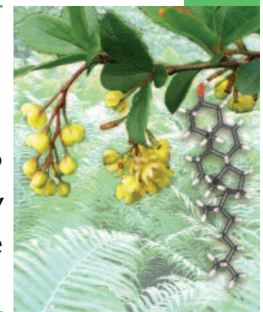
Nutra*foods* (2012) 12:73-81
DOI 10.1007/s13749-012-0032-0



Quantitative ethnobotany and traditional functional foods

A review

Marco Valussi, Antonella Silvia Scirè

Correspondence to:
Marco Valussi
marco@infoerbe.it

Keywords:
Relative Cultural Importance Indices, relational efficacy, ethnopharmacology, bitter, pungent

Received: 29 February / Accepted 7 March 2012
© Springer Healthcare – CEC Editore 2012

Abstract

The term functional foods is a modern one, but plants used interchangeably as foods and as medicines, or foods "good for your health" have been part of human heritage since prehistoric times. Defining functional foods in ethnobotanical terms helps to identify a cross-disciplinary, heuristic approach to this field of study, which addresses the issue of relevance of ethnobotanical and historical data for present-day concerns. The so-called ethnobotanical approach to bioprospecting has been said to be more efficient than the random one, in particular when used alongside a phylogenetic approach. This article critically reviews theoretical bases, strengths and weaknesses of the quantitative ethnobotanical method, and proposes its use for a cross-cultural comparison of plant remedies for gastrointestinal problems. These remedies show a very high prevalence in traditional pharmacopoeias, and a significant segregation in few taxa with very similar phytochemical content, and the use of the ethnobotanical filter to the field of functional foods apparently bypasses some of the more cogent critiques to this method.

Marco Valussi (✉), Antonella Silvia Scirè
marco@infoerbe.it

Introduction and objectives

Those foods loosely defined as "functional foods" – that is as plants consumed as foods but acting beyond their basic nutritional function as food by providing protection against or reducing the risk of chronic disease – are a fast growing sector of the market [1, 2]. Since the introduction of the term "physiologically functional foods" in 1984 by the Japanese Ministry of Education Science and Culture and the subsequent adoption in 1991 of the category "Foods for Specified Health Uses" (FOSHU) [3], many other portmanteau terms have been used to describe this complex and multifaceted grey area: *pharmafood*, *phytoceutical*, *phytonutrient*, *medicinal food*, *designer food*, etc. However, "functional food" remains the most commonly encountered term, at least in the generalist news media.

Although these terms have been around for perhaps 20 years, foods which are "good for your health" (defined here as those plants traditionally used both as foods and as medicines – *traditional functional foods* (TFFs)) have been around for much longer. Medical historians have stressed the fact that the distinction between medicines and food was blurred and at times non-existent in ancient and preliterate societies, and that it was only modern medicine that artificially constructed a defined *hiatus* between diet and therapy, food and medicine [4].

Since the 1970s, ethnobotanical literature has provided evidence that this blurring of boundaries is present in contemporary traditional societies and, although vanishing, even in industrialised societies [5, 6]. Many studies have shown that non-cultivated wild-gathered plants play an important role in the health benefits attributed to the Mediterranean diets, and in a study on local wild food plants, more than half of the vegetables were perceived by locals as also having medicinal properties [1, 7–13]. Ethnobotanists have pointed out that it would be more appropriate to talk about a *continuum* linking the opposite poles of medicines and foods in *traditional knowledge* (TK) [14–19]. Pieroni and Quave have come up with a way of mapping this *continuum*, describing three other categories beyond those of food and medicine [20]:

- *Plants used multi-functionally*, simultaneously as food and medicines, but without any relationship between the two uses [21].
- *Folk functional foods* are weedy species or foods eaten because they are healthy but with a general rather than unique and specific health action. Besides their main nutritional or enjoyment purposes they have other effects on body functions.
- *Food medicines/medicinal foods* are ingested in a food context but are assigned specific medicinal properties, or they are consumed in order to obtain a specific medicinal action.

