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Wild and cultivated plants used in traditional alcoholic beverages in Italy: an ethnobotanical review

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Abstract
This study aims to gather, analyze, and discuss the ethnobotanical information regarding wild and cultivated plants used in traditional alcoholic beverages in Italy. The online literature search allowed data collection from 161 articles concerning the use of wild and cultivated plants in Italy for liqueurs preparation. Overall, we identified 130 taxa belonging to 35 families, among them Rosaceae is the most cited (21.4%) followed by Asteraceae (14.3%), Lamiaceae (12.7%), Apiaceae and Pinaceae (5.6% each). Tuscany ($N=49$), Friuli Venezia Giulia ($N=46$) and Lombardy ($N=36$) show the largest number of species used in a single region. The common use of liqueurs as aperitif and digestive is also discussed. This work increases the ethnobotanical data of traditional alcoholic beverages from Italy, till now not well explored. This study can be the basis for future research on the supposed bioactivity and toxicity of alcoholic beverages.

Keywords Liqueurs · Wine · Grappa · Digestive · Ethyl alcohol · Ethnobotany · Italy

Introduction

Alcoholic beverages have been a distinctive component of many cultures for thousands of years and in most human communities they are still part of the traditional knowledge [1]. Liqueurs are produced by flavoring distillate of various origin with aromatic components, such as herbs (leaves, roots, seeds and flowers), fruits (whole fruit, peel and stones), as well as other food products, and sweetened with sugar, honey or other sweetening agents [2, 3]. According to EC Regulation 110/2008 liqueur is a spirit drink having a minimum sugar content, expressed as invert sugar, of 100 g per liter, and a minimum alcoholic strength of 15% ABV (alcohol by volume). The liqueur is produced either directly by distillation/maceration or by the mixture of a spirit drink with other drinks, spirit drinks, or ethyl alcohol or distillates of agricultural origin. The process of distillation should be performed on naturally fermented products, with or without added flavorings, while the process of maceration should be performed in ethyl alcohol of agricultural origin or in distillates of agricultural origin. The liqueur can be also directly produced by the addition of flavorings, sugars or other sweetening products and/or other agricultural/food products to ethyl alcohol of agricultural origin and/or to distillates of agricultural origin and/or to spirit drinks [4].

The use of aromatic plants and spices to prepare beverages dates back to ancient Mediterranean history [5]. With time, changes in consumer preferences have caused a continuous evolution in the type of flavored alcoholic beverages consumed, but nevertheless aromatic plants and essential oils continue to have an important role as the source of flavoring of these products [5]. Worldwide, in 2016 more than half (3.1 billion) of the global population aged 15 years and over had abstained from drinking alcohol in the previous 12 months. Some 2.3 billion people are current drinkers. Alcohol is consumed by more than half of the population in only three World Health Organization regions—the Americas, Europe and Western Pacific [6]. Traditional alcoholic beverages are homemade and informal preparations produced at local or family level. These beverages are included by the WHO in the "unrecorded alcohol" that are produced and consumed in the community or in homes [6]. Traditional alcoholic beverages are perceived by local communities as a keystone part of their culture, with practices that are deeply embedded into the local environment and history [7]. Some

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liqueurs are consumed also for their supposed pharmacological activity. However, according to Tonutti and Liddle [5] it is difficult to imagine an alcoholic beverage in a 'normal serving', that could contain the typical levels of active substances of aromatic plants which have been shown to produce any pharmacological effect.

In recent decades, several Italian ethnobotanists have sought to analyze the persistence of traditional uses of plants and their products [8–14]. Despite this, and according to Egea et al. [1], traditional alcoholic beverages have received marginal attention so far, especially in Italy. In this scenario, also according to Pieroni et al. [15] and Rivera et al. [16], to focus on the traditional uses of plants in the preparation of liqueurs can constitute an important tool for analyzing and preserving traditional ecological knowledge (TEK) and cultural diversity in the Mediterranean area. In this context, the aim of the present paper is to review the use of wild and cultivated plants as traditional local ingredients in the alcoholic beverages preparation. Therefore, the main objectives of the present study were to:

- Document folk knowledge regarding wild and cultivated plants used as seasoning or involved in the preparation of alcoholic beverages in Italy.
- Identify the most frequently used plant parts in the alcoholic beverages preparation and aromatization.
- Assess the persistence of some most popular alcoholic beverages and describe their preparation methods and aromatic profiles.
- Highlight the supposed therapeutic reported uses of some alcoholic beverages.
- Underline the risk that harvesting could endanger some plant species in the Italian regions.

Materials and methods

A comprehensive literature search on the plants used for the preparation of alcoholic beverages was carried out using existing online scientific databases such as Scopus, Web of Science, Wiley Online Library, Science Direct and Google Scholar. Only studies in English and Italian were recovered, and no chronological limits were applied in our search strategy. The selected articles were read in full. The criteria for article selection were defined a priori to avoid personal bias. The search terms included were: ethnobotany, liqueurs, spirits, alcoholic beverages, grappa, Italy. Further articles were gathered from previously collected papers. Based on the results obtained, we set up a database reporting the following data: taxon (when helpful, due to the recent changes in nomenclature, synonyms are reported in parentheses), vernacular name(s) (when mentioned), life form, chorology, plant part(s) used, region(s) in which the species is reported, references, type of alcoholic beverage (liqueur, wine, grappa), any therapeutic uses. In this review, we included only species collected by people in the wild or those cultivated in home gardens for family use. We did not record plants used in the preparation of alcoholic macerates having medicinal properties, since they are not consumed within food contexts.

Overall, 161 articles were found in the databases as well the previously collected papers. Of those, 34 contained reports of plants specifically used for the liqueurs and wine preparation or as spirit flavoring. The plants nomenclature follows The Plant List Database [17]. Families are organized based on APG IV for Angiosperms [18]. Abbreviations of authors are standardized according to Brummitt and Powell [19], as recommended by Rivera et al. [20].

