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1. Medicinal and food plants in ethnobotany and ethnopharmacology: Folk functional foods in Catalonia (Iberian Peninsula)

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Abstract. Ethnobotanical studies have focused with particular intensity -especially in industrialized countries- on food and medicinal plant properties and management claimed by informants. Nevertheless, the uses on the interface between both areas have not been addressed to the same proportion, although they have a very important place both in ethnological and in health issues. We present in this paper the results of ethnobotanical prospections carried out in Catalonia regarding folk functional foods and nutraceuticals. A total amount of 1,888 use reports from 195 taxa, belonging to 64 botanical families, corresponding to this category have been collected and analyzed. The most quoted taxa are *Thymus vulgaris*, *Allium sativum*, *Ruta chalepensis* and *Sambucus nigra*, the most cited families are Lamiaceae, Rosaceae, Rutaceae, Amaryllidaceae, Asteraceae and Apiaceae. Aerial parts of the plants are by an ample margin the most used, and alcoholic

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beverages are the most common way of preparation of the products, closely followed by the direct ingestion of raw materials. The results obtained in ethnobotanical prospections related to the folk functional food (FFF) concept are numerous and robust enough to appear as promising for new commercial nutraceutical products development.

Introduction

Ethnobotanical and ethnopharmacological studies are very abundant all over the World, including not only developing areas, a priori richer in folk knowledge about biodiversity and its management, but in industrialized areas such as North America and Western Europe as well. In these investigations, food and medicinal information occupies a preeminent place in the ranking of popular uses, usually being the two first ones, whereas other plant uses, such as, to give two examples, artisanal or dyeing ones, are less commonly preserved, particularly in developed regions [1, 2, and references therein]. The interface of those two more relevant uses is particularly attractive, although it has scarce attention in ethnobotany. In the present paper we contribute data on folk functional foods or nutraceuticals in Catalonia (NE Iberian Peninsula) coming from ethnobotanical prospections carried out in this area.

1. Ethnobotany and ethnopharmacology

Ethnobotany, a term coined in 1895 and published the following year [3], is a multiapproach discipline placed on the interface of human and natural sciences [4], which deals with plant knowledge, use and management by human groups. It is a branch of ethnobiology, together with ethnozoology, ethnoecology or ethnomycology (the latter dealing with folk knowledge on fungi, and most frequently merged with ethnobotany). On the one hand, it belongs to the domains of economic botany (together with industrial botany, for instance) and ethnosciences (at the same level as popular chemistry in cooking, as an example). On the other hand, the ethnobotanical corpus of popular wisdom is an important part of the traditional ecological knowledge [5]. Finally, it has a non-negligible component of citizen science, since people are at the basis of research, although, logically, conducted by scientists, and has relevant issues linked both to primary and secondary education [2, 6, 7]. Ethnobotanical data linked to aspects of health (mostly medicine, but also food in many respects) are included in the field of medical or

pharmaceutical ethnobotany, which has a close and intimate relationship with ethnopharmacology, a term coined in 1967, sharing some aspects with pharmacognosy and phytotherapy [2]. Ethnopharmacology shows a larger reach than pharmaceutical ethnobotany, since it comprises not only knowledge on plants and fungi, but on animals and on mineral products as well, and it addresses also pharmacological issues. Ethnobotany in general, has, in its turn, a larger scope than ethnopharmacology, dealing not only with medicinal and associate uses, but with any popular knowledge on plants. In any case, both disciplines share a significant part of aims, methods, results and their derivatives. Pharmaceutical ethnobotanical and ethnopharmacological approaches have been considered as forming a platform for new drug design and development [8]. In this respect, one of the recipients of 2016's Nobel Prize for Medicine or Physiology was recognized for her development of antimalarial plants from traditional Chinese medicine ethnobotanical evidence [9]. The medicinal uses of food plants, and the leads they can achieve and generate, clearly fall within this common area of ethnobotany and ethnopharmacology.

