make the index application more practical without additional calculations. In the suggested correcting factor, *N* mean represents the typical group size, helping to balance the effect of sample size on the index. On the other hand, *N* min (the smallest group size) represents the variability in sample sizes; moreover, the square root helps moderate its influence on the result.

In order to provide an example of the application of this index, we proposed five data sets representing five cultural groups (A, B, C, D, and E). The hypothetical data enable us to test the influence of each factor/element in the index on the final value of BEI. Each of the groups (B, C, D, and E) demonstrates a different value of a specific factor compared with the control group (A) keeping other values similar to those in group (A). Group (A) services as baseline for comparison against other groups. For instance, in order to examine the impact of the mean number of species reported per participant, group (C) had a value of (ms = 13) compared to (ms = 9) in group (A), while other factors remained identical among both groups.

By calculating the Botanical Ethnoknowledge Index for each of the cultural groups in Table 1 and by applying the previously mentioned formula, we find:

$$\begin{aligned}\text{BEI for the group A} &= \left[\left(\text{ms/Sg}\right) + \left(\text{mc}/N\right)\right] * \text{Sg/St}\\ &= [(9/25) + (8/30)] * 25/50\\ &= [0.36 + 0.267] * 0.5\\ * &= 0.627 * 0.5 = 0.313\end{aligned}$$

$$\begin{aligned}\text{BEI for the group B} &= \left[\left(\text{ms/Sg}\right) + \left(\text{mc}/N\right)\right] * \text{Sg/St}\\ &= [(9/25) + (8/33)] * 25/50 = 0.301\end{aligned}$$

$$\begin{aligned}\text{BEI for the group C} &= \left[\left(\text{ms/Sg}\right) + \left(\text{mc}/N\right)\right] * \text{Sg/St}\\ &= [(13/25) + (8/30)] * 25/50 = 0.393\end{aligned}$$

$$\begin{aligned}\text{BEI for the group D} &= \left[\left(\text{ms/Sg}\right) + \left(\text{mc}/N\right)\right] * \text{Sg/St}\\ &= [(9/25) + (11/30)] * 25/50 = 0.363\end{aligned}$$

Table 1 Hypothetical data as an example for the application of Botanical Ethnoknowledge Index (BEI)

Cultural group	Number of participants in a particular group (*N*)	Mean number of species reported per participant in a particular group (ms)	Total number of species reported by all participants in a particular group (Sg)	Mean number of citations per species in a particular group (mc)	Total number of species reported by all compared groups in the study (St)
A	30	9	25	8	50
B	33	9	25	8	
C	30	13	25	8	
D	30	9	25	11	
E	30	9	35	8	

$$\begin{aligned}\text{BEI for the group E} &= \left[\left(\text{ms/Sg}\right) + \left(\text{mc}/N\right)\right] * \text{Sg/St}\\ &= [(9/35) + (8/30)] * 35/50 = 0.367\end{aligned}$$

If the sample sizes would be equal, we would adopt the above results. However, since there are variations in the sample sizes, we need to apply the correction factor, as follows:

$$\begin{aligned}\text{F} &= N\ \text{mean}/(N\ \text{mean} + \sqrt{N}\ \text{min})\\ &= 30.6/\left(30.6 + \sqrt{30}\right)\\ &= 30.6/(30.6 + 5.477) = 0.85.\end{aligned}$$

And the corrected BEI values would be as follows:

$$\text{BEI for the group A} = 0.313 * 0.85 = 0.266$$

$$\text{BEI for the group B} = 0.301 * 0.85 = 0.256$$

$$\text{BEI for the group C} = 0.393 * 0.85 = 0.334$$

$$\text{BEI for the group D} = 0.363 * 0.85 = 0.309$$

$$\text{BEI for the group E} = 0.367 * 0.85 = 0.312$$

The results show that reasonable differences in sample sizes will have a negligible influence on the value of BEI, particularly after applying the correcting factor. The BEI value for group (B) is very close to the one of group (A) despite the different number of participants (*N*) in the mentioned groups.

The BEI result in group (C) compared with the one of group (A) confirms the positive correlation between the mean number of species reported per participant in a particular group (ms) and the value of BEI.