Results and discussion

Based on the literature review, we documented 130 taxa as being used to aromatize spirits or prepare liqueurs and wine (Table 1). The plant species belong to 35 families: Rosaceae is the most cited family (21.4%) followed by Asteraceae (14.3%), Lamiaceae (12.7%), Apiaceae and Pinaceae (5.6% each), and Fabaceae, Gentianaceae and Rutaceae (4.0% each). The most used life form is Phanerophytes (44.4%), followed by Hemicryptophytes (35.7%) (Fig. 1). Adding phanerophytes and chamaephytes, it is clear that the woody plants constitute more than half of the used species (54.7%). The chorological spectrum (Fig.1b) is quite representative of the floristic distribution of the Italian peninsula. The contribution of the Steno-Mediterranean species (11.2%) is due to the central-southern coastal regions, while the Orophytic (12.9%) and the Boreals (8.6%) are certainly more widespread in the Alpine regions.

As shown in Fig. 2, fruits were the most frequently used plant parts (29.7%), followed by leaves (23.0%) and flowers and aerial parts (11.5% each).

The use reports concern liqueurs ($N = 100$), wines ($N = 18$) and grappa aromatizer ($N = 57$). As shown in Fig. 3, from the analyses carried out at a regional scale we found that Tuscany has the largest number of species used in a single region ($N = 49$), followed by Friuli Venezia Giulia ($N = 46$) and Lombardy ($N = 36$).

Figure 4 shows a summary of the 17 most commonly cited taxa in the Italian regions. The most cited plants being: *Juniperus communis* ($N = 15$), *Juglans regia* ($N = 13$) and *Foeniculum vulgare* ($N = 10$), followed by *Citrus limon* and *Prunus spinosa* ($N = 9$ each).

Table 1 Wild and cultivated plants used in traditional alcoholic beverages in Italy

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Abies spp.	Pinaceae	Abete	P	–	Resin, shoots	Fvg, Tus	[83, 84]	X		X
Achillea erba-rotta All.	Asteraceae	Ruotta, ruta di montagna (Pie)	Ch	Endem. Alp	Aerial parts	Pie	[48]	X		
Achillea erba-rotta subsp. *moschata* (Wulfen) I.Richardson (= Achillea moschata Wulfen)	Asteraceae	Erba iva, tanéda	Ch	Endem. Alp	Flowers, fruits	Lom	[72, 85]	X		
Achillea millefolium L.	Asteraceae	Tanéda mata (Lom); Troneto (Cam); Ozebar (Fvg)	H	Eurosiber	Aerial parts	Cam, Fvg, Lom	[26, 84, 86]	X		X
Achillea nana L.	Asteraceae	Tanéda	H	Endem. Alp	Flowers	Lom	[85]	X		
Agrimonia eupatoria L.	Rosaceae	Erba pel mal de corp (Fvg)	H	Subcosmop	Leaves	Liguria	[87]		X	
Aloysia citrodora Paláu (= Lippia triphylla (L'Hér.) Kuntze)	Verbenaceae	Cedrina, cedrata (Cam); Cedrina, erba Luisa (Tus)	P	Casual alien (S-Amer.)	Leaves	Cam, Emi, Fvg, Tus	[1, 37, 84, 88–91]	X	X	X
Anethum graveolens L.	Apiaceae	Aneto	T	Casual alien (W-Asia.)	Flowers	Fvg	[84]			X
Angelica sylvestris L.	Apiaceae	Angelica (Pie)	H	Eurosiber	Roots	Pie	[48]	X		
Arbutus unedo L.	Ericaceae	Albatrella, baciulle (Tus); Aruamule, cacungolo, etc. (Cal); Sa mela e lidone, Su lidone (Sar)	P	Steno-Medit	Fruits	Cal, Fvg, Sar, Tus	[83, 84, 90, 92, 93]	X		X
Artemisia absinthium L.	Asteraceae	Nascienzo (Cam); Erbo bon (Tus); Ašénz, ešénz, etc. (Lom); Pelìn (Fvg)	Ch	Subcosmop	Leaves, flowering tops	Cam, Fvg, Lig, Lom, Tus	[50, 83–85, 87, 88]	X	X	X
Artemisia dracunculus L.	Asteraceae	Dragoncello	Ch	Casual alien (C—Asia and Siberia)	Aerial parts	Fvg	[84]			X

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Artemisia eriantha Ten. (=A. umbelliformis Lam. subsp. eriantha (Ten.) Vallès-Xirau & Brañas)	Asteraceae	Genepì (Abr)	Ch	Orof. S-Europ	Flowering tops, aerial parts, leaves	Abr	[58]	X		
Artemisia genipi Weber ex Stechm	Asteraceae	Genepì (Pie); Genepì maschio, genepì scur (Lom)	Ch	Endem. Alp	Flowering tops, aerial parts	Lom, Pie	[48, 72, 77, 85, 86]	X		X
Artemisia glacialis L.	Asteraceae	Genepì (Pie)	Ch	Subendem	Flowering tops	Lig, Pie	[48, 50, 77]	X		
Artemisia umbelliformis Lam	Asteraceae	Genepì fumél (Pie); Female genepì (Lom)	Ch	Orof. SW-Europ	Flowering tops, aerial parts	Lom, Pie	[48, 72, 77, 85, 86]	X		X
Artemisia vulgaris L.	Asteraceae	Genepì (Abr)	H	Circumbor	Flowering tops, aerial parts	Abr	[58]	X		
Carum carvi L	Apiaceae	Chiréi, cummel (Pie); Chimel, ciarièl (Fvg); Choré, sèm da prá, etc. (Lom)	H	Paleotemp	Fruits	Fvg, Lom, Pie	[48, 77, 84, 85, 87]	X		X
Castanea sativa Miller	Fagaceae	Cjastinis, kostànj (Fvg); Cistagnier (Cal)	P	SE-Europ	Fruits, flowers	Cal,Fvg, Tus	[1, 84, 92]	X		X
Ceratonia siliqua L	Fabaceae	Sciusciella (Cam)	P	Steno-Medit	Fruits	Cam	[37]	X		
Citrus × *limon* (L.) Osbeck	Rutaceae		P	Cult. (Asia)	Fruits	Cam, Tus, Sic	[1, 37, 90, 94–98]	X		
Citrus sinensis (L.) Osbeck	Rutaceae		P	Cult. (Asia)	Fruits	Sic, Tus	[1, 94]	X		
Cornus mas L.	Cornaceae	Kumja (Mol); Vrinniàne (Abr); Crognolo (Tus); Quargno, dria (Fvg)	P	SE-Europ	Fruits	Emi, Fvg, Mol, Tus	[1, 58, 83, 84, 88, 89, 99]	X		X
Crataegus laevigata (Poir.) DC	Rosaceae	Biancospino (Tus); Calavrighe, Calavie (Sar)	P	Centroeurop.-Subatl	Fruits	Sar, Tus	[83, 93]	X		
Crataegus monogyna Jacq	Rosaceae	Bianc de špín, Špín, Biancospín	P	Eurasiat	Flowers	Lom, Mar	[85, 100]	X		X

