UNIVERSITÀ DEGLI STUDI DEL MOLISE

Department of Agricultural, Environmental and Food Sciences

PhD Course in:
AGRICULTURE TECHNOLOGY AND BIOTECHNOLOGY
(CURRICULUM: SUSTAINABLE PLANT PRODUCTION AND PROTECTION)

CYCLE(XXXIII)

Related Disciplinary Scientific Sector: BIO/03 (Applied Botany)

PhD Thesis

WILD EDIBLE PLANTS IN ITALY. A DATABASE AND ITS APPLICATIONS IN DETERMINING FUNCTIONAL COMPOUNDS IN FIVE ITALIAN FLORA SPECIES.

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Academic Year 2019/2020

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Abstract

The alimurgic flora represents, for Italy, a strategic resource to which it is possible to associate numerous positive values: ecological, nutritional, socio-cultural, agri-food.However, this "intangible" patrimony, of inestimable value for Italy, is at great risk of disappearance, both because of the lifestyles imposed by progress and globalization, This is due to the lack of biological studies which quantify and document the alimentary use of these species.The information, in fact, sometimes substantial and well structured, refers to restricted territories that, at most, concern a regional scale.Although several studies on WEP have been published in Italy, one does not have a complete view of their knowledge.Therefore, this Thesis has been focused on two strands of research.The first concerned the design of a Database of the Italian alimurgic flora, with the aim of systematizing the wealth of the vast knowledge of WEP acquired in Italy over the last 100 years, creating an easy-to-read tool not only for purely speculative but also practical purposes (e.g. evaluate bioactive compounds).The design and population of the database were carried out through the discovery and analysis of the bibliographical resources of 358 works (books and scientific articles) from 1918 to the present day. From the analysis of the texts, only alimurgic species were considered, excluding occasional and cultivated alien ones. The analyzes relating to the number of entities have evaluated the part of the plant used, the method of use, the regional distribution in Italy, the chorotype, determining that most of the species are Mediterranean in character as the use of alimurgic species appears to be unbalanced in favor of the southern regions of our country, testifying to a use that is still well present.From the analysis of the biological forms, it has been found that the most frequent alimurgic species are the Emicriptofite (39%) and the Terophytes (25%).This result, considering the general habitus of these biological forms, is predictable as the most consumed parts are the leaves, the basal rosettes and the young shoots.The knowledge on the use of spontaneous edible species in Italy, amounted to 1103 entities, equal to 13.9% of the entire Italian floristic heritage.The most common family is that of the Asteraceae (20,22%); the most utilized species are *Cichorium intybus* and *Borago officinalis.*The non-homogeneous regional distribution of Weps has been interpreted (maximum in the south and minimum in the north).The published texts reached an exponential peak in the decade 2001-2010.In summary, it is important for Italian alimurgic plants to have a database, to be used with the aim of describing the richness of this knowledge, so it could also be a vehicle for development in the agricultural field.The second research area dealt with concerns the study

of five species *Crepis vesicaria* L., *Sonchus asper* L., *Sonchus oleraceus* L., *Tragopogon porrifolius* L., (Asteraceae), *Blitum bonus-henricus* (Chenopodiaceae).Commonly consumed in the Mediterranean diet, they have been examined for their nutritional composition and the content of carotenoids, tocols, thiamine and riboflavin.Analysis of the data shows that all species were found to be sources of xanthophylls (violaxanthine, neoxanthine, lutein, zeaxanthine and β-cryptoxanthine) and carotenes (α-carotene, β-carotene, 9-cis-βcarotene and 13-cis-β -carotene).Lutein accounted for the highest content (approximately 4 mg / 100 g).Furthermore, they possessed good amounts of tocols, in particular α-tocopherol (about 2-3 mg / 100 g).Therefore the analyzed plants can be declared as a source of fiber, vitamin A and E, considering the recommended daily allowance (RDA) established by the EU Regulation.All plants showed a good amount of thiamin, especially Crepis vesicaria.They can be considered a source of thiamine, while they are secondary to the riboflavin content.A preliminary survey was conducted for Sonchus oleraceus and Sonchus asper to assess the effect of domestic cooking (boiling, steaming) on the main carotenoids (lutein and β-carotene) and tocols.It has been found that leaching of soluble solids defined by domestic cooking causes a revenue in bioactive compounds studied in cooked vegetables, so as to cause an apparent increase in content in both specieThese data can be useful in promoting WEP as a niche market product for functional food development.