There is an important difference between the definitions of "functional foods" derived from the industry and from nutritional and medical associations (which have a normative dimension, in that they dictate which characteristics a functional food should have), and those obtained from the study of local folk use of plants (which are descriptive in nature), and it is the aim of this paper to show what this difference is, why it matters and how this can contribute to the field of nutraceutical research. For a start, ethnobotanical definitions are not normative and static, reflecting only the *status quo*, but instead they are derived from the observation of dynamic processes by which people choose one plant as relevant, and hence can be used as a heuristic tool. Moreover, the ethnobotanical perspective puts the TFFs in relation to their use by people, helping to contextualise possible health effects they might have. Last but not least, while Western pharmaceutical companies are losing interest in ethnopharmacological bioprospecting, the results of research in the TFF area can be integrated and applied to the traditional populations who use those plants and who still bear the greater disease burden; and can inform us about the importance of those plants that are most at risk of disappearance through reduced species diversity.

Ethnobotanical methods in bioprospecting

It has been proposed that, since plants are natural laboratories able to synthesise complex secondary metabolites, screening of this natural pool of bioactive molecules should be a more efficient way of discovering new interesting drugs than screening synthetic chemicals. There are various methods of going about drug discovery using higher plants [22–25]:

- Random selection followed by chemical screening
- Random selection followed by one or more biologic assays
- Follow-up of biologic activity reports
- Taxonomic method
- Ethnobotanical method

Many authors have suggested that the ethnobotanical method is superior to the random one because of the assumption that traditional people do not rely on blind trial-and-error in their search for medicinal plants and that their choices depend in part on the chemical make-up of the plants, mediated by evolutionary and cultural mechanisms [22, 23]. This hypothesis seems supported by the fact that healers in traditional societies rely on a limited set of herbal resources and that these medicinal resources do exhibit a considerable patterning [25–28]; moreover, recent studies have shown that such a common pattern can also be seen when comparing medicinal Floras belonging to very distant regions and cultures [25, 29, 30]. Moerman and colleagues have applied a statistical treatment to the taxonomic data coming from five different Floras (using a linear regression model and residual analysis) and have shown a highly clustered scenario: Asteraceae, Lamiaceae and Apiaceae were the three most used families (as a mean value) in comparable yet distant Floras belonging to the Holarctic region, while Floras belonging to the Neotropical region showed different patterns of usage [25].

To explain this overlap the authors suggest both botanical and ethnological factors: firstly, Floras belonging to the one floristic area are related at family and genus level, and they share similar biochemistry, making it easier for humans to generate similar medicinal knowledge over broad geographic regions. Secondly, the authors propose that different migrating populations could have carried medicinal knowledge with them from the Paleolithic period onwards, adapting it when presented with very different Floras (as when migrating into Neotropical regions from the Holarctic one) [25].

Two more recent papers support the findings of Moerman and colleagues, but suggest that the common knowledge held by the migrating peoples should not be understood as a fixed knowledge but as a set of plant-selection criteria, depending not only on the composition of the flora but also on culture-specific, organoleptic, morphologic and ecological criteria [29, 30].

One of the hypotheses is that perceived effectiveness and people's experimentation and discovery of beneficial phytochemicals rely on the sensory perceptions of the environment (morphological features and organoleptic cues) and/or on more abstract forms of understanding (humoralism, Doctrine of Signature). Johns has proposed that taste, combined with cognitive and cultural mechanisms to overcome aversion to bad taste, allows humans to optimise the ingestion of biologically active compounds [15, 31]. The over-expression of certain taxa (i.e., Asteraceae) in medicinal Floras would thus reflect the abundance of bitter active compounds (usually from sesquiterpene lactones) in those plant species. However, these studies cannot by themselves rule out the role of symbolic, cultural and social factors.