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Cydonia oblonga Miller	Rosaceae	Cotogno (Abr); Mela chidonza, Sa mela'e donza (Sar)	P	Cult. (W-Asia)	Fruis, seeds	Abr, Sar	[58, 93]	X		
Foeniculum vulgare L.	Apiaceae	Finucco (Bas); Fhinucchiu, fneugl (Cal); Finucchiello, fenucchio (Cam); Fenule selvaje, komarač (Fvg)	H	Steno-Medit	Fruits	Bas, Cal, Cam, Emi, Fvg	[37, 83, 84, 89, 90, 92, 96, 97, 101, 102]	X	X	X
Fragaria vesca L.	Rosaceae	Fragola (Abr); Mažóštri, fraer, etc. (Lom); Jaguca (Fvg); Aula, etc. (Cal)	H	Cosmop	Fruits, flowers	Abr, Cal, Fvg, Lom, Tus	[1, 58, 83–85, 90, 92]	X		
Fragaria viridis Duchesne	Rosaceae	Fragola	H	Eurosib	Fruits	Abr	[58]	X		
Galium odoratum (L.) Scop	Rubiaceae	Stellina odorosa (Abr)	G	Eurasiat	Aerial parts	Abr	[58]	X		
Gentiana acaulis L. (=Gentiana kochiana Perr. et Song.)	Gentianaceae	Braio d'cucuc, pirulet, chausso de cucù, etc. (Pie); Scenziana, scienzo, etc. (Tus)	H	Orof. S-Europ	Roots, flowers	Pie, Tus	[48, 77, 90]	X	X	X
Gentiana cruciata L	Gentianaceae	Genzianella (Mol)	H	Eurasiat	Roots	Mol	[103]	X		
Gentiana lutea L.	Gentianaceae	Genziana (Bas); Argensiana, gënsano (Pie); Karšutnjak (Fvg)	H	Orof. S-Europ	Roots	Abr, Bas, Emi, Lom, Mar, Pie	[48, 58, 77, 80, 84, 89, 100, 101]	X	X	X
Gentiana punctata L.	Gentianaceae	Genzàna, gianzána, riš, radisc, etc	H	Orof. S-Europ	Roots	Lom	[85]	X		
Gentiana spp.	Gentianaceae	Sclop, heziawurtze, ansiana, etc. (Fvg)	H	–	Roots	Fvg	[87]	X	X	
Glycyrrhiza glabra L.	Fabaceae	Rigoliz, argalizia (Cal)	G	Steno-Medit.-W-Asia	Roots	Bas, Cal	[92, 101]	X	X	
Hippophaë fluviatilis (Soest) Rivas Mart. (=Hippophae rhamnoides L. subsp. fluviatilis Soest)	Rhamnaceae	Špin d'asen	P	Eurasiat	Fruits	Lom	[85]	X		

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Hypericum perforatum L.	Hypericaceae	Érba desant Ĝoán	H	Cosmop	Flowers, leaves	Lom	[85]			X
Iris spp.	Iridaceae	Fior de spada, xii, gili zelesti, etc. (Fvg)	G	–	Rhizome	Fvg	[87]		X	
Juglans regia L.	Juglandaceae	Nughe, Nue (Sar)	P	Cult. (W-Asia)	Fruits	Cal, Cam, Emi, Fvg, Lom, Mol, Sar, Tus	[1, 37, 83–85, 89, 90, 92, 93, 103–106]	X		X
Juniperus communis L.	Cupressaceae	Kronebit, brinje, etc. (Fvg); Genebbolo (Cam); Ženébro, Sgenebro,Genébro (Lom); Zèneveru (Lig)	P	Circumbor	Cones	Cal, Fvg, Emi, Lig, Lom, Mol, Tus	[1, 36, 50, 72, 83, 85, 87, 89, 90, 92, 103–105, 107]	X	X	X
Juniperus oxycedrus L. subsp. *oxycedrus*	Cupressaceae		P	Euri-Medit	Cones	Mar, Sar	[100, 108]			X
Larix decidua Miller	Pinaceae	Làras, larĝé, etc. (Lom)	P	Orof. Centroeurop	Flowers, shoots	Fvg, Lom	[84, 85]			X
Laurus nobilis L	Lauraceae	Lauro, alevena (Cam); Dafina (Cal)	P	Steno-Medit	Leaves	Cal, Cam, Emi, Sic, Tus	[1, 37, 83, 89, 92, 109]	X		
Leontopodium nivale (Ten.) Huet ex Hand.-Mazz	Asteraceae	Stela alpina (Pie)	H	Subendem	Flowering tops	Pie	[48]	X		
Levisticum officinale W.D.J.Koch	Apiaceae	Luštrih, levistico, selin	H	Casual alien (SW-Asiat.)	Aerial parts	Fvg	[84]			X
Malus domestica Borkh	Rosaceae	Mele, mele antiche	P	Cult. (Eurasiat.)	Fruits	Tus	[1]	X		
Malus sylvestris Miller	Rosaceae	Mele selvatiche	P	Europ.-Caucas	Fruits	Tus	[1]	X		
Malva sylvestris L.	Malvaceae	Slis	H	Subcosmop	Aerial parts	Fvg	[84]			X
Matricaria chamomilla L.	Asteraceae	Komilca (Fvg); Camomigl, calumiggia (Cal)	T	Subcosmop	Inflorescences	Cal, Fvg, Mar, Tus	[1, 84, 88, 90, 92, 100]	X		X
Medicago falcata L.	Fabaceae	Érba médiĝa gálda, Érbamédiĝa salvádiĝa	H	Eurasiat	Aerial parts	Lom	[85]	X		
Medicago sativa L.	Fabaceae	Érba médiĝa	H	Eurasiat	Aerial parts	Lom	[85]	X		