Similarly, the BEI values of group (D) compared with group (A) clearly show the positive impact of the mean number of citations per species in a particular group (mc) on the final value of the index.

Table 1 and the result of the BEI in group (E) demonstrate that the index values increase with the increase in the total number of species reported by all participants in a particular group (Sg).

In order to provide a real empirical example of the application of the proposed index, data from a previously published study will be used [3]. The selected study investigated ethnobotanical knowledge of wild food plants used by Kurds in western Iran. The study aimed to identify similarities and differences in plant foraging practices among Hawraman and Mukriyan Kurdish groups in western Iran (Table 2). Both groups live in neighbouring areas in western Iran where the climate is classified as humid continental based on the Köppen Climate Classification.

By calculating the Botanical Ethnoknowledge Index for each cultural group in Table 2 and by applying the previously mentioned formula, we find:

$$\begin{aligned}&\text{BEI for the Hawraman Kurd}\\&=\left[\left(\mathrm{ms}/\mathrm{Sg}\right)+\left(\mathrm{mc}/N\right)\right]*\mathrm{Sg}/\mathrm{St}\\&=[(10.857/33)+(6.457/21)]*33/44\\&=[0.329+0.307]*0.75=0.477\end{aligned}$$

$$\begin{aligned}&\text{BEI for the Mukriyan Kurd}\\&=\left[\left(\mathrm{ms}/\mathrm{Sg}\right)+\left(\mathrm{mc}/N\right)\right]*\mathrm{Sg}/\mathrm{St}\\&=[(10.273/28)+(5.714/22)]*28/44\\&=[0.367+0.258]*0.636=0.398\end{aligned}$$

Since the compared group sizes are not equal, we apply the correcting factor as follows:

$$\begin{aligned}\mathrm{F}&=N\text{ mean}/(N\text{ mean}+\sqrt{N}\text{ min})\\&=21.5/\left(21.5+\sqrt{21}\right)\\&=21.5/26.083=0.824.\end{aligned}$$

And the corrected BEI values would be as follows:

$$\text{BEI for the Hawraman Kurd}=0.477*0.824=0.393$$

$$\text{BEI for the Mukriyan Kurd}=0.398*0.824=0.328$$

The results of the applied index show that the Hawraman group has a higher knowledge of wild food plant foraging than Mukriyan group. This result aligns with the study finding that the Hawrmani group showed a higher diversity of wild food plants than Mukriyan. The higher result of BEI for Hawrmani is not only due to the relatively higher number of species reported by all participants in the group (Sg), but it is also impacted by the relatively higher mean number of citations per species (mc) which shows the spread knowledge/use of reported species among the sampled participants. The study attributed the differences in knowledge of wild food plants, including the reported used species, to the origin of both groups and the dominant agricultural activities in the land of origin (horticulturalism and pastoralism), as the Hawraman are considered to be descended from the people of Gilan near the Caspian Sea, who themselves are a mix of South Caucasians (Georgians, Armenians, etc.) and Persians [3].

The above-presented results, both hypothetical and real data, statistically prove the correctness of the suggested index formula as they provide a clear indication of the contribution of the critical ethnobotanical factors (e.g. total number of species reported by all participants in a particular group, mean number of species reported per participant in a particular group, and mean number of citations per species in a particular group) to the final value of BEI.

Table 2 Application of the Botanical Ethnoknowledge Index (BEI) on the comparison between Hawraman and Mukriyan Kurds in western Iran. The data are derived from a previously published study [3]

Cultural group	Number of participants in a particular group (*N*)	Mean number of species reported per participant in a particular group (ms)	Total number of species reported by all participants in a particular group (Sg)	Mean number of citations per species in a particular group (mc)	Total number of species reported by all compared groups in the study (St)
Hawraman	21	10.857	33	6.457	44
Mukriyan	22	10.273	28	5.679	

Applications and limitations of the presented index

The proposed index is applicable in multiple cases when comparing the ethnobotanical knowledge within one group, between two groups, or more. Below there are some cases where the index is applicable:

- Intra-group comparison: This is based on gender, age, occupation, education, and/or other socioeconomic indicators [24].
- Intra-group comparison on a temporal basis: Compare the botanical ethnoknowledge of the same group. For instance, comparing data published in 1970 and data collected in 2020 in the same study area with the same cultural group [26, 27].
- Cross-group comparison between two, or more, groups: This comparison can be between ethnic, linguistic, religious, and/or cultural groups [5].