Given this evidence, the ethnobotanical method appears to be a potentially very efficacious screening tool. Lewis et al. (cited by [32]) give a figure of a 30% success rate in discovering useful anti-HIV molecules for ethnomedically driven research that looked at anti-infective plants vs. a mere 8.5% for random methods. The hit rate went up to 71.4% when the ethnomedical method was used with anti-viral plants, and there are many more studies (eight reviewed in [23]) comparing the random approach to the ethnomedical one, showing varying, but always positive, degrees of success.

Critiques of the ethnobotanical method

Firn [24] and McClatchey [33], from different perspectives, challenge this conclusion, or, more precisely, its validity for translation from ethnopharmacology to biomedicine.

McClatchey emphasises the fact that the success in finding a higher percentage of plants with good *in vitro* activity does not automatically translate into a higher probability of producing a marketable drug, and that–despite these numbers–this ethnobotanical method has failed overall, since there have been no new drugs developed from ethnobotanical leads in the last 30 years [26, 33].

Firn gives some reasons for this apparent failure: Firstly this approach needs great expertise and suitable locations, and it is expensive and time-consuming. Secondly, the knowledge held by local communities is not necessarily relevant for industrialised countries (because of differences in disease prevalence, age structure, etc.) and hence for the pharmacological industry. Thirdly, pharmacological companies need single, highly specific and very active molecules, while, contrary to common understanding, evolution in plants has not favoured the capacity to produce few potent molecules. It has in

fact favoured the ability to generate and retain greater sustainable plasticity, that is, chemical diversity, even if that meant maintaining a very high percentage of molecules with no immediate use, and many with very low biological activity [24].
Moreover, traditional use of plant remedies is usually of crude, whole extracts, and it is doubtful whether a direct translation between traditional remedy use and single-molecule drugs can be justified.

Quantitative ethnopharmacology

The above-mentioned critiques notwithstanding, ethnobotanical methods do hold an important place in the exploration of medicinal plants and functional foods.
In order to make use of ethnobotanical data to support the use of plant extracts and TFFs, the use of quantitative methods is needed: a way of evaluating and comparing these data with a hypothesis-driven quantitative approach [34]. A model of such quantitative cross-cultural ethnopharmacology has been proposed in a seminal paper by Browner, de Montellano and Rubel for "combining the emic perspective of ethnomedicine with the etic measures of bioscience" and to examine "the degree to which empirical criteria confirm the probable efficacy of the ethnomedical use of plants based on a biomedical grounded understanding of human physiology in the context of the ethnomedical concepts of the cultural group" (see Table 1 for the original hierarchy of relevance proposed by the authors) [35]. While these methods are now proliferating, it is sobering to ponder on the difficulties in defining TK: it comprises many different dimensions and fields, making it difficult to encapsulate a universal definition with one method. Moreover, as Moerman has stated, plants are not pills in disguise, which means that the fact that a plant is effective in the local context is due both to the presence of an active phytochemical, and to the accompanying practices and beliefs [34].
Recent quantitative indices developed to be used in examining TK are the *Relative Cultural Importance Indices* (henceforth RCI) [36]: quantitative measures developed for measuring the cultural importance of useful plants, transforming that complex concept into standardised and comparable numerical scales or values, thus allowing different hypotheses to be tested.
There is a wide array of these indices (examined in detail in [36] and [37]), some of which, termed *Uses totalled/Research tally*, are very simple enumerating indices, simply listing uses and non-uses for each plant, without any attempt at measuring degrees of importance for different uses or statistical relevance, but easily adapted to secondary (literature) research [36]. Others, termed *Subjective allocation/Researcher score*, add to the previous indices a weighted score or rank, based on the researcher's evaluation and knowledge of the context, thereby allowing measures of degrees of importance but introducing researcher's bias and making it difficult to use in literature analysis (see Table 2) [36–38].
However, the most used and mentioned indices are the *Informant consensus* ones, based on the degree of agreement among the various interviewees/sources. They all share the theory of cultural consensus, that is the assumption that culture is the same for all informants and it is defined as the answer that most people give. Hence the reasonable assumption that the greater the salience of a given plant or use in the community, the more likely it is to be mentioned