2. Functional foods, nutraceuticals and their popular knowledge and management

The borders between the concepts of food and medicine have always been diffuse. Already Hippocrates (5th and 4th centuries BC) stated that food can be medicine and medicine can be food for human beings [10]. Consistently with this idea, the concept of nutraceutical (also spelled nutriceutical) arose in 1979 to define foods providing health benefits, both for preventing or treating diseases [11, 12]. Other terms, such as medicinal food or pharmafood or functional food (the latter, appearing in 1993 [13], quite extended) have also been used as synonyms or quasi-synonyms of nutraceuticals to indicate any kind of food with physiological functional properties in the human organism [14]. Commercially and according to health products legislation (and, again, in some cases with no total coincidence in the concept but, in any case, quite related), the term 'nutritional supplement' alludes to foods or food derivatives with these properties as well. Probably one of the oldest-dated and most popular commercialized functional food or nutraceutical product is milk with added omega-3 and omega-6 acids (those coming from salmonids and related cold-water fishes), having protective properties against cardiovascular troubles and hypercholesterolemia [15]. Quite recently, the term 'superfood' was coined to mean "a food (such as salmon, broccoli, or

blueberries) that is rich in compounds (such as antioxidants, fiber, or fatty acids) considered beneficial to a person's health" (Merriam-Webster dictionary, <http://www.merriam-webster.com/dictionary/superfood>, accessed October 10, 2016). Irrespective of legal and trade considerations, this term has a very similar sense to the nutraceuticals' concept. All these terms and the high number of food products put on the market with direct or indirect allusions to medicinal properties account for the relevance of this concept that make the link between nutrition and medicine [11]. Independent of logical pros and cons [16], a large experience exists of marketing such products, either as drugs or -more frequently because it is easier or cheaper due to legal dispositions-, as food supplements [17].

Despite the concept of nutraceutical (and the above-mentioned associated terms) having been early addressed by ethnobiologists [14, 18] and a compilation of health foods existing [19], research on plant-based nutraceuticals with ethnobotanical approaches is still scarce. Nevertheless, apart from seminal Etkin's works [14, 18], several authors have addressed this question in Mediterranean territories [20, 21] as well as in North America

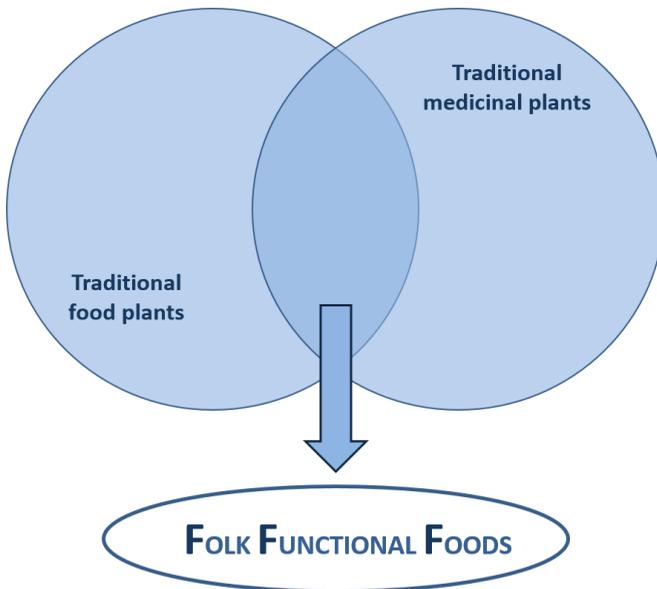


Figure 1. Folk functional foods and their relationships with traditionally-used medicinal and food plants.

[22, 23]. According to these and other examples, as well as our own data from previous ethnobotanical prospections in Catalan-language territories, we proposed the term ‘folk functional food’ (hereafter FFF) to name the concept of popular medicinal knowledge and use of food plants [24] (Fig. 1). This concept was less restrictive than the same one used by Pieroni & Quave [25], who distinguished three levels in medicinal uses of food plants and reserved FFF for taxa eaten because they are healthy in general terms. We believe that this concept is basically equivalent to the term ‘salutiferous’ and that the idea of FFF encompasses more uses than this one (Fig. 1). Later, the term ‘traditional functional food’ was coined [26] with the same sense as our FFF. In this paper, FFF will be specifically addressed in depth on the basis of our data from ethnobotanical prospections in several regions of Catalonia.

3. Methodology

The area considered is constituted by Catalonia, located in the northeastern Iberian Peninsula. The territories where ethnobotanical studies have been performed, going from sea level to high mountain, are shown in Fig. 2.