In addition to ethnobotany, the presented index may be applicable in some other ethnobiological subfields such as ethnozoology and ethnomycology. For instance, when applying it in ethnozoology, we consider "animal" species instead of "plant" species in the above provided examples.

However, as limitations, the presented index is not designed to compare groups that belong to distanced geographical locations where significant differences in vegetation can introduce bias in surveyed data and, consequently, in the index value. For instance, BEI cannot be used to compare two sets of participants, one living in the Mediterranean and the second in the tropical rainforest. Despite the suggested correction factor, extreme differences in sample sizes are not recommended in order to avoid the potential statistical bias. The results of the index cannot be generalized to the studied community unless the size of the sampled group statistically represents the population number of the relevant community. Although the presented index employs several important indications of ethnobotanical knowledge, it does not include every factor that may influence ethnobotanical knowledge.

Conclusion

This study proposes a novel index that will provide a tangible number that represents the overall/general ethnobotanical knowledge of a particular human group. It will enable researchers in the field to compare ethnobotanical knowledge of two, or more, ethnic/ religious/ linguistic/ cultural groups. It is also possible to conduct intra-group comparisons (on a temporal and socioeconomic basis). The index has employed complexly several (e.g. total number of species reported by all participants in a particular group, mean number of species reported per participant in a particular group, and mean number of citations per species in a particular group) that have been proven to be critical when assessing ethnobotanical knowledge. The importance of this index comes from combining all these factors in one single formula that reflects the general ethnobotanical knowledge of a particular group of participants. The index is designed to be mainly used in the field of ethnobotany; however, it is usable in some other ethnobiological subfields such as ethnozoology and ethnomycology and may be applicable to other studies related to traditional knowledge assessment. Researchers in the field are invited to use this index and suggest improvements in order to have clearer and more precise tools for assessing ethnobotanical/ ethnobiological knowledge.

Abbreviation

BEI Botanical Ethnoknowledge Index

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Author contributions

It is a single-author article. I have done all the work of this article.

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Data availability

The data that support the findings of this study are presented in the article.

Declarations

Ethics approval and consent to participate

Not applicable.

Competing interests

Not applicable.