Level 1:	Reports of parallel usage in populations among whom diffusion is unlikely
Level 2:	Level 1 evidence plus phytochemical analyses verifying presence of active phytochemicals that can produce an effect or in vitro bioassay suggesting therapeutic effect
Level 3:	Level 2 evidence plus plausible mode of action which would likely produce a therapeutic effect in a living patient
Level 4:	Level 3 evidence plus clinical studies

Table 1 Hierarchy of relevance of data on medicinal plants [35]

Use value
Index of Cultural Significance
Cultural Significance Index
Cultural Food Significance Index

Table 2 Subjective allocation/researcher score

Corrected fidelity level/rank order priority
Use values
Overall use value (and plant value)
Cultural practical and economic value
Cultural importance index
Informant consensus factor/informant agreement ratio

Table 3 Informant consensus [28, 34, 37, 39, 40]

[39]. Each plant citation is recorded separately and referred to as an "event" and the same plant and the same informant may participate in many "events". These procedures share the assumption that measuring the extension of knowledge of a plant in a culture gives us an indirect measure of the perceived cultural importance of that plant, and a more objective one than those derived from *Subjective allocation* [36] (see Table 3).

The *Informant Agreement Ratio* has been applied by Grace and colleagues to a systematic analysis of the literature to evaluate the utility and bicultural value of a single genus (*Aloe*) [40].

A recent paper cites a different technique, called *Relative Importance*, developed as a mean between the number of pharmacological properties and the number of body systems it affects, which has been used for measuring the usefulness of medicinal plants [41]. It too can be used with secondary data since the results are influenced by use categories.

A few authors [31, 34, 37] have embarked on an evaluation of the different indices to see whether they give comparable results and have obtained a general agreement. One paper concludes that although there seemed to be a weak correlation between the indices of ecological knowledge, they all reflect an underlying construct, TK, which is multidimensional, a feature that suggests that researchers need to select the right method for the dimension to be studied [34].

In another paper the author combines the use of these indices (in this case the informant consensus model) with an *intercultural consensus model*, and with evidence of biological activity in an attempt to assess the intra- and intercultural level of agreement about which plants are valued for medicinal use. She concludes that for the eight most frequently mentioned medicinal plants all data converge to support the likely efficacy [42].

Critiques of the Cultural Importance Indices

Not all authors agree about the relevance of RCI: some point out discrepancies between data obtained with different methods [34], or between active knowledge (which plants people use) and passive knowledge (what people know about a plant's use) [37]. Others point out that the correlation between knowledge and consensus might not be simple and linear, that it might depend on whether we study medicinal plants or crop plants, on who we decide to interview as an informant (healer, children, men, women, etc.) and on the difference between shared knowledge and idiosyncratic knowledge [13, 31].

Casagrande also questions the assumption that the plants used most frequently are those perceived as more efficacious, hence the correlation between RCI and emic efficacy [43]. The results of his study show, for instance, that the first plants to be used in case of illnesses are the most accessible ones and that the more efficacious ones are used only in the case of failure to solve the problems. Since symptoms can abate on their own, efficacious plants are less likely to be used. This is not to say, according to Casagrande, that plants used by people are not efficacious, but that patterns of distribution of knowledge do not represent an optimal fit between illness-based needs and all the available phytochemicals.