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Melissa officinalis L.	Lamiaceae	Melisa, miluse, etc. (Fvg)	H	Euri-Medit	Leaves and flowering tops	Fvg	[84, 87]	X	X	X
Mentha aquatica L.	Lamiaceae	S'amenta	H	Subcosmop	Leaves	Sar	[93]	X		
Mentha arvensis L.	Lamiaceae	Menta, mentuccia	H	Circumbor	Leaves	Cal, Fvg, Sar, Tus	[83, 84, 92, 93]	X		X
Mentha longifolia L.	Lamiaceae	Menta	H	Paleotemp	Leaves	Cam	[96]	X		
Mentha pulegium L.	Lamiaceae	Iuri di menta (Sic)	H	Subcosmop	Leaves	Cam, Sic	[96, 110]	X		
Mentha spicata L.	Lamiaceae	Amentastru, scordiu, rintuzza (Sic); Menta selvatica (Tus)	H	Euri-Medit	Leaves	Cam, Lom, Sic, Tus	[1, 86, 96, 109, 110]	X		
Mentha spp.	Lamiaceae	Menta	H	–	Leaves	Emi, Tus	[88, 89]	X		
Mentha suaevolens Ehrh	Lamiaceae	Amenta, amintastru, mintastru (Sic)	H	Euri-Medit	Leaves	Sic	[109]	X		
Mentha × *piperita L*	Lamiaceae	Menta	H	Paleotemp	Leaves	Fvg, Sar, Tus	[84, 90, 93]			X
Mespilus germanica L.	Rosaceae	Nèspua (Lig)	P	S-Europ	Seeds, fruits	Cal, Cam, Liguria	[36, 37, 83, 92]	X		
Morus alba L.	Moraceae	Amuricivice, cerso, etc	P	Cult. (E-Asiat.)	Fruits	Cal	[92]	X		
Myrtus communis L.	Myrtaceae	Murtella, mortella (Cam); Mutta, Sa murta (Sar); U mirtu (Sic)	P	Steno-Medit	Fruits	Cam, Sar, Tus	[37, 83, 87, 90, 93, 96, 108, 111, 112]	X		X
Ocimum basilicum L.	Lamiaceae	Basilico	T	Cult. (Asia)	Leaves	Tus	[1, 88, 107]	X		
Olea europaea L.	Oleaceae		P	Steno-Medit	Leaves	Cal	[92]	X		
Opuntia ficus-indica (L.) Mill.	Cactaceae	Fik de mori	P	Invasive alien (Trop. Amer.)	Fruits	Cal	[92]	X		
Origanum majorana L.	Lamiaceae	Maggiorana	H	Cult. (Saharo-Sind.)	Aerial parts	Fvg	[84]			X
Petroselinum crispum (Miller) Fuss	Apiaceae	Savors	H	Cult. (E-Medit.)	Leaves	Fvg	[84]			X
Pimpinella anisum L.	Apiaceae	Anice (Bas); Anèsc, Anèsam, Fenoċ (Lom)	T	Cult. (Asia)	Fruits	Bas, Lom, Sar	[85, 101, 113]	X	X	X
Pinus cembra L.	Pinaceae	Gémbro (Lom); Elvio (Pie)	P	Eurosiber	Seeds, cones	Lom, Pie	[77, 86]	X		

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Pinus mugo Turra	Pinaceae	Zette, baranci di mont, etc. (Fvg)	P	Orof. Eurasiat	Young shoots	Fvg	[84, 87]	X		X
Pinus nigra J.F. Arnold	Pinaceae		P	Euri-Medit.-Nordo-rient	Buds	Lig, Tus	[1, 50]	X		X
Pinus strobus L.	Pinaceae	Pino strobo	P	Naturalized alien (N-Americ.)	Shoots	Fvg	[84]			X
Pinus sylvestris L.	Pinaceae		P	Orof. Eurasiat		Lig	[50]			X
Plantago lanceolata L.	Plantaginaceae	Plantain tarpotac	H	Cosmop	Leaves	Fvg	[84]			X
Polypodium vulgare L.	Polypodiaceae		H	Circumbor	Roots	Lom	[72]			X
Portulaca oleracea L.	Portulacaceae		T	Subcosmop	Leaves	Emi	[89]	X		
Potentilla spp.	Rosaceae	Gosia trava, pendente, frèule mate (Fvg)	H	–	Rhizome	Fvg	[101]		X	
Primula veris L.	Primulaceae		H	Euri-Medit	Leaves, flowers	Lom	[86]	X		
Primula vulgaris Hudson	Primulaceae	Primula (Lig)	H	Europ.-Caucas	Young leaves, flowers	Lig	[36]	X		
Prunus avium L.	Rosaceae	Cerase (Mol); Cerasa (Cam); Sceregia, sciresa (Lom)	P	Eurasiat	Fruits, leaves, peduncles	Cam, Lom, Mol, Tus	[1, 85, 90, 95, 97, 103]	X	X	
Prunus cerasifera Ehrh	Rosaceae	Prugne selvatiche	P	Cult. (W-Asiatica)	Fruits	Tus	[1]	X		
Prunus cerasus L.	Rosaceae	Visciole, amarene (Abr); Marasco (Tus); Amarena servatica, cerese (Cal)	P	Cult. (Pontica)	Fruits, seeds, leaves, peduncles	Abr, Cal, Cam, Emi, Tus	[1, 37, 58, 83, 88, 89, 92, 95]	X	X	
Prunus domestica L.	Rosaceae	Prugne	P	Cult. (SW-Asiat.)	Fruits	Tus	[1]	X		
Prunus laurocerasus L.	Rosaceae	Agoro (Tus)	P	Cult. (W-Asiatica)	Fruits	Emi, Tus	[1, 88, 89]	X		
Prunus persica (L.) Batsch	Rosaceae	Pesche	P	Cult. (Asia)	Fruits	Tus	[1]			
Prunus prostrata Labill	Rosaceae	Sa prunischedda	P	Paleotrop	Fruits	Sar	[93]	X		