Riassunto

La Flora alimurgica rappresenta, per l'Italia, una risorsa strategicaalla quale è possibile associare numerosi valori positivi: ecologici, nutrizionali, socio-culturali, agroalimentari. Tuttavia, tale patrimonio "immateriale", di inestimabile valore per l'Italia, è fortemente a rischio di scomparsa, sia per via degli stili di vita imposti dal progresso e dalla globalizzazione, che per la scarsa presenza di studi organici che quantifichino e documentino l'uso alimentare di queste specie. Le informazioni, infatti, talvolta corpose e ben strutturate, rimandano a territori ristretti che, al massimo, riguardano una scala regionale. Sebbene, siano stati pubblicati in Italia diversi studi sulle WEP, non si ha una visione completa della loro conoscenza. Pertanto, la presente Tesi, è stata incentrata su due filoni di ricerca. Il Primo ha riguardato la progettazione di un Databasedella flora alimurgica italiana, con lo scopo di sistematizzare il bagaglio della vasta conoscenza delle WEP acquisita in Italia negli ultimi 100 anni, creando uno strumento di facile lettura non solo per finalità puramente speculative ma anche pratiche (ad esempio valutare i composti bioattivi). La progettazione e la popolazione della banca dati sono state eseguite mediante la scoperta e l'analisi delle risorse bibliografiche di 358 opere (libri e articoli scientifici) dal 1918 ad oggi. Dall'analisi dei testi, sono state considerate solo le specie alimurgiche, escludendo quelle aliene occasionali e coltivate. Le analisi relative al numero di entità hanno valutato la parte di pianta utilizzata, la modalità di utilizzo,la distribuzione regionale in Italia, il corotipo, determinando che la maggior parte delle specie è a carattere Mediterraneo in quanto l'uso delle specie alimurgiche risulta essere sbilanciato a favore delle regioni meridionali del nostro Paese, a testimonianza di un uso ancora ben presente.Dall'analisi delle forme biologiche, si è riscontrato che le specie alimurgiche maggiormente frequenti, sono le Emicriptofite (39%) e le Terofite (25%). Tale risultato, considerando l'habitus generale di tali forme biologiche, è prevedibile in quanto le parti maggiormente consumate sono le foglie, le rosette basali ed i giovani getti. Le conoscenze sull'utilizzo delle specie spontanee eduli in Italia, si attesta a 1103 entità, pari al 13,9% dell'intero patrimonio floristico Italiano. La famiglia più diffusa è quella delle Asteraceae (20,22%); le specie più utilizzate sono Cichorium intybus e Borago officinalis. È stata interpretata la distribuzione regionale non omogenea dei WEP (massimo al sud e minimo al nord). I testi pubblicati hanno raggiunto un picco esponenziale nel decennio 2001-2010. In sintesi, è importante per le piante alimurgiche italiane avere un database, da utilizzare con l'obiettivo di descrivere la ricchezza di questa conoscenza, per tale motivo potrebbe essere anche un veicolo di sviluppo in campo agricolo.

La seconda area di ricerca trattata riguarda lo studio di cinque specie *Crepis vesicaria* L., *Sonchus asper* L., *Sonchus oleraceus* L., *Tragopogon porrifolius* L., (Asteraceae), *Blitum bonus-henricus* (Chenopodiaceae). Comunemente consumate nella dieta mediterranea, sono state esaminate per la loro composizione nutrizionale e il contenuto di carotenoidi, tocoli, tiamina e riboflavina. Dall'analisi dei dati si può dichiarare che tutte le specie sono risultate fonti di xantofille (violaxantina, neoxantina, luteina, zeaxantina e β-criptoxantina) e caroteni (α-carotene, β-carotene, 9-cis-βcarotene e 13-cis-β-carotene). La luteina rappresentava il contenuto più elevato (circa 4 mg / 100 g). Inoltre, possedevano buone quantità di tocoli, in particolare α-tocoferolo (circa 2-3 mg / 100 g). Quindi le piante analizzate possono essere dichiarate come fonte di fibra, vitamina A ed E, considerando la dose giornaliera raccomandata (RDA) stabilita dal Regolamento UE. Tutte le piante hanno mostrato una buona quantità di tiamina, in particolare *Crepis vesicaria*. Possono essere considerati una fonte di tiamina, mentre sono secondari per il contenuto di riboflavina. È stata condotta per *Sonchus oleraceus* e *Sonchus asper* un'indagine preliminare mirata a valutare l'effetto della cucina domestica (bollitura, cottura a vapore) sui principali carotenoidi (luteina e β-carotene) e sui tocoli. È stato rilevato che la lisciviazione di solidi solubili definita dalla cottura domestica causa un ricavo nei composti bioattivi studiati nelle verdure cotte, in modo da causare un apparente aumento del contenuto in entrambe le specie. Questi dati possono essere utili nel promuovere le WEP come prodotti di un mercato di nicchia per lo sviluppo di alimenti funzionali.