Relational efficacy

A further evolution of the use of quantitative methods has been proposed by Bletter. The author puts forward a model of enquiry, called relational efficacy technique, that combines the intra- and intercultural indices of consensus (as done by [42]) with taxonomic and phytochemical data, in a sort of triangulation that compares medicinal Floras and uses among distant cultures, to give further support to the ethnobotanical data [32]. The author starts with an assumption: the less related the cultures studied, the less the chance that these two cultures shared plant knowledge; hence closely related plants used in different cultures to treat the same disease are more likely to have been discovered independently and should be assumed to have a higher potential to be used for the disease. The evidence would be strongest when there was no evidence of communication, human groups were culturally and geographically distant, plants were used in both communities for a long time and were all native, the two Floras shared at least some elements at genera or family level, and the diseases were related via common underlying causes, mechanisms or aetiopathogenesis [32]. The use of taxonomic tools would help to highlight any non-random clustering that could then be correlated with ethnobotanical data; any evidence for a common phytochemical profile of the plants used would provide stronger support for the independent, biologic based selection of plants. If the phytochemical profile could be matched (with *in vitro* or *in vivo* studies) with the pathological mechanisms of the illnesses studied, we would have very strong evidence for a naturalistic choice of plant remedies [32].

The authors explain that the statistical tool developed by Moerman et al. [25] can only give binary measure (belonging/not-belonging to a given taxon), and deals with taxa, which do not circumscribe consistent degrees of proximity at the same rank. To overcome these limitations they propose phylogenetic analysis as a solution [32].

Phylogenetic analysis deals with evolutionary-based hierarchies and not with artificial ones, and its use in this field is based on the hypothesis of phylogenetic conservatism in medicinal properties. In a very recent paper it is, for instance, observed that of the 300 species of the family *Plectranthus*, 62 are used medicinally, and most of these species were found within the same large phylogenetic clade [26]. Similar results were obtained for the medicinal flora of South Africa, and again for the medicinal species belonging to the *Narcissus* and *Pterocarpus* families. One study moreover shows that two types of alkaloids in *Narcissus* medicinal species are phylogenetically constrained and the phylogeny of *Narcissus* can be used to predict the presence of active alkaloids in non-investigated species [44]. Hence it is proposed that phylogenetic analysis can be used to isolate phylogenetic nodes that have a high potential for bioscreening; or to prioritize for screening close relatives of species with known bioactivity; or, in the absence of pharmacological data, plants with similar ethnomedical properties [26].

Digestive traditional functional foods

Plants used as digestion-enhancing remedies (digestive, appetite stimulants, anti-dyspeptics, carminative, antispasmodics) are widespread, and they constitute a good example of a subject matter where ethnobotanical research methods could be tested, in particular in relation to the significance of taste. In a comparison between indigenous and biomedical Pharmacopoeias cited by Balick and Cox, summarising data referring to 15 different geographical areas, it was shown that "indigenous plant remedies are focused more on gastrointestinal disorders than Western Pharmacopoeias"; in fact the main indication for plant-based remedies were gastrointestinal disturbances (accounting for 15% of the total, equal only to dermatological complaints) [45]. These data are confirmed by more recent research both for medicinal plants ([27] and references therein) and for TFFs [5].

When looking at these remedies, the main data that emerges is the predominance of some taxa and of some chemical groups. As has been observed for generic medicinal plants, even in this case the most cited families are Asteraceae (*Matricaria*, *Sonchus* and *Artemisia*), Lamiaceae (*Mentha* and *Ocimum*) and Apiaceae, but in certain studies Zingiberaceae, Chenopodiaceae, Piperaceae and Rutaceae (dominated by *Citrus* spp.) are also cited often. Other taxa mentioned, but at much lower frequencies, were Fabaceae, Euphorbiaceae and Rosaceae,

all families with a potentially toxic chemical profile, containing irritant latex, toxic lectins and cyanide-producing molecules, often characterised by a strong bitter taste [20, 27–29].
These taxa very often contain bitter, aromatic and pungent compounds, with strong salience and a long history of use throughout the world and since ancient times for gastrointestinal ailments (bitter and spices).