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References

1. Martin GJ. Ethnobotany: a methods manual. London: Routledge; 2010.
2. Balick MJ, Cox PA. Plants, people, and culture: the science of ethnobotany. New York: Garland Science; 2020.
3. Sulaiman N, Salehi F, Prakofjewa J, Cavalleri SAE, Ahmed HM, Mattalia G, Rastegar A, Maghsudi M, Amin HM, Rasti A, Hosseini SH, Ghorbani A, Pieroni A, Sõukand R. Cultural vs. state borders: plant foraging by Hawraman and Mukriyan Kurds in Western Iran. Plants. 2024;13(7):1048. https://doi.org/10.3390/plants13071048.
4. Sulaiman N, Pieroni A, Sõukand R, Whitney C, Polesny Z. Socio–cultural significance of Yerba Maté among Syrian residents and diaspora. Econ Bot. 2021;75:97–111.
5. Shah AA, Raza A, Sulaiman N, Khadka D, Majid A, Aziz MA, Abbasi AM, Ahmad M, Pieroni A. The importance of sharing: wild plant knowledge in three valleys of Northern Pakistan. Plant Biosyst. 2024;158(6):1390–405.
6. Medeiros MFT, Silva OS, Albuquerque UP. Quantification in ethnobotanical research: an overview of indices used from 1995 to 2009. Sitientibus Sér Ciências Biol. 2011;11(2):211–30.
7. de Albuquerque UP, Hurrell JA. Ethnobotany: one concept and many interpretations. In: Recent developments and case studies in ethnobotany. p. 87–99.
8. Phillips OL. Some quantitative methods for analyzing ethnobotanical knowledge: Advances in economic botany. In: Alexiades M, Sheldon JW, editors. Selected guidelines for ethnobotanical research: A field manual. New York: New York Botanical Garden Press; 1996. p. 171–97.
9. Martin GJ, Etnobotani SMK. The world wide fund for nature. 1995.
10. Heinrich M, Edwards S, Moerman DE, Leonti M. Ethnopharmacological field studies: a critical assessment of their conceptual basis and methods. J Ethnopharmacol. 2009;124(1):1–17.
11. Albuquerque UP. Quantitative ethnobotany or quantification in ethnobotany? Ethnobot Res Appl. 2009;7:001–3.
12. Hoffman B, Gallaher T. Importance indices in ethnobotany. Ethnobot Res Appl. 2007;5:201–18.
13. Fraser JA, Junqueira AB. How important is a use? Critical reflections on the conceptualization of use and importance in quantitative ethnobotany. In: Albuquerque UP, Hanazaki N, editors. Recent developments and case studies in ethnobotany. Recife: Brazilian Society of Ethnobiology and Ethnoecology (SBEE)/Publication Group of Ecology and Applied Ethnobotany (NUPEEA); 2010. p. 113–26.
14. Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC, McMillen H. Theories and major hypotheses in ethnobotany. Econ Bot. 2017;71:269–87.
15. Leonti M. The relevance of quantitative ethnobotanical indices for ethnopharmacology and ethnobotany. J Ethnopharmacol. 2022;288: 115008.
16. Prance GT, Baleé W, Boom BM, Carneiro RL. Quantitative ethnobotany and the case for conservation in Ammonia. Conserv Biol. 1987;1(4):296–310.
17. Turner NJ. "The importance of a rose": evaluating the cultural significance of plants in Thompson and Lillooet Interior Salish. Am Anthropol. 1988;90(2):272–90.
18. Ali-Shtayeh MS, Yaniv Z, Mahajna J. Ethnobotanical survey in the Palestinian area: a classification of the healing potential of medicinal plants. J Ethnopharmacol. 2000;73(1–2):221–32.

19. Phillips O, Gentry AH. The useful plants of Tambopata, Peru: I Statistical hypotheses tests with a new quantitative technique. *Econ Bot*. 1993;15-32
20. Kvist LP, Andersen MK, HESSELSØE M, Vanclay JK. Estimating use-values and relative importance of Amazonian flood plain trees and forests to local inhabitants. *Commonwealth For Rev*. 1995;293–300.
21. Kremen C, Raymond I, Lance K. An interdisciplinary tool for monitoring conservation impacts in Madagascar. Conserv Biol. 1998;12(3):549–63.
22. González-Tejero MR, Casares-Porcel M, Sánchez-Rojas CP, Ramiro-Gutiérrez JM, Molero-Mesa J, Pieroni A, ElJohrig S, et al. Medicinal plants in the Mediterranean area: synthesis of the results of the project Rubia. J Ethnopharmacol. 2008;116(2):341–57.
23. Tardío J, Pardo-de-Santayana M. Cultural importance indices: a comparative analysis based on the useful wild plants of southern Cantabria (Northern Spain). Econ Bot. 2008;62(1):24–39.
24. Sulaiman N, Verner V, Polesny Z. Socioeconomic dimensions of wild food plant use during the conflict in Syria. Econ Bot. 2023;77(3):267–81.
25. Sulaiman N, Pieroni A, Sõukand R, Polesny Z. Food behavior in emergency time: wild plant use for human nutrition during the conflict in Syria. Foods. 2022;11(2):177.
26. Sulaiman N, Zocchi DM, Borrello MT, Mattalia G, Antoniazzi L, Berlinghof SE, Bewick A, Häfliger I, Schembs M, Torri L, Pieroni A. Traditional knowledge evolution over half of a century: local herbal resources and their changes in the Upper Susa Valley of Northwest Italy. Plants. 2024;13(1):43. https://doi.org/10.3390/plants13010043.
27. Alrhmoun M, Sulaiman N, Pieroni A. Shifting herbal knowledge: the ecological and cultural dynamics behind plant use changes in the Southern Occitan Alps. Plants. 2025;14(3):367. https://doi.org/10.3390/plants14030367.

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