Structure of the thesis

After an introduction illustrating the many qualities of WEPs, which often play a key role for different populations on Earth and the complex interrelations with different issues (health, agriculture, biodiversity), specific reference will be made to the themes that have been developed in this research, regarding the creation of a database of the Italian alimurgic floras and its website (***Section I***).The methods, results and conclusions related to the AlimurgITA database are reported in the publication: Design a Database of Italian Vascular Alimurgic Flora (Alimurgita): Preliminary Results (Paura et al., 2021) attached to this thesis. In a subsequent step, the results of the functional properties of 5 alimurgic species *Sonchus oleraceus* L., *Sonchus asper* L., *Crepis vesicaria* L., *Blitum bonus-henricus* L., *Tragopogon porrifolius* L., chosen as representative of traditional Italian cuisine but little or nothing investigated in their composition (***Section II***). These plants have been characterized by their centesimal composition and vitamin content, with particular reference to the content of B vitamins (thiamine and riboflavin) and fat-soluble vitamins (tocols and carotenoids).The results of the discussions and conclusions related to the nutritional composition of *Sonchus asper*, *Sonchus oleraceus* and *Crepis vesicaria*, are reported in the work attached to this thesis: Bioactive Compounds in Wild Asteraceae Edible Plants Consumed in the Mediterranean Diet (Panfili et al.,2020)This work therefore aims to bring new knowledge on alimurgic plants as a source of bioactive compounds and consequently promote the food use of these plant resources. Some paragraphs will be dedicated to WEPS as I think they are necessary to understand the background dealing with nutrition and with the functional characteristics where they fit. Therefore important issues concerning the anthropological and economical aspects of WEPs will only be hinted at because, although they are important, they would make the dissertation dispersive and distance the reader from the analysis of the set goals of this research. I have eventually chosen to go into greater depth on some topics which have not been suitably developed in previous works, albeit avoiding repetitions of what I have already written in the scientific works published during the doctorate course; reference will be made to them in this work and links will be highlighted.The hope of the writer is that this work serves in part to restore the complexity and charm of this interdisciplinary field in which our ignorance far exceeds the knowledge of our rich cultures of origin that are rapidly changing or disappearing, buried under an avalanche of indifference.

Introduction

1.1 The relationship between Man and wild edible plants

Gathering herbs and wild fruit has always accompanied Man's life on Earth and his diet. Nutrition, a vital function for the existence of mankind, is variously defined in every human culture as a set of fundamental practices, which can be summed up in the gathering, growing, keeping, preparing and consuming food. (Bellagamba, 1997). It has been able to take advantage of wild plants, whose gathering and consumption have taken different forms, in place and time and have been more or less important, from essential to residual.

Even though occasional in the past way of life, gathering wild plants and fruits for everyday cuisine, has never ceased to be one of activities carried out, even in our industrial and postindustrial society of the past century, retaining in some cases anthropological features not too different from earlier ones, in spite of the passing of time. The gathering of herbaceous plants was and is predominant. The most common culinary preparations, in ancient agricultural society were wild herb soups and stews, or at most spring omelets, or boiled herbs as a side dish; nowadays they allow for innovation and mix with the dominant gastronomical culture. Any place where the features of agricultural society have faded no longer than two generations away, still keeps some kind of traditional recipe in present use, or at least in the elders' memory.

In fact, several studies (Quave C. L., Pieroni, 2007; Hadjichambis et al., 2008) show that the consumption of wild plants is still a residual part in the traditional diets in limited areas of the Mediterranean and Near East; they also show that when they are traditionally consumed as medicine food, wild plants retain their beneficial effect on health. The progressive loss of knowledge and the overall reduction of the consumption of Wild Edible Plants (or WEPs) are part of the risk factors of the main “western” diseases (along with other well-known factors such as reduced physical activity); on the other hand, their potential benefits are subject to an important and ever wider area of biomedical investigation. Given the specific reference to traditional food culture, these investigations are carried out especially in areas which, historically and geographically, have remained relatively isolated from the more developed areas, and where certain types of food consumption have survived. (Pieroni 2001)

Further back in the past, at least till the end of the XIX century, wild plants have rarely sparked the interest of naturalists, agronomists and scholars at large. In the past thirty years, however, in Italy and all’over Europe, there have been plenty of ethnobotanical studies, sometimes presented as “the driving force” to bridge the gap between biological/biophysical sciences and social/anthropological sciences or to supply basic data in the field of all that currently goes under the name of “bio-cultural diversity”, which is progressively replacing the former concept of sheer biodiversity. In fact, in the ethnobotanical investigations present in the literature, much attention is paid to the relationship between popular traditions and geographic delimitation and socio-economic conditions. (Taffetani et al., 2015)

As far as publications are concerned, since 1990 there has been a proliferation of mostly territorial themed contributions; on the one hand they have kept witness of the survival of popular culture in the ehtnobotanical/ foraging beds; on the other hand, they suffer the lack of a national synthetic framework.