Conclusions: an ethnobotanical approach to digestive functional foods

The author proposes to adapt the ethnobotanical approach described in [32] to the study of TFFs with digestive activities, on the assumption that such an adaptation would bypass some of the limits described above for classic, pharmacological bioprospecting. Specifically: (1) Although it seems true that knowledge held by local communities is not necessarily relevant for the health needs of people in affluent countries, functional digestive disturbances are in fact quite common both in local communities and in industrialised countries, and as such local knowledge on these ailments would be relevant. (2) Pharmacological companies need single molecules with high specificity and great power of action to develop innovative drugs. However, if the objective is to develop and market foods with health effects, the focus will not be in single, specific and very potent molecules; to the contrary, the absence of highly active (hence possibly toxic at a certain dosage) molecules is a prerequisite of functional foods, which are said to be active because of a constellation of non-toxic molecules. (3) It has been rightly stated that it is doubtful whether a direct translation between traditional remedy use and single-molecule drugs can be justified; however, in studying TFFs with the purpose of developing foods with health effects, the translation would not be between a complex and dynamic biochemical entity and a single-molecule drug, but between very similar objects: a food-medicine plant and a healthy food-product.
The author also believes that digestive TFFs offer a very interesting test-piece, because of the predominance in these plants of tastant molecules (bitter, pungent, aromatic, astringent). This characteristic lends itself to the exploration of the overlap between cultural salience and digestive bioactivity of these molecules [46].
The author is well aware that the role of tastant molecules is likely very complex; that it cannot be reduced to a simple, linear adaptive response to a dangerous chemical environment; that, as Shepard argues, sensations should be understood as bio-cultural phenomena rooted in human physiology but also constructed through individual experiences and culture [47]; and that taste–together with other features like shape and colour–likely plays a mnemonic and prototypical role and not simply a chemical-ecological one [7, 43]. However, recent discoveries relative to bitter and pungent receptors in the gut seem to give a rationale for the use of bitter and pungent plants in gastrointestinal disorders [46]. While it has been pointed out that bitter receptors are not selective enough to discriminate between different chemical groups responsible for eliciting bitter responses, and hence that bitterness (and, *mutatis mutandis*, probably pungency and aromatic properties) are an inadequate predictor of digestive activities [43], it seems that some of the physiological modifications of the GIT state (motility and secretions) after the ingestion of bitter or pungent compounds are mediated by the interaction with the receptors themselves. That is, the physiological response is to the bitter compound as bitter-receptor-binding molecule, irrespective of its chemical make-up. Hence the gastrointestinal tract seems to respond to these molecules as a group and not as single specific molecules. If this is true then a role for organoleptic compounds can be salvaged.
Furthermore, it might be worthwhile considering using this approach for literature sources. Although clearly limited in depth and detail, this approach could allow a quicker, cheaper and wider analysis of the data, which could then be used to identify

promising leads that could be further studied through direct ethnobotanical investigation and preliminary clinical observations.