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Prunus spinosa L.	Rosaceae	Prùnul, sbrumùl (Lom); Atrìgnl (Abr); Scancio (Mar)	P	Eurasiat	Fruits, seeds	Abr, Emi, Fvg, Lom, Mar, Tus	[1, 58, 83–86, 89, 100]	X		X
Pulmonaria officinalis L.	Boraginaceae	Plucniak	H	Europ	Aerial parts	Fvg	[84]			X
Punica granatum L.	Lythraceae	Shegga	P	Cult. (W-Asiatica)	Seeds	Cal	[92]	X		
Pyrus communis L.	Rosaceae	Pere snace, pere cestello	P	Eurasiat	Fruits	Tus	[1]	X		
Pyrus pyraster Burgsd	Rosaceae	Pere selvatiche	P	Eurasiat	Fruits	Tus	[1]	X		
Rheum officinale Bill	Polygonaceae	Rabarbaro	G	Naturalized alien (Asia)	Roots	Fvg	[84]			X
Rheum rabarbarum L.	Polygonaceae	Rabarbar	G	Cult. (Siberia, China)	Leaves, stems	Lom	[85]	X		
Ribes rubrum L.	Grossulariaceae	Ribis, ua de S. Joan, etc. (Fvg)	P	Centroeurop	Fruits	Abr, Fvg	[58, 101]	X		
Ribes uva-crispa L.	Grossulariaceae	Uva spina, p'urcìn (Abr)	P	Eurasiat	Fruits	Abr	[58]	X		
Robinia pseudoacia L.	Fabaceae	Acasia, acàcja	P	Invasive alien (N-Americ.)	Flowers	Fvg, Tus	[1, 84]	X		X
Rosa canina L.. (s.l.)	Rosaceae	Fròsula, Špin de frósola, etc. (Lom); Rosa servaggia (Cal); Pizzacui, tàrnje (Fvg); Sa rosa burda,	P	Paleotemp	Flowers, fruits	Cal, Fvg, Lom, Tus	[1, 84–86, 90, 93, 102]	X		X
Rosa sempervirens L.	Rosaceae		P	Steno-Medit	Petals	Cam	[37]	X		
Rosmarinus officinalis L.	Lamiaceae	Rožmarin (Fvg); Rosemarino, rumarin (Cal)	P	Steno-Medit	Leaves	Cal, Emi, Fvg, Tus	[1, 84, 89, 92]	X		X
Rubia peregrina L.	Rubiaceae		P	Steno-Medit		Sic	[109]	X		
Rubus fruticosus L. (Rubus plicatus Weihe & Nees)	Rosaceae	Móra (Lom); Rogo, scepe, etc. (Tus)	P	Subatl	Fruits	Lom, Tus	[85, 90]	X	X	X
Rubus hirtus W. et K	Rosaceae		P	Centroeurop	Fruits	Tus	[1]	X		

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Rubus idaeus L.	Rosaceae	Lamponi (Abr, Cal, Tus); Ampómola (Lom)	P	Circumbor	Fruits	Abr, Cal, Lom, Tus	[58, 83, 85, 92]	X		X
Rubus ulmifolius Schott	Rosaceae	More; Sa mura, S'orrubu (Sar)	P	Euri-Medit	Fruits	Cal, Sar, Sic, Tus	[83, 92, 93, 109]	X		
Ruta angustifolia Pers	Rutaceae	Rua	Ch	Steno-Medit	Leaves	Lig	[36]			X
Ruta chalepensis L.	Rutaceae	Aruta (Sic); Ruta (Tus)	Ch	Steno-Medit	Leaves	Lig, Sic, Tus	[36, 90, 114]	X		X
Ruta graveolens L.	Rutaceae	Ruda, rude (Fvg); Érba rúĝa (Lom); Rut, rudda (Cal)	Ch	S-Europ.-S-Siber	Leaves	Fvg, Cal, Lig, Lom, Mar, Mol, Tus	[1, 36, 83, 85, 92, 93, 99–101, 115]	X		X
Salvia officinalis L.	Lamiaceae	Sálvia	Ch	Steno-Medit	Leaves	Cal, Lom, Tus	[1, 85, 90, 92]	X		X
Salvia pratensis L.	Lamiaceae		H	Euri-Medit	Leaves	Emi	[89]			
Sambucus ebulus L.	Adoxaceae	Ebbi, ebbiacci	G	Euri-Medit	Fruits	Tus	[1]	X		
Sambucus nigra L.	Adoxaceae	Paparozzo, sammuch (Abr); Sambuc (Pie); Sambugo (Tus); Bazovina (Fvg); Sambucu, Samuhu (Sar)	P	Europ.-Caucas	Flowers, fruits	Bas, Emi, Fvg, Pie, Tus	[1, 58, 77, 83, 90, 93, 116]	X	X	X
Sambucus racemosa L.	Adoxaceae	Sambūch salvádik, sambúch mat, etc	P	Orof. S-Europ	Flowers, fruits	Lom	[85]	X		
Sorbus domestica L.	Rosaceae	Sovere (Cam); Sorbole (Tus)	P	Euri-Medit	Fruits	Cam, Tus	[1, 97]	X	X	
Tanacetum balsamita L.	Asteraceae		H	Casual alien (W-Asia)	Leaves	Emi, Fvg	[84, 89]	X		X
Tanacetum parthenium (L.) Sch. Bip	Asteraceae	Camumill' do Partenio (Cam); Madriaria, madriauco	H	Eurasiat	Flowering tops	Cam, Fvg, Lom	[84, 117]	X		X
Tanacetum vulgare L	Asteraceae	Archebüse, tanaìa (Pie)	H	Eurasiat	Leaves	Pie	[48, 77]	X		
Taraxacum campylodes G.E.Haglund (=T. officinale XXX)	Asteraceae	Pissacan, pissaleto, passalet, etc. (Tus); Talla, lidrichessa, modac (Fvg)	H	Cosmop	Leaves	Fvg, Tus	[84, 90]			X
Teucrium scordium L.	Lamiaceae	Scordiu (Sic)	H	Europ.-Caucas	Leaves	Sic	[109]	X		

Table 1 (continued)