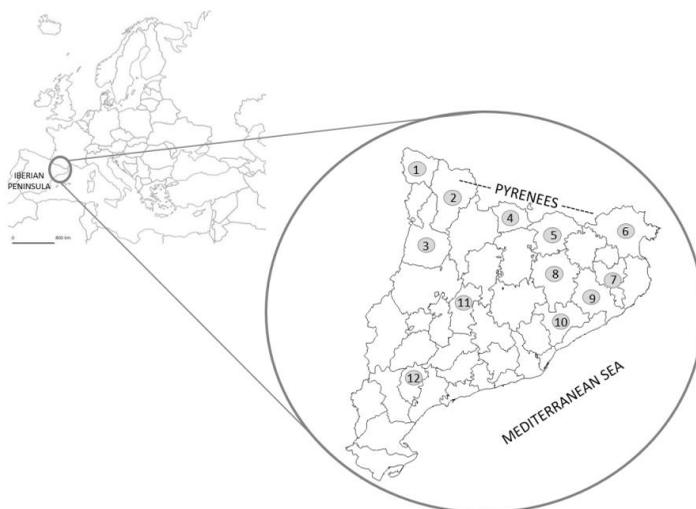


Figure 2. Studied areas: Vall d’Aran (1), Pallars (Pallars Sobirà, 2; Pallars Jussà, 3), Cerdanya (4), Ripollès (5), Alt Empordà (6), Gironès (7), Guileries (8, 9), Gallecs (10), Vall del Tenes (10), Montseny (8, 9, 10), Segarra (11), Ulldemolins (12).

The ethnobotanical research was carried out between 1987 and 2016, not at the same time in all the regions, but overlapping in many of them. The informants were selected in each area starting with some of them known by the interviewers (in each studied region at least one interviewer was closely linked to the territory concerned) and then according to a snowball model [27]. Most informants were middle-aged to elderly people, who were born in the studied area or have lived there a very significant part of their lives, and a large number of them have primary studies and professions linked to agricultural and cattle raising activities.

The basic survey method was the semistructured interview [28], consisting of general, but subject-oriented conversations, after prior informed consent from the interviewees. Interviews were developed avoiding asking direct questions, which could influence, direct or bias the informants' responses. The interviews were developed in the Catalan language, except in Vall d'Aran, where they were carried out in the Occitan language (locally called Aranese); in all cases the language was common to interviewers and interviewees.

All plants quoted in each territory were collected and identified using the *Flora manual dels Països Catalans* [29]. For botanical families, Angiosperm Phylogeny Group criteria were used ([30], <http://www.mobot.org/MOBOT/research/APweb>, accessed October 10, 2016). A voucher for each taxon in each territory was prepared and deposited at the herbarium BCN, of the *Centre de Documentació de Biodiversitat Vegetal, Universitat de Barcelona*.

Once finished, the interviews were transcribed and the results entered to our research team's database. Analyses performed consisted of descriptive statistics (percentages, mean, standard deviations, ranges) for botanical variables (species, families, part used and mode of preparation). Indexes accounting for the consistency and reliability of the data collected have been calculated: percentage of taxa and uses quoted by at least three independent informants [31, 32] and the informant consensus factor (F_{IC} [33]; number of use reports minus number of taxa divided by number of use reports minus 1).

4. Results and discussion

Use reports, data reliability, taxa, and families

A total of 1,888 use reports (hereafter UR) were collected for 195 taxa belonging to 64 botanical families. The results obtained show a high

consistency and reliability. On the one hand, a total of 79 taxa, representing a 40.51%, have at least one use (and in some cases, more than one) quoted by three or more independent informants, which is a criterion for reliability of ethnobotanical data [31, 32]. On the other hand, the F_{IC} , accounting for the consistency (and non-dispersion) of the information reported by the informants, is very high (0.90, out of a maximum of 1.00), suggesting a solid corpus of popular knowledge on FFF and a high relevance of such uses in the territories studied. The high values of these indexes concerning this use category (FFF) agree with the results obtained, in the same cultural and geographical area, in other use categories (medicinal, food, and other uses) [34, and references therein].

Apart from the species level, the 195 taxa include 23 subspecies and five varieties, and four entities have only been determined to the generic level. All taxa but two fungal species belong to plants, with no representative of algae and bryophytes, and only one of pteridophytes. The 18 most quoted species, roughly representing half of the UR (50.05%), are listed in Table 1. Eleven out of these 18 top taxa are included in the “Dictionary of Nutraceutical and Functional Foods” [35]. This means, on the one hand, that a significant number of the plants most used as FFF in Catalonia is consistent with the state-of-art of the subject at global level. On the other hand, this also means that a not less relevant number of such taxa have not (or have only scarcely) been considered to date as functional foods (at least at global and commercial levels), but do have their properties, claimed at popular level, so that they could constitute a good target for further research focused on new nutraceutical product development.