References

1. Nebel S, Pieroni A, Heinrich M (2006) Ta chorta: wild edible greens used in the Graecanic area Ta cho in Calabria, Southern Italy. Appetite 47:333–342
2. Health Canada (1998) Nutraceuticals/functional foods and health claims on foods: policy paper. http://www.hc-sc.gc.ca/fn-an/label-etiquet/claims-reclam/nutra-funct_foods-nutra-fonct_aliment-eng.php#1. Accessed 15 February 2012
3. Dai Y, Luo X (1996) Functional food in China. Nutr Rev 54:S21–23
4. Etkin NL (2006) Edible medicines: an ethnopharmacology of food. Arizona University Press, Tucson, AZ, p 207
5. Rivera D, Obon C (1993) Plant food as medicine in Mediterranean Spain. Actes du 2e Colloque Européen d'Ethnophannacologie et de la 1 le Conference internationale d'Ethnomédecine, Heidelberg, 24–27
6. Sandhu DS, Heinrich M (2005) The use of health foods, spices and other botanicals in the Sikh community in London. Phytother Res 19:633–642
7. Pieroni A, Nebel S, Quave C et al (2002) Ethnopharmacology of liakra: traditional weedy vegetables of the Arbereshe of the Vulture area in southern Italy. J Ethnopharmacol 81:165–185
8. Bonet MA, Vallés J (2002) Use of non-crop food vascular plants in Montseny biosphere reserve (Catalonia, Iberian Peninsula). Int J Food Sci Nutr 53:225–248
9. Rivera D, Obon C, Inocencio C et al (2005) The ethnobotanical study of local mediterranean food plants as medicinal resources in Southern Spain. J Physiol Pharmacol 56[Suppl]:97–114
10. Tardío J, Pascual H, Morales R (2005) Wild food plants traditionally used in the province of Madrid, Central Spain. Econ Bot 59:122–136
11. Tardío J, Pardo-de-Santayana M, Morales R (2006) Ethnobotanical review of edible plants in Spain. Bot J Linn Soc 152:27–71
12. The Local Food-Nutraceuticals Consortium (2005) Understanding local Mediterranean diets: a multidisciplinary pharmacological and ethnobotanical approach. Pharmacol Res 52:353–366
13. Pieroni A, Houlihan L, Ansari N et al (2007) Medicinal perceptions of vegetables traditionally consumed by South-Asian migrants living in Bradford, Northern England. J Ethnopharmacol 113:100–110
14. Etkin NL, Ross PJ (1982) Food as medicine and medicine as food: an adaptive framework for the interpretation of plant utilisation among the Hausa of northern Nigeria. Soc Sci Med 16:1559–1573
15. Johns T (1990) With bitter herbs they shall eat it. University of Arizona Press, Tucson
16. Grivetti LE, Ogle BM (2000) Value of traditional foods in meeting macro and micronutrients needs: the wild plant connection. Nutr Res Rev 13:31–46
17. Ogle BM, Grivetti LE (1985) Legacy of the chameleon: edible wild plants in the kingdom of Swaziland, southern Africa. A cultural, ecological, nutritional study. Part I: Introduction, objectives, methods, Swazi culture, landscape and diet. Ecol Food Nutr 16:193–208
18. Ogle BM, Grivetti LE (1985) Legacy of the chameleon: Edible wild plants in the kingdom of Swaziland, southern Africa. A cultural, ecological, nutritional study. Part II: Demographics, species, availability and dietary use, analysis by ecological zone. Ecol Food Nutr 17:1–30
19. Ogle BM, Grivetti LE (1985) Legacy of the chameleon: edible wild plants in the kingdom of Swaziland, southern Africa. A cultural, ecological, nutritional study. Part IV: Nutritional values and conclusions. Ecol Food Nutr 17:41–64
20. Pieroni A, Quave C (2006) Functional foods or food medicines? On the consumption of wild plants among Albanians and Southern Italians in Lucania. In: Pieroni A, Leimar Price L (eds) Eating and healing. Haworth Press
21. Preuss A (1999) Characterisation of functional food. Dtsch Lebensm-Rundsch 95:468–472
22. Fabricant DS, Farnsworth NR (2001) The value of plants used in traditional medicine for drug discovery. Environ Health Perspect 109[Suppl 1]:69–75
23. Oliveira DR, Leitao GG, Coelho TS et al (2011) Ethnopharmacological versus random plant selection methods for the evaluation of the antimycobacterial activity. Rev Bras Farmacogn 21:793–806
24. Firn RD (2003) Bioprospecting: why is it so unrewarding? Biodivers Conserv 12:207–216
25. Moerman DE, Pemberton RW, Kiefer D, Berlin B (1999) A comparative analysis of five medicinal floras. J Ethnobiol 19:49–67
26. Saslis-Lagoudakis CH, Klitgaard BB, Forest F et al (2011) The use of phylogeny to interpret cross-cultural patterns in plant use and guide medicinal plant discovery: an example from Pterocarpus (Leguminosae). PLoSONE 6:e22275
27. Molares S, Ladio A (2009) Chemosensory perception and medicinal plants for digestive ailments in a Mapuche community in NW Patagonia, Argentina. J Ethnopharmacol 123:397–406
28. Pardo-de-Santayana M, Tardío J, Blanco E et al (2007) Traditional knowledge of wild edible plants used in the northwest of the Iberian Peninsula (Spain and Portugal): a comparative study. J Ethnobiol Ethnomed 3:27
29. Leonti M, Ramirez FR, Sticher O, Heinrich M (2003) Medicinal Flora of the Popoluca, Mexico: a botanical systematical perspective. Econ Bot 57:218–230