To optimize and verify the natural restoration processes carried out on spontaneous vegetation in uncultivated land, it is necessary to carefully study the natural sequences that support the development of the restoration phases. (Taffetani et al., 2003)

Furthermore, of particular importance was the use of bio-indicators based on flora and vegetation, which allowed the classification, evaluation and development of conservation policies for threatened natural and semi-natural habitats and species (Taffetani et al., 2009)

The awareness of this natural current limit in the field of foraging knowledge in Italy has given the impetus to collect, in one comprehensive overview, the enormous wealth of ethnobotanical knowledge of the Italian territory, which is currently scattered in a multitude of publications.

After consulting a great number of bibliographic sources, it is evident that WEPs contain as many, if not more, nutrients than the more widely available commercial crops (Fernández-Ruiz et al. 2016; Morales et al., 2014; Morales et al., 2016). Therefore, if suitably assessed and managed, WEPs could be regularly introduced in the diets which often focus on the quantity of staple food rather than on the actual nutrient content in industrial agriculture foods.

Applying this concept to the nutritional system known as “Mediterranean diet” (Keys, 1975), even though it is qualitatively important, it is still hardly known and correctly assessed by nutritionists and food system historians (Łuczaj et al. 2012; Pieroni et al. 2005; Rivera et al. 2006). Therefore, it is crucial to know the nutritional composition of wild edible plants and their processing techniques; in fact, assessing these aspects is as important as making a list of the species, as indicated by Jacob e Albuquerque (2020).

Complete data on food composition are therefore a first critical step. (McBurney et al.2004; Flyman & Afolayan 2006; Frison et al.2006). However, understanding the micro and macro nutritional properties of wild foods is currently quite far behind cultivated species (Vincetti et al. 2008).

To date, the data of the safety of WEPs use in dietary supplements are scarce because only a very limited range of plant species have been studied in depth and large arrays of species are only tentatively listed (ESCO workgroup on botanical products and botanical preparations, 2009).

Scientific researches have focused on a limited number of species, bypassing a great many which, due to their frequent consumption and territorial spread, can be considered as key ingredients in popular Italian cuisine. We have focused on five of these species, aiming at filling this wide knowledge gap.

1.2 The importance of wild foods

According to FAO estimates, about "one billion people use wild foods in their own diets" (Aberoumand, 2009). WEPs keep playing a crucial role in the survival of many human populations especially when food crops are scarcely available, when family budget does not guarantee the purchase of enough food, or when access to markets is difficult (Bharucha, Pretty, 2010; Heywood, 2013; Asprilla-Perea, Díaz-Puente, 2019; Broegaard et al., 2017; Carvalho, Barata, 2016).

Forests, for example, provide food and sustenance for about 300 million people through non-timber forest products (NTFP). Generally, food safety and NTFPs are strictly connected in rural communities, especially as regards the most vulnerable groups (Belcher et al. 2005) also found in farming communities. (Vincetti et al. 2008).

An important aspect of the use of wild foods concerns the poorest families, as they are their most important means of support. Thorough studies, however, do not show direct univocal correlations between the wealth and use of resources (de Merode et al. 2003; Allebone-Webb, 2009) because of the relevance of a number of context specific social and economic factors (for example price, individual or cultural preferences and wealth).

Beyond financial resources, wild foods are also an integral part of traditional food systems and have a high cultural and nutritional value for many populations, especially natives.

(Heywood, 1999; Bharucha, Pretty, 2010; Kuhnlein, 2009; Kuhnlein, 2017). Being deeply linked to their land, the native populations, which represent 5% of the world population (United Nation, 2019), are often the only keepers left of a whole knowledge – hereby rich and diversified- about the use of plants and about traditional food systems, and the existing local dietary biodiversity.

In many European areas, in spite of the gradual abandonment of traditional practices and the changes in lifestyle, partly brought about by market pressures, the interest for the gathering and use of WEPs has recently been rekindled, especially in urban areas. (Tardío, 2005).

WEPs are usually sold in local markets, especially in the Mediterranean countries, such as Italy, Croatia, Greece, Spain and Turkey. (Dogan et al., 2013) but they are also starting to be available from health food stores in many European countries (e.g. Italy, Spain, France, Poland, Estonia). They offer food products made of or supplemented with wild plants for example coffee made from Cichorium intybus roots, Taraxacum spp., syrups and pasta made from powder from *Urtica* spp.