Species	Family	Vernacular name	Life form	Chorotype	Part used	Region	References	Liqueur	Wine	Grappa aromatizer
Thymus praecox subsp. polytrichus (A. Kern ex Borbás) Jalas (Thymus polytrichus Kern. Ex Borbás)	Lamiaceae	Érba peverína, peverèl, timu	Ch	Orof. S-Europ	Aerial parts	Lom	[85]	X		
Tilia cordata Mill	Malvaceae	Lipa	P	Europ.-Caucas	Flowers	Fvg	[84]			X
Tussilago farfara L.	Asteraceae	Lipienza	G	Paleotemp	Aerial parts	Fvg	[84]			X
Urtica dioica L.	Urticaceae	Ortíĝa, urtíĝa (Lom); Surtis, urtis, pokriva(Fvg)	H	Subcosmop	Aerial parts	Fvg, Lom	[84, 85]	X		X
Vaccinium myrtillus L.	Ericaceae	Bàĝa (Lom); Popan (Fvg)	P	Circumbor	Fruits	Fvg, Lom, Tus	[1, 84–86]	X		X
Verbena officinalis L.	Verbenaceae		H	Cosmop	Leaves	Sic				
Veronica allionii Vill	Plantaginaceae		H	Endem. W-Alpica	Leaves	Lig	[50]	X		
Viola odorata L.	Violaceae	Viola	H	Euri-Medit	Flowers	Fvg	[84]			X
Vitis labrusca L.	Vitaceae	Uva fragola	P	Cult. (N-America)	Fruits	Tus	[1]	X		
Ziziphus jujuba Mill.	Rhamnaceae	Iuiule, Iuiuma, Iuiu	P	Cult. (E-Asia)	Fruits	Cal	[92]	X		

Abr Abruzzo, *Bas* Basilicata, *Cal* Calabria, *Cam* Campania, *Emi* Emilia Romagna, *Fvg* Friuli Venezia Giulia, *Lig* Liguria, *Lom* Lombardy, *Mol* Molise, *Pie* Piedmont, *Pug* Puglia, *Sar* Sardinia, *Sic* Sicily, *Tus* Tuscany

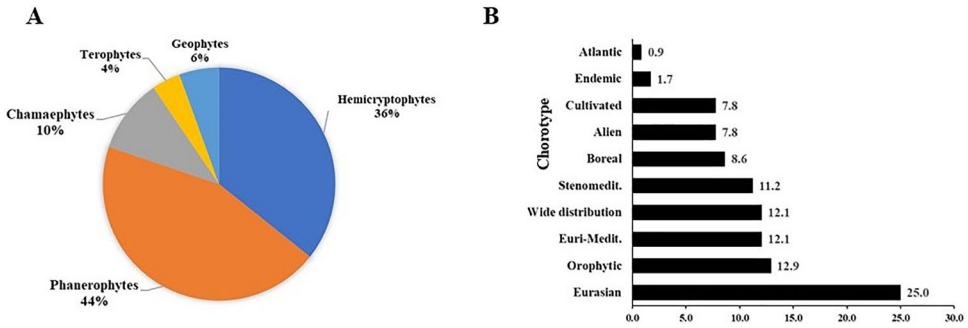

Fig. 1 Life form spectrum (**a**), and chorological spectrum (**b**) expressed as percentage, of the 130 taxa used to aromatize spirits, prepare liqueurs or wine

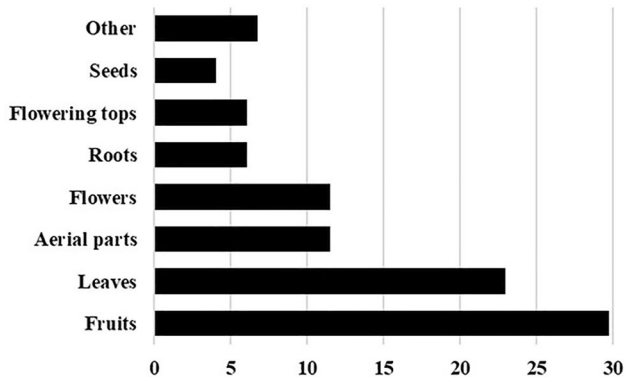

Fig. 2 Plant parts used for different preparation (percentage values)

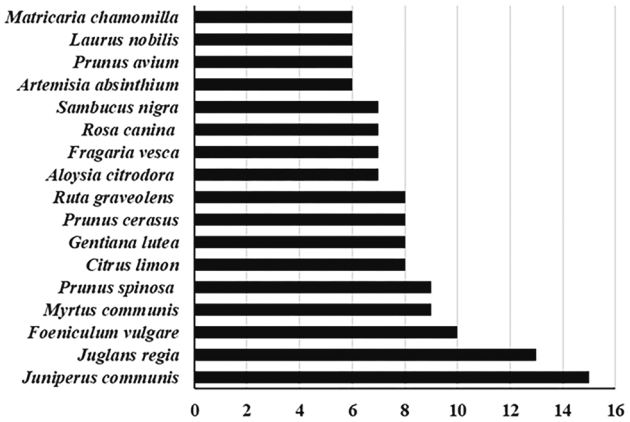

Fig. 3 Cumulated number of taxa used in each Italian region

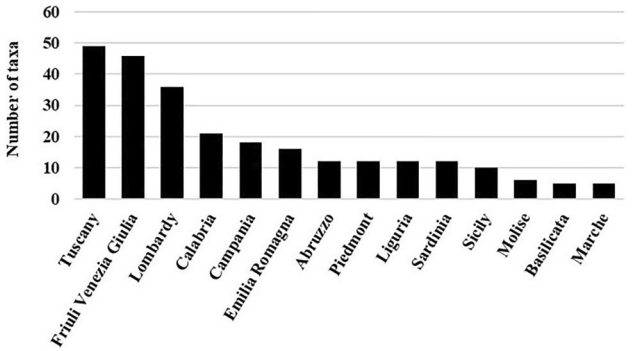

Fig. 4 Most cited species in all Italian regions used for alcohol beverages preparation

Alcoholic beverages

A total of 130 taxa, previously reported in original research papers are recorded for plant-based alcoholic beverages preparation. They are commonly used to prepare alcoholic infusion of flowers, leaves, fruits, or seeds. Most of the species are simply used to flavor spirits or wine. Below, we report the most popular liqueurs in Italy whose preparation is still consolidated in the folk tradition.