30. Treyvaud Amiguet V, Thor Arnason J, Maquin P et al (2006) A regression analysis of Q'eqchi' Maya medicinal plants from Souther Belize. Econ Bot 60:24–38
31. Vandebroek I (2010) The dual intracultural and intercultural relationship between medicinal plant knowledge and consensus. Econ Bot 20:1–15
32. Bletter N (2007) A quantitative synthesis of the medicinal ethnobotany of the Malinké of Mali and the Asháninka of Peru, with a new theoretical framework. J Ethnobiol Ethnomed 3:36
33. McClatchey W (2005) Medicinal bioprospecting and ethnobotany research. Ethnobot Res Appl 3:189–190
34. Reyes-Garcia V, Vadez V, Tanner S et al (2006) Evaluating indices of traditional ecological knowledge: a methodological contribution. J Ethnobiol Ethnomed 6:32
35. Browner CH, Ortiz de Montellano BR, Rubel AJ (1988) A methodology for cross-cultural ethnomedical research. Curr Anthr 29:681–702
36. Hoffman B, Gallaher T (2007) Importance indices in ethnobotany. Ethnobot Res Appl 5:201–218
37. Tardio J, Pardo-de-Santayana M (2008) Cultural importance indices: a comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain). Econ Bot 62:24–39
38. Garibay-Orijel R, Caballero J, Estrada-Torres A, Cifuentes J (2007) Understanding cultural significance, the edible mushrooms case. J Ethnobiol Ethnomed 3:4
39. Reyes-Garcia V (2010) The relevance of traditional knowledge systems for ethnopharmcological research: theoretical and methodological contributions. J Ethnobiol Ethnomed 6:32
40. Grace OM, Simmonds MSJ, Smith GF, van Wyk AE (2009) Documented utility and biocultural value of Aloe L. (Asphodelaceae): a review. Econ Bot 63:167–178
41. Albuquerque UP, Lucena RFP, Monteiro JM et al (2006) Evaluating two quantitative ethnobotanical techniques. Ethnobot Res Appl 4:51–60
42. Johnson LM (2006) Gitksan medicinal plants-cultural choice and efficacy. J Ethnobiol Ethnomed 2:29
43. Casagrande DG (2000) Human taste and cognition in Tzeltal Maya medicinal plant use. J Ecol Anthr 4:57–69
44. Ronsted N, Savolainen V, Molgaard P, Jager AK (2008) Phylogenetic selection of Narcissus species for drug discovery. Biochem Syst Ecol 36:417–422
45. Balick M, Cox L (1996) Plants, people, and culture: the science of ethnobotany. Scientific American Library, New York
46. Valussi M (2011) Functional food with digestion-enhancing properties. Int J Food Sci Nutr 63[Suppl 1]:82–89
47. Shepard GH (2004) A sensory ecology of medicinal plant therapy in two Amazonian societies. Am Anthropol 106:252–266

AUTHOR QUERIES

- The meaning of the final sentence of the **Abstract** ("These remedies show…") is a little unclear. Please rewrite if possible.
- Please provide affiliations for the authors and a postal address for the corresponding author.
- In the fourth paragraph, the sentence beginning 'Moreover, the ethnobotanical…' has been changed. Please check the meaning.
- In the second paragraph of *Quantitative ethnopharmacology*, is the ref. no. [34] correct?
- Please provide the publisher location for ref. 20.