At the same time, new gastronomy trends and experimental cuisines, within a number of business ventures, have shown a growing interest for wild foods, drawing on the WEP repertoire.

Functional foods belong to this context; they are an important tool available for consumers to reach their own health goals,

However, in spite of the (almost exponentially) growing interest, the physiological meaning of WEP consumption is largely unexplored (apart from some exceptions described by Heinrich et al., 2006b; Schaffer et al., 2005).

In fact, the actual impact of a regular consumption of these foods is not known as regards the prevention of preventable chronic food related diseases.

In general, spontaneous plants tend to have a higher content of micronutrients and bioactive secondary metabolites compared to their cultivated counterparts. (Heinrich et al., 2006a, 2006b). Several studies have indeed shown that wild vegetables often contain high concentrations of minerals, proteins, high levels of vitamin A and vitamin C and significant percentages of fiber, often higher than in cultivated vegetables. (Aberoumand and Deokule, 2009; Amirul Alam et al., 2014; Guil Guerrero et al., 1998).

Wild edible plants generally feature a wide range of vegetal secondary metabolic products such as polyphenols, terpenoids, polysaccharides, and so on, which make them good prospective "nutraceutics", that is to say functional food containing potentially healthy ingredients.

More than mere food, WEPscan be proto-dietary supplements with possible cardio- and chemo- preventive properties. (Visioli e Galli, 2001; Visioli et al., 2004), for example through the modulation of the microbiota (Goulet, 2015) or through nitrate supply (Bondonno et al., 2015).

These properties considered, the market for functional foods and nutraceutics is constantly growing so much so that it reached a total turnover of 43 billion euro in 2017 (Marone et al., 2018).

However, data on the safety of WEPs use in dietary supplements is scarce because only a very limited range of plant species have been studied in depth and large arrays of species are only tentatively listed (ESCO workgroup on botanical products and botanical preparations 2009).

The metabolic pathways of WEPs can also produce toxic compounds, which must be detected in order to safeguard humans' and animals' health. (Mohan e Kalidass, 2010).

Lastly, we must bear in mind that WEPs can also contain high levels of toxins drawn from the environment. It is important to make sure that plants used for human and animal food are gathered from safe grounds considering that many of these species have a high potential for bioaccumulation of toxins, which could be exploited in the phytoremediation of contaminated soils.

Apart from those strictly linked to human food, the functions of WEPs, can also add other agriculture related practices and activities such as:

(i) domestication of wild species.

(ii) management of wild species and their habitats within and around production systems to promote the supply of ecosystem services.

(iii) introduction of wild species in production and consumption systems, for example by creating a demand for given species and regulating their harvesting in the wild.

WEPs could also be central to the efforts to empower local market players, as well as to bridge the gap between consumers and producers and the excessive dependence on lengthy centrally and globally managedsupply-chains.

Although a recent research by Kinnunen et al. (2020) points out the impossibility to localize the production of important global staple food, such as rice, corn and cereals, there is growing evidence that the local trade of minor crops, traditional varieties and WEPs can empower communities and increase means of support in rural areas, especially for women and young people (Padulosi et al., 2015; Shackleton et al., 2011).

In the meantime, the COVID-19 crisis has revealed how much our global food systems are sensitive to the upheavals and shocks connected to the disease (Torero, 2020; HLPE, 2020; Béné, 2020). For example, travel restrictions imposed on people and goods have caused logistic bottlenecks in the food supply chains. (Fernandes, 2020).

Because of international and national trade restrictions long supply chains have struggled to cope with the increased demand for nonperishable food supplies (United Nations, 2020) while short supply chains have suffered when local and informal street markets closed down (Vandebroek, 2020); this is where most of the world population still gets fruit, vegetables and other perishable goods. (United Nations, 2020; Cappelli, 2020).

At the same time, the Covid pandemic has offered opportunities for a new paradigm in the food system, which supports local self-reliance and domestic farming production; it also regards home gardens and community gardens, the traditional agroecosystems and farmers‘markets as essential services. (Vandebroek, 2020; IPES, 2020). As food shortage hits high value specialized vegetable crops (Poppick, 2020), people are addressing traditional vegetables and WEPs as a sustainable source of vitamins and nutrients (Mururia, 2020), let alone herb based ingredients, traditional medicine formulas and new biopharmaceuticals. (Vandebroek, 2020; Giuliano, 2020; Timoshyna, 2020).