Thymus vulgaris occupies a preeminent first position in this ranking, followed by *Allium sativum*, *Ruta chalepensis* and *Sambucus nigra*. The first and fourth of these taxa are always among the top ones in pharmaceutical ethnobotanical studies in the area considered and, in general, in the Mediterranean region [24, and references therein]. In addition, the soup prepared with *Thymus vulgaris* is a very typical dish of traditional (and now even gastronomic) cuisine [36]. The other two taxa, although being relevant in such studies, are not in the very first places. This may be due to the fact that both taxa are specifically considered as FFF: *Allium sativum*, the only species quoted as FFF in the 12 areas prospected, is frequently consumed as food and medicine at the same time, and *Ruta chalepensis* is particularly used, in very small amounts, to flavor drinking chocolate and to give medicinal properties to this food.

Table 1. Plant taxa most quoted as folk functional foods in the territories considered. AE: Alt Empordà, CE: Cerdanya, GA: Gallecs, GI: Gironès, GU: Guillerries, MO: Montseny, PA: Pallars, RI: Ripollès, SE: Segarra, UL: Ulldemolins, VA: Vall d'Aran VT: Vall del Tenes. Asterisk (*) after the scientific name indicates the reference of the taxon in the “Dictionary of Nutraceuticals and Functional Foods” [35].

| Taxon (herbarium voucher) | Vernacular Catalan (and Occitan-Aranese, when reported) names | Use reports | Medicinal uses | Territories |
|--|---|-------------|--|--|
| <i>Thymus vulgaris</i> L.* (BCN 25023) | farigola, timó (timonet) | 116 | Anticephalalgic. Antidysmenorrhoeal. Digestive. Gastrointestinal antiseptic and anti-inflammatory. Tonic, reinforcing, vitamin | AE, CE, GA, GI, GU, MO, PA, RI |
| <i>Allium sativum</i> L.* (BCN 24708) | all (alh) | 90 | Antialgic. Antihelmintic. Antihypertensive. Antirheumatic. Cardiotonic. Digestive. Hematocathartic. Hipolypemiant. Internal antiseptic. Resolutive. Salutiferous. Vasotonic | AE, CE, GA, GI, GU, MO, PA, RI, SE, UL, VA, VT |
| <i>Ruta chalepensis</i> L. (BCN 24980) | ruda | 77 | Antidiarrhoeal. Antidysmenorrhoeal, Antihelmintic. Anti-nauseous. Digestive. Gastrointestinal antiseptic and anti-inflammatory. Labour and post-labour coadjuvant. Sedative. Tranquillizer | AE, CE, GI, GU, MO, PA, RI |
| <i>Sambucus nigra</i> L. (BCN 24984) | bonarbre, saüc (saüquèr) | 77 | Antidysmenorrhoeal. Digestive. Gastrointestinal antiseptic and anti-inflammatory. Refreshing | AE, CE, GI, GU, MO, RI |
| <i>Mentha spicata</i> L.* (BCN 24930) | herba-sana, menta (menta) | 68 | Antidysmenorrhoeal, Antihelmintic. Anti-nauseous. Digestive. Gastrointestinal antiseptic and anti-inflammatory. Refreshing | AE, CE, GA, GI, MO, RI |
| <i>Citrus limon</i> (L.) Burm.* (BCN 27241) | llimoner (limon) | 58 | Anticatarral. Antidiarrhoeal. Antidysmenorrhoeal. Antihypertensive. Digestive. Gastrointestinal antiseptic and anti-inflammatory. Hematocathartic. Internal antiseptic | AE, CE, GA, GI, GU, MO, PA, RI, SE, VA, VT |