Nocino (or "nocillo" in Campania region) is an after-dinner walnut liqueur of Celtic origin, typical of Modena in Emilia Romagna, but also produced in other Italian regions [21]. Walnut based liqueurs are also produced in other European countries such as Slovenia, Romania and Serbia, in the latter it is called Orahovača [22–24]. Nocino liqueur, is prepared from the unripe fruit, gathered, according to tradition, on June 24, Saint John's day, the time of year when the hull of the fruit is at its most aromatic and best able to favor digestion [25]. The whole nuts are washed, quartered and left to steep in food-grade ethanol together with various herbs and spices such as cloves, nutmeg, vanilla, cinnamon, coriander, coffee beans and lemon zest which create diversity in the formulations [21, 26]. At the end of the brewing period, the steeped mass is pressed to separate the liquid phase from the solid matter and syrup made up of sugar and water is added, so that the alcohol content reaches around 40% ABV [27]. The most important phenolic components of walnut liqueur are chlorogenic acid, gallic acid, ellagic acid, 1,4-naphthoquinone and juglone [24, 28]. *Nocino* is a liqueur the flavor of which is given mainly by maceration and/or distillation of whole green walnuts with a minimum sugar content of 100 g/l expressed as invert sugar [4]. The minimum alcoholic strength by volume of nocino shall be 30% ABV.

Limoncello is a liquor obtained from the alcoholic extraction of essential oils from lemon peel (flavedo or epicarp). The oil droplets are dispersed in a continuous water/ethanol/sucrose medium and contains several volatile and nonvolatile minor compounds (ca. 2%), which are fundamental for its sensory characteristic [29, 30]. This beverage is becoming increasingly popular in Italy and abroad due to its natural aroma and taste, which recall the fresh lemon, as well as for its supposed digestive properties [30]. The traditional recipe foresees the maceration in 95% vol. ethanol of washed, pesticide-free lemon peels for 1 week to 40 days. After this period, peels are eliminated and a sugar syrup is added to obtain a final product with ca. 32% ABV. The most important components are limonene, β-pinene, γ-terpinene and in lower percentage sabinene, α-pinene and myrcene [31, 32]. "Liquore di limone di Sorrento" and "Della costa di Amalfi" are comprised among the Geographical Indications [4].

Mirto is a very popular liqueur in Sardinia island, obtained by alcoholic maceration of the *Myrtus communis* berries for about 40 days. After this period, berries are gently pressed and then eliminated; a sugar syrup is added to obtain a final product 30–50% ABV. Phenolic compounds and anthocyanins, in particular, are the most important phytochemicals in myrtle berries [33]. Tuberoso et al. [34] investigated the phenolic fraction of myrtle liqueur by HPLC-DAD and LC–MS/MS analysis. Data showed that myrtle liqueur is composed by arabinoside derivatives, flavonols, flavanols, hydroxybenzoic acids, and anthocyanins with malvidin-3-*O*-glucoside, petunidin-3-*O*-glucoside and delphinidin-3-*O*-glucoside as the most representative ones. The volatile composition of myrtle liqueur is characterized by high amounts of α-pinene, 1,8-cineole, β-caryophyllene and β-elemene [35].

A popular liqueur, known as *nespolino*, consists of peeled seeds (or inner part) of medlar (*Mespilus germanica*), water, 90% ABV, sugar, and vanilla beans as flavor [36, 37]. Benzaldehyde is the major component in the essential oil obtained from medlar seeds [38]. It is also reported that crude extracts prepared from medlar seeds possess a diphenolase activity toward catechol, 4-methyl catechol, l-3, 4-dihydroxyphenulalanine, epicatechin and 3-(3, 4-dihydroxyphenol) propionic acid [39].

Artemisia species (*A. eriantha*, *A. ginipi*, *A. glacialis*, *A. umbelliformis*, *A. vulgaris*) were historically used to prepare the *Genepì*, a traditional liqueur characterized by a bitter taste and a peculiar flavor [40]. The best-known species is *A. absinthium*, traditionally known as wormwood and in widespread use since Roman times as the base for aromatic wines and liqueurs [41, 42]. The liqueur is obtained by hydroalcoholic infusion for about 30 days. A sugar syrup is added to obtain a final product 30–40% ABV (http://www.genepy.it/liquore.php). Thujones are natural monoterpenoids widely present in *Artemisia* species. A- and β-thujones are the most abundant volatiles and are characterized by recognized activity on the human central nervous system [41, 43]. Other main components are 1,8-cineole, borneol, and β-pinene [41, 44]. The maximum content of thujone in Artemisia-based beverages is limited to 35 mg l^{-1} in the EU [4].[4][4] The same regulation (Annex III) comprises Genepî della Valle d'Aosta, "Genepî del Piemonte", and "Génépi des Alpes/Genepî delle Alpi (France/Italy) among the Geographical Indications.

Fennel liqueur, somewhere called *Finocchietto*, is produced by *Foeniculum vulgare* fruits maceration in alcohol for a period of about 7 days. Water and sugar are added to obtain a liqueur with about 30% ABV. Fennel seeds are rich of volatile oil, with its main compounds being fenchone and trans-anethole. Other main components of the essential oil are camphene, estragole, fenchone and α-pinene; minor constituents are limonene, neophytadiene and phytol [45–47]. Fennel liqueur is comprised among the Aniseed-flavoured spirit drinks [4].

Another popular liqueur called *Archebuse* (or arquebuse) is made using *Tanacetum vulgare*, testifying an overlapping with the French tradition [48–50]. The main constituens of *T. vulgare* volatile oil are: 1,8-cineole-borneol, β-thujone, camphor and myrtenol [51, 52].

Grappa is the spirituous beverage made from direct steam marc distillation or distilled after adding water or wine lees to marcs [53]. According to a definition recognized by European Union, grappa is the name reserved for "the spirit produced from pomace" obtained from plants located in Italy, distilled in the Italian territory and complying well-defined requirements [4]. The same EU regulation labelled eight types of grappa as Geographical Indications (Piedmont, Lombardy, Trentino-Alto Adige, Veneto, Friuli, Sicily, and Marsala) and established the product and process parameters allowing the distillate of marc to be called grappa. As a consequence, liquors obtained by the same process outside the Italian Country cannot use this name [54]. Moreover, Italian regulations permit the addition of a maximum sucrose content of 2%, or the addition of botanical ingredients [53]. Among distillates, the volatile composition of *Grappa* is probably the richest one in terms of number and complexity of the molecular structures involved. This structural variability depends on the grape variety/varieties present in the marcs, the fermentation and distillation processes, aging and maturation in bottles [55]. The volatile profile of a grape pomace distillate is typically composed of two classes of compounds: the grape-derived compounds (primary aroma, determined by the grape variety used), and the compounds resulting from the activities of yeasts and bacteria during the fermentation [56]. The main aroma compounds of grapes belong to the chemical class of terpenols e.g., linalool, geraniol, nerol, etc. [56]. Volatiles originating from the fermentation and distillation process are mainly alcohols (e.g.,

2-methyl-1-propanol, β-phenylethanol, etc.) and terpenols (e.g., α-terpineol, terpinen-4-ol) [57]. Other volatile compounds are formed by lignin degradation during the ageing in wooden barrels, (e.g., vanillin, eugenol, 4-vinylguaiacol, 4-ethylguaiacol, syringaldehyde, coniferaldehyde, benzaldehyde, and acetovanillone) [56]. In the present review 57 taxa are reported as *Grappa* aromatizer, the most cited are conifers such as *Juniperus* spp., *Abies* spp., and *Pinus* spp., or *Ruta* spp. *Gentiana* spp., *Artemisia* spp. and *Gentiana lutea* subsp. *lutea* among Angiosperms.