1.3 Wild edible species and human health

Although science still tends to consider nutrition and pharmacology as separate elements/topics, popular wisdom in the Western world and in other cultures all’over the globe see them as overlapping and complementary. Countless examples are available in support of this mindset and behavior. Tibetans have long since acknowledged the medicinal properties of food and have codified them in an XVIII century work dealing with the dietetic principles of health and healing. Vietnamese farmers use about half the food plants gathered in the wild also as medicine and a similar behavior has been recorded for many Grecanica and Abresche speaking areas in Basilicata and Calabria. (Quave, Pieroni, 2007; Pieroni et al., 2002)

Therefore, in every age, at least since agriculture became able to supply plentiful harvests in relation to the population to feed, in times of plenty, wild plants and fruits have been regarded as the exception, good only for the times of shortage (only for the most destitute country people) or connected to some specific religious rituals. Herbs and fruits could at most be taken into consideration for being freely and effortlessly available and destined exclusively for therapeutic uses. After all, the herbs that tradition called "good", not so long ago, were the only possible medicine for the poorer and quite a few plants were eaten mainly to prevent minor discomforts which are now addressed by functional foods.

Revisiting historically the functional links between food and medicineup to our time helps shedding light on this topic returning, albeit minimally. the rich casket of knowledge sedimented in the Italic culture.

1.3.1 WEPs and health: historical use in the Greco-Roman culture

In the gastronomical culture of Ancient Rome, vegetables, second to cereals and pulses, played a particularly important role. The Romans' diet, based on fruit and vegetables should however be considered in its historical evolution, so it was not always the same. The initial phase was characterized by wild plants and fruit gathering, followed by a phase of cultivation within private gardens. Before the advent of agriculture, the Romans used to eat shrub shoots such as *Vitis vinifera* subsp. *sylvestris* or *Dioscorea communis*. In fact, the branches of these plants were kept as food intake. Asparagus were also greatly appreciated by the Romans. Moreover, they grew in such quantity in the wild all'over the Italian territory that there was no need to grow them. They also knew about a hundred of edible plants including *Urtica dioica* (Nettle); actually, it was widely believed that eating nettle in spring would protect from diseases for a whole year. (Ref. Pliny., N.H., XXI, 93). Wild edible plants and wild fruits were an important supplement to the daily diet. Autumn was the time to pick berries, wild fruits and chestnuts on higher grounds; thanks to their nutritious qualities they could partly substitute cereals. Actually, cultivated plants and wild plants alike often had supposed therapeutic properties and effects, or more simply a carminative function. In spring, the gathering focused mainly on cleansing plants; they were useful after the winter diet based mainly on preserved food, therefore poor in vitamins. An important role on the Romans' tables is held by *Brassica oleracea* (Cabbage). In his "De agricultura" Cato describes it as the principal vegetable, and recommends to eat it not only cooked but also raw, macerated with vinegar and highly praises its purgative and diuretic properties, as well as its easy digestibility.

In fact, he claimed that cabbage was a kind of universal panacea, especially the crispy leafed one, which was supposed to be useful to treat sprains, wounds and so on. (Alberto Jori 2016). Cato does not build his conviction only on the Romans' empirical knowledge, as he was well learned about notions from Greek medicine. For his part, Pliny mentions not only that the Greek also used cabbage against drunkenness but also that the Greek physician Chrysippus had even written a treatise exclusively devoted to its therapeutic properties.

The artichoke (*Cynara cardunculus*), was also particularly appreciated and recommended for its digestive qualities. It must be considered that the species the Romans knew and ate were rather different from those we use nowadays; artichokes, for instance, did not have a developed heart as modern artichokes have. Therefore, whereas we eat the heart and the softer part of artichoke leaves, the Romans, like the Greek, ate only the outer part. *Portulaca oleracea* was already well-known for its medicinal properties in Ancient Greece and Ancient Rome. In fact, it is mentioned by Greek physicians, like Hippocrates, Dioscorides and Galen, who had always considered it as an edible plant and the Roman agronomist, Columella, wrote down a recipe to preserve its leaves and fruits. (Manzi 2020)

Drawing a parallel between the Roman and Greek gastronomic cultures, we cannot help noticing analogies. Infact, in Greek culture too staple food was mainly wheat, barley and vegetables. The importance of the concept of diet and nutrition dates to the Greek physician, Hippocrates. In the treatise On Diet in the Corpus Hippocraticum, which includes about seventy texts written between mid-V century and mid-IV B.C., Hippocrates mentions first of all barley and barley bread, together with stews based on this cereal, like maza (barley flour diluted in water, oil, honey or milk).