Table 1. Continued

| | | | | |
|---|--|----|---|------------------------------------|
| <i>Hyssopus officinalis</i> L. (BCN 24906) | hisop | 56 | Antidiarrhoeal. Antidysmenorrhoeal. Antinauseous. Digestive. Gastrointestinal antiseptic and anti-inflammatory. Labour and post-labour coadjuvant | CE, GU, MO, PA, |
| <i>Rosa canina</i> L. (BCN 20772) | gavarrera, roser de pastor (garrauèr) | 56 | Digestive. For child weakness (<i>enaiguament</i>). Tonic, reinforcing, vitamin | CE, GU, VA |
| <i>Cydonia oblonga</i> Mill. (BCN 24758) | codonyer (codonhèr) | 52 | Antidiarrhoeal. Digestive. Gastrointestinal antiseptic and anti-inflammatory. Refreshing | AE, CE, GA, GI, MO, PA, RI |
| <i>Gentiana lutea</i> L. (BCN 24893) | gençana, genciana (jançana) | 46 | Antianorectic, aperitive. Hematocathartic. Tonic, reinforcing, vitamin | CE, RI, VA |
| <i>Oryza sativa</i> L.* (BCN-Etno 16) | arròs | 38 | Antidiarrhoeal | AE, CE, GA, PA, RI, SE |
| <i>Allium cepa</i> L.* (BCN 27279) | ceba (ceba) | 35 | Cardiotonic. Diuretic. Hematocathartic. Laxative | AE, CE, GA, GU, MO, PA, RI, SE, VA |
| <i>Taraxacum officinale</i> Weber in Wiggers* (BCN 25015) | pixallits, xicoina (chicòia) | 34 | Antianorectic, aperitive. Antipelochemic. Hematocathartic | AE, CE, GI, MO, PA, RI, VA |
| <i>Juniperus communis</i> L.* (BCN 24910) | ginebre, ginebró (gimbros) | 30 | Digestive. For child weakness (<i>enaiguament</i>). Salutiferous | AE, CE, GU, MO, RI |
| <i>Daucus carota</i> L.* (BCN 46847) | carrota, pastanaga, safranòria (carròta) | 28 | Antidiarrhoeal. Visual restaurative | AE, CE, GA, MO, PA, RI, VT |
| <i>Juglans regia</i> L.* (BCN 24908) | noguer, noguera (escarèr) | 28 | Antidysmenorrhoeal. Digestive. Hypolipemiant | AE, GA, GU, MO, PA, RI |
| <i>Mentha pulegium</i> L. (BCN 113598) | poliol, poniol | 28 | Antidysmenorrhoeal. Refreshing | AE, GU, MO, UL |
| <i>Prunus domestica</i> L.* (BCN 46834) | pruner, prunera | 28 | Laxative | AE, CE, GA, PA, RI, VT |

Apart from two families of fungi, one of ferns and two of gymnosperms, the remaining 59 are angiosperms. The most cited families (Fig. 3) were Lamiaceae (412 UR), Rosaceae (233 UR), Rutaceae (162 UR); Amaryllidaceae (133 UR), Asteraceae (130 UR), and Apiaceae (125 UR). Percentages are shown in Fig. 3. Most of these families appear in the top of the ranking in practically all ethnobotanical works performed in Catalonia dealing with pharmaceutical, food or other uses [34, and references therein], because they are big families (Asteraceae, for instance, is the largest one in plants) with a relevant presence in the Mediterranean region. Conversely, two of the families (Rutaceae and Amaryllidaceae) do not occupy the first positions in such rankings, although they have a non-negligible presence. The intense and specific nutraceutical uses of *Citrus limon* and *Allium sativum* (see Table 1), respectively belonging to those two families, may explain this situation. In Amaryllidaceae, Rutaceae and Apiaceae families, the UR are concentrated in a few species (4, 6, and 10, respectively), whereas in the Rosaceae, Lamiaceae and Asteraceae the number of species is higher (22, 24, and 26, respectively). Some of these families (Asteraceae, Lamiaceae, Rosaceae, Rutaceae) are quoted as top ones in FFF in other territories, and well-known for their chemical composition justifying their nutraceutical properties [26, and references therein].

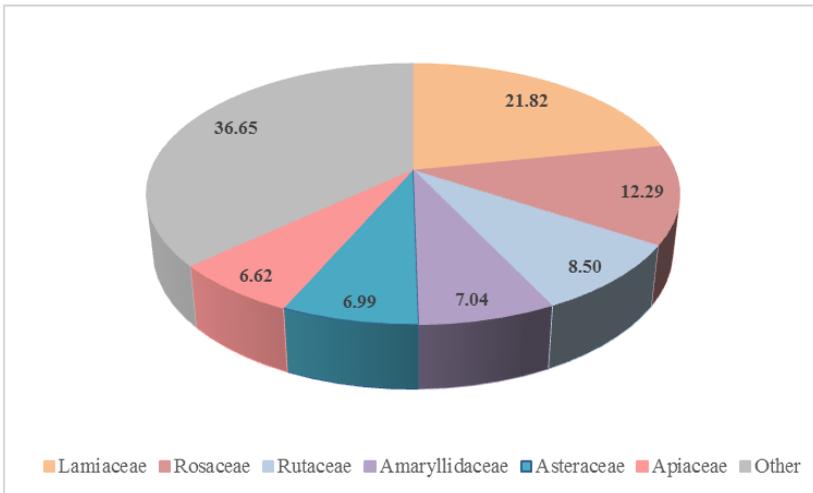


Figure 3. Main families providing plant folk functional foods in the studied areas.