Other wines or liqueurs are made using *Prunus armeniaca* kernels or fruits; *P. spinosa* seeds; *P. cerasus* leaves, fruits and peduncles [1, 36, 37, 58].

Aperitif and digestive liqueurs

Italy seems to produce the largest number and widest variety of bitter, herbal liqueurs traditionally consumed as aperitifs or digestives, usually called "amari", or, literally, "bitters" [59]. In the present review, 32 plant-based liqueurs are reported to be consumed also for their supposed aperitif or digestive properties. The most cited species (e.g., *Gentiana*, spp., *Artemisia* spp., *Achillea* spp.) are well known for their bitterness properties. In the second half of the XIX century, the digestive properties of the liqueur *genepi* became so popular that were immortalized by Edmondo De Amicis with the following sentence: "a liqueur of field flowers that would make you digest a boiled bomb" [60].

As a rule, heightened perception of bitterness is one of the principal reasons for food rejection [61, 62], but bitterness is not always automatically rejected [63]. In selected beverages, for example, a certain degree of bitterness is paired with a desirable attribute [64]. As highlighted by several authors the presence of bitterness taste per se in ingested solutions does not appear to signal to influence gastric emptying or appetite perceptions [65]. A possible mechanism by which bitter tastants could positively influence digestion is altering gastric-phase postprandial haemodynamics and supporting postprandial hyperaemia [66].

Although our work focuses on traditional alcoholic beverages consumed in Italy, previous studies reported that pure ethanol solutions (4–40% ABV), beers, wine, liqueurs used as digestifs (e.g., fernet, aquavit, brandy) and whiskey prolong gastric emptying of a subsequently consumed meal [67–71]. Most probably, the widespread custom of using alcoholic beverages to help digestion after comprehensive meals come from the proved digestive activity of some medicinal plants used for liqueurs preparations [72]. To the best of our knowledge, there are no scientific data regarding the positive effect of postprandial alcoholic beverages on gastric motility.

Nowadays, it is well known the correlation between the abuse of alcohol and a variety of disease including hypertension, peptic ulcer, kidney stones, age-related macular degeneration, bone density, and cognitive function [73]. However, according to the recommendations of the Dietary Guidelines for Americans moderate consumption of alcoholic beverages may have beneficial effects on human health [74]. The famous sentence "*Omnia venenum sunt: nec sine veneno quicquam existit. Dosis sola facit, ut venenum non fit*" clearly states the importance of the dose for the product toxicity [75]. Indeed, in accordance with the Dietary Guidelines for Americans the alcohol beverages are recommended to be consumed in moderation, up to one drink per day for women (not in pregnancy) and up to two drinks per day for men, and only by adults of legal drinking age [74]. The supposed therapeutic effects of liqueurs might be associated with the presence of phenolic compounds. Several studies about liqueurs are based on the investigation of their chemical composition and in vitro antioxidant activity and vasodilatory properties of the alcohol beverages at different conditions of temperature and time storages, sugars and alcohol percentages [34, 76].

Threatened species

Over time, the massive harvesting has endangered some taxa in Italian regions. The continued, widespread, and intensive collection from the wild of the aerial parts of Alpine wormwood (*Artemisia* spp.) for the preparation of liqueurs should be seriously reconsidered in terms of sustainability, given the relative rarity of these species [77]. *Artemisia genipi* and *A. umbelliformis* are in the IUCN Red List of Threatened Species [78, 79] while *Gentiana lutea* subsp. *lutea*, and *A. genipi* are in the list of endangered species at least since 2013, year of publication of the updated Red List of Italian Flora [80, 81]. *G. lutea* subsp. *lutea* is also included in the Annex V of the Directive 92/43/EEC [82]. In South Tyrol *G. lutea* subsp. *lutea*, is under partial protection, meaning that permission for collection in the wild or use can be granted through exceptions issued by the regional authority [10]. In the Abruzzo, Lazio and Molise National Park at the onset of the last century *G. lutea* subsp. *lutea* was threatened by overharvesting in the wild to produce liqueur, so limits to exploitation of this species were set by law since 1920s [58]. *Artemisia genipi* and *A. umbelliformis* are also subject to regulated foraging in some Italian administrative regions (e.g., Veneto, Marche, Lombardy).

Conclusions

From our ethnobotanical findings, 130 plant species are used in Italy to aromatize spirits or prepare liqueurs and wine. These species are representatives of 35 families, the most cited of which are Rosaceae, Asteraceae and Lamiaceae.

This study expanded the existing knowledge regarding the cultivated and wild plants traditionally used in Italy for the preparation of alcoholic beverages. However, there is still a lack of understanding regarding the in vivo supposed therapeutic effects of moderate consumption of liqueurs. This ethnobotanical review provides the basis for future studies which should focus on extensive investigation of the supposed bioactivity, phytotherapy and as well as the toxicity of alcohol beverages.

Author contributions RM: conceived the research idea; compiled the literature sources, data analysis, and wrote the manuscript. GB: made a substantial contribution to data analysis and manuscript evaluation. BdF extracted relevant information regarding the phytochemistry, wrote the *Aperitif and digestive liqueurs* paragraph and made a substantial contribution to the manuscript evaluation. All authors read and approved the final manuscript.

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Availability of data and materials All data collected and analyzed in this paper are included within the article.

Declarations

Compliance with ethics requirements This article does not contain any studies with human or animal subjects performed by any one of the authors.

Conflict of interest All authors certify that they have no competing financial interests to declare that are relevant to subject matter or materials discussed in this manuscript.

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