The interest of ancient scholarsin diet is confirmed by Galen; in his treatise titled "The slimming Diet" (Peri leptynouses diaites) published around 180 A.D., he gives information which are still up to date. He suggested that "vegetables are better than cereals, not to exceed with meat and limit dairy products." After all, as Galen wrote, "diet is medicine's most powerful weapon."

1.3.2 WEPs and health: current use

In recent years, new consumers' demands and the interest of markets in varieties of innovative products, have sparked a particular attention in developing research aiming at improving the technological characteristics of agricultural products. Among the characteristics sought preference is given to those supporting the healthy qualities of the products. This is because, especially in the most developed countries, modern food diets have brought about the spread of chronic degenerative diseases of the human body. (Ness e Powles, 1997). In fact, a number of studies conducted on individuals belonging to populations from countries with different food cultures from different geographical areas, have documented that the onset of cancer depends on risk factors linked to life style, for example, the prolonged exposure to carcinogenic substances in the environment and in food, as well as to a sedentary lifestyle and a diet rich in calories, simple sugars, proteins and refined food but poor in natural food such as fruit and vegetables. The worth of many natural compounds in preventing the onset of malignant tumors has been substantiated by epidemiological studies (Kaur e Kapoor, 2001). Vegetables and fruit contain phytochemicals which can prevent DNA damage associated to the degeneration of reactive oxygen compounds; these phytochemicals protect our body because they limit the metabolic activation of carcinogens thus regulating the activity of detoxifying enzymes; moreover, they inhibit inflammatory processes and cell proliferation, inducing the cancerous cells into molecular mechanisms leading to cell cycle arrest or to apoptotic death.In 2016, the World Health Organization has published the data from the Global Health Observatory (GHO), showing that heart diseases and ischemic strokes cause 15.2 million deaths. Therefore, the introduction of these plants in modern diets might increase dietary fiber and bioactive compounds intake. Many of these compounds have proved to have an antioxidant activity associated with health benefits such as reducing cardiovascular diseases and the incidence of many types of cancer, as well as protecting from chronic diseases.

Of course, in spite of the doubtless virtues of nutrient-rich wild plants, it is important not to underestimate the presence of potentially toxic substancesthat some vegetal species produce as defense mechanisms (Pinela et al., 2017), and which are therefore dangerous for human health (not all things natural do Man good).

1.4 WEPs and genetic biodiversity

Food safety has become dependent on a handful of widely cultivated species. Over 50% of the world daily need for proteins and calories comes from three crops: wheat, corn and rice. (Jaenicke & Hoschle-Zeledon 2006); 12 species make up 80% of the overall food intake.

On the contrary, wild foods supply a larger dietary diversity to those who rely on them. Ethnobotanical surveys of wild plants show that over 7,000 species have been used in human diets at some point in history. (Grivetti & Ogle 2000).

Besides their health-related properties, WEPsare therefore a priceless reservoir of the genetic assortment of crops and of biological diversity at farm level. WEP species and varieties feature a wide genetic variation as well as a typical resilience to droughts and climate changes, apart from being resistant to pests and diseases, as they have passed through the bottleneck of domestication (Dempewolf et al., 2014).

As they are often crop wild relatives (CWR), WEP species can play an important role in the breeding of crops towards greater adaptability and resilience. WEPs can also be tested as sources of new domesticable plants to grow in farms. (FAO, 2010).

The introduction of new vegetable crops is an important contribution towards the diversification of agricultural production at more levels. Revitalizing the usual cultivated plants by incorporating the wild germplasm and ensuring the genetic diversity of the newly domesticated species could improve their nutritional value and resistance to diseases, parasites and weeds.

Kitchen gardens are particularly important for many small landowners and are noticeably different, sometimes containing over 200 useful species (Galluzzi e Negri, 2010).

Some highly regarded species in the past, such as wild parsnip (Pastinaca sativa L.), purslane (Portulaca oleracea L.), common malva (Malva neglecta L.) and garden cress (Lepidium sativum L.) have lost their importance as source of nourishment, have been cast aside or even completely forgotten

Some have been naturalized and grow in ditches or along cultivated grounds, as evidence of their past agricultural use, while many of them feature as weeds.

However, these species have played an important role in human evolution and nowadays, they are an important source of health beneficial ingredients, and an opportunity for the diversification of crops in inorganic farms (FAO, 2010). FAO (op.cit.) acknowledges that "nutrition and biodiversity converge towards a common pathway leading to dietary safety and sustainable development " and that "wild species and intraspecific biodiversity play a key role in global nutritional safety ".

Accumulated evidence show that wild edible plants yield substantial benefits for the health and economy of developing countries (Shumsky et al., 2014).