Parts of plants used and preparation forms

The parts of plants employed for nutraceutical purposes are presented in Fig. 4.

Aerial part is largely dominating. Apart from the complete aerial part itself, some aerial organs, such as fruits, leaves and flowers complete this more easily available part of the plant. The use of the flowered aerial part of *Thymus vulgaris*, with more than 100 UR (see Table 1), make this part of the plant particularly important. Plants used as salads help to complete this first position in the ranking. Some subterranean parts (roots and tubers, very typically consumed in food plants) occupy a discrete, but not at all null, place.

The modalities of preparation of the plant products claimed as FFF are presented in Fig. 5, and Fig. 6 illustrates a few examples of some of the commonest forms.

Alcoholic beverages received almost one third (29.61%) of the UR. This basically comes from liqueurs or different kind of wines, which are often used for different purposes, such as aperitive or digestive. Among those, *ratafia*, a very typical Catalan liqueur including *Juglans regia* unripe fruits, along with a number of other plant taxa, overpassing 50 in

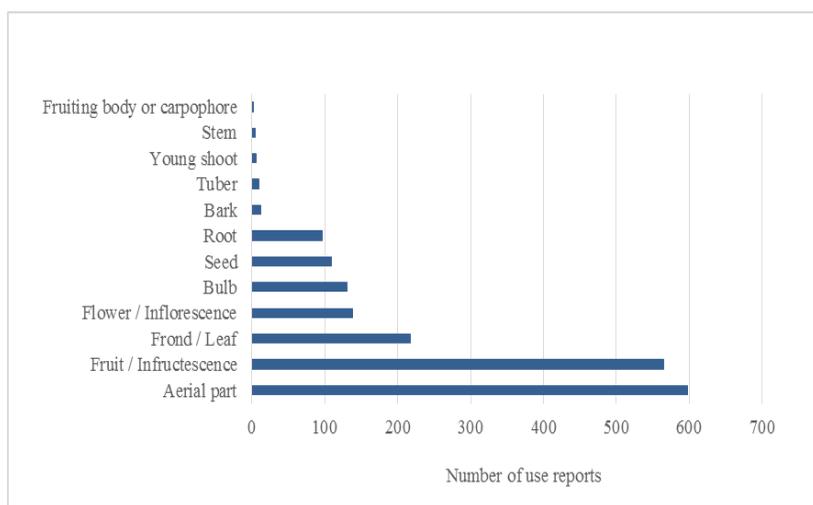


Figure 4. Plant (and fungal) parts used as folk functional foods in the studied areas.

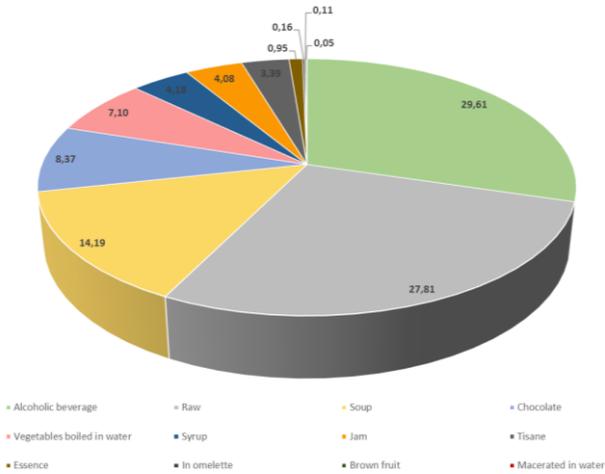


Figure 5. Preparation forms of folk functional foods in the studied areas.



Figure 6. Examples of four out of the five most quoted preparation forms of folk functional foods in the studied areas. A. First step of *ratafia* (a digestive and antidysmenorrhoeal liqueur) preparation, with abundant *Juglans regia* and other taxa. B. Salad of *Taraxacum dissectum*, diuretic and hematocathartic. C. Boiled leaves of *Chenopodium bonus-henricus*, blood depurative. D. Soup with *Thymus vulgaris*, digestive and antidiarrhoeal.

some cases [37], predominates. The other highly relevant form is just the one without preparation (apart from cleaning): raw plant consumption, most often linked to their use as salads, represents more than a quarter (27.81%) of the UR. Hot, drinking chocolate is an also relatively common (and rather original) vehicle (8.37% of UR) for different plant taxa that confer it functional activities. Conversely, tisane, one of the major preparation or administration forms in pharmaceutical ethnobotany and folk phytotherapy, shows a very low occurrence (3.39% of UR) among FFF. This can be explained by the fact that nutraceutical uses are predominantly linked to plant consumption as food, and tisane is perceived by the informants more as a specific medicine than an alimentary product.

Nutraceutical uses

The main types of uses of the plants claimed to constitute FFF by our informants are presented in Table 2, which contains the main uses, representing 73.09% of the total.

Table 2. Number and percentage of use reports of the kinds of nutraceutical uses in the areas studied.

| Nutraceutical uses | Use reports | % |
|---|-------------|-------|
| Antidysmenorrhoeal | 262 | 13.88 |
| Digestive | 220 | 11.65 |
| Gastrointestinal antiseptic and anti-inflammatory | 219 | 11.60 |
| Antidiarrhoeal | 167 | 8.85 |
| Hematocathartic | 129 | 6.83 |
| Refreshing | 96 | 5.08 |
| Anti-nauseous | 79 | 4.18 |
| Laxative | 73 | 3.87 |
| For child weakness (<i>enaiguament</i>) | 49 | 2.60 |
| Tonic, reinforcing, vitamin | 47 | 2.49 |
| Antianorectic, aperitive | 39 | 2.07 |
| Other uses | 508 | 26.91 |

The most frequent nutraceutical property, by far, is the one linked to troubles of the digestive system: digestive itself, gastrointestinal antiseptic and anti-inflammatory, antidiarrhoeal, anti-nauseous, and laxative. This is consistent with the fact that digestive use is one of the commonest in pharmaceutical ethnobotanical prospections [38, and references therein], and also with the idea that, in general, phytotherapeutic uses are basically addressed to mild and chronic diseases [39], among which gastrointestinal ones are important. Nevertheless, stronger uses, such as blood depurative or appetite stimulating, are relevant too. Indeed, the first position (if we do not associate all digestive system troubles) is occupied by the antidysmenorrhoeal use. This is mostly linked to the classical and considerable consumption of the liqueur called *ratafia*, in general terms considered as digestive, by women having troubles in menstruation. Another use with a high number of reports is related to a degraded physical state of children due to psychological reasons. The Catalan word *enaiguament* (textually meaning flooding) designates the state of children when they feel themselves not well attended by their parents when a smaller child is born. This syndrome, consisting on a general organic weakness, is treated with food with functional properties.

Some nutraceutical properties have less UR, but are not uninteresting and deserve a comment. Antioxidant, a very relevant function in commercial nutraceuticals, has received only two UR, indicating that this relatively recent medical concept is not yet present in traditional thinking. Another property quite usual in dietary supplements and nutraceutical products collected 24 UR, far from the top ones in the ranking (Table 2): salutiferous (sometimes expressed as panacea and equivalent to what is usually called adaptogenic in phytotherapy); this means that most FFF in the studied area are addressed to specific troubles rather than to general health maintenance.

5. Conclusion

This paper represents a first approach to the FFF in several areas covering different biogeographical regions of Catalonia. Tradition (in classical plants for the territory, such as *Thymus vulgaris*) and innovation (in plants such as *Actinidia chinensis*, which appeared on the food market in Catalonia not a lot of years ago, but is already used as medicine) go together to configure an interesting field of folk knowledge and ethnobotanical research. The search for information concerning FFF is not

as simple as that for collecting data on medicinal or food uses separately, since some concepts applied to food, such as salutiferous, are not easy to follow. Nevertheless, the results obtained in ethnobotanical prospections related to the FFF concept are both numerous and robust enough to appear as promising and interesting for the design and development of new commercial nutraceutical products. In addition, only human-directed nutraceutical properties have been addressed here, and we believe that it would be worth investigating the same topic in an ethnoveterinary context.

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