While WEPsshow such a great potential to improve dietary safety, nutrition, welfare and agrobiodiversity, there is a significant lack of data about their conservation, variety termination and genetic erosion.

Available data often lack an accurate quantification, are anecdotal or are based on variations in nomenclature rather than on actual genetic variations (Maxted et al., 2011). Many WEPs and their ecotypes are threatened by the loss, dilapidation and fragmentation of their natural habitats, which tend to be disturbed, as happens for the field margins, forest edges and roadsides and they are also threatened by competition from invasive alien species.

Furthermore, a recent research has pointed out that wild edible species are becoming less and less represented in field gathering all'over the world. (Maxted e Kell, 2007).

1.5 WEPs and Crop Wild Relatives (CWR)

Scholars agree that agriculture may have started in some tropical and subtropical regions during the Neolithic age, roughly between 12,000 and 6,000 B.C.This decisive step for mankind helped create the dichotomous categories of domestic or cultivated plants vs wild plants, the borders between these categories are sometimes rather vague and quite variable in place and time.Both categories are the result of the domestication process of more and more new species and of the creation of hybrids, and, on the opposite end, of the wilding of other species.Both processes are still running before our eyes, especially the first one, if not in numbers at least in importance.Over the past centuries, the long-lasting course has largely benefited from the continuous progress of scientific knowledge and of more and more complex and advanced techniques, making an ever-greater number of species substantially “dependent” on human action.Agriculture was, however, a choice that not all peoples decided to make and surely not all of them made the decision at the same time.Nowadays, those who base their survival mainly on gathering in the wild are a very small part of the world population and live mostly in outskirt environments.We generally refer to Australian aborigines, Central African pygmies, Andaman populations, bushmen and so on.

Proof of the fact that the advent of agriculture did not mean giving up phytoalimurgy completely is the wealth of findings of fruit and vegetables in Mesolithic and early Neolithic sites; this suggests that these products were gathered in the wild and used for dietary purposes. (Castelletti, 2001)

Based on these findings, it is possible to hypothesize continuity in gathering, meaning that wild plants and fruit had a crucial role in human nutrition. With the beginning of agriculture, Man started to prefer easy to grow species which ensured suitable crops, excluding those now called wild plants and weeds; thanks to agriculture, Man went from nomadic to sedentary and the first communities started to develop. (Montanari,2005). Thus, Man ensured a greater quantity and continuity of food supplies, guaranteeing sustenance for the rural communities. However, the cultivated products did not always succeed in satisfying the dietary needs, so Man went back to gathering wild species in case of famines caused by several factors. This goes to show that WEPs have been, and still are in some parts of the world, a necessary resource for man's life. Rich in nutrient bioactive substances, they were the staple diet of our forefathers, representing for over 190,000 years, the main source of fiber, vitamins, and antioxidants. (Cortes Sánchez-Mata et al., 2016). Several studies document that the consumption of wild plants is still part of the traditional diets in limited areas of the Mediterranean and Near East; they also document that wild plants, when regularly taken as medicine food, keep performing their beneficial activity on human health (Quave, C. L., & Pieroni, A. 2007; Hadjichambis et al., 2008). The areas of origin and differentiation of cultivated species have been identified in Asia, in the Mediterranean basin, in the Balkans, Middle East, Central and South America and in Africa; anyway in geographic areas characterized by temperate climate (Vavilov, 1926). Over the years, the centers of origin indicated by Vavilov underwent changes, but all the classifications so far displayed indicate the Mediterranean Basin as an important area of origin of present species of horticultural interest (Zhukovskij, 1968). According to Vavilov (1926) the species which surely originated in the Mediterranean Basin are: *Allium cepa* L.*; Allium kurrat* Schweinf.; *Allium porrum* L.; *Allium sativum* L.; *Anethum graveolens* L.; *Anthriseus cerefolium* Hoffm.; *Apium graveolens* L.; *Asparagus officinalis* L.; *Beta vulgaris* L.; *Blitum rubrum* Rchb.; *Brassica campestris* L.; *Brassica napus* L.; var. rapifera Metzg.; *Brassica oleracea* L.; *Cichorium indivia* L.; *Cichorium intybus* L.; *Crambemarittim*a L.; *Cynara scolymus* L.; *Lactuca sativa* L.; *Lepidium sativum* L.; *Pastinaca sativa* L.; *Petroselium sativum* L.; *Portulaca oleracea* L.; *Rutagraveolus* L.; *Rheum officinale* Boill.; *Rumex acetosa* L.; *Satureja hortensis* L.; *Scolymus hispanicus* L.; *Smyrnium olusatrum* L.; *Tragopogon* *porrifolium* L. The presence in a given territory of plants that are suitable for human diets, and fit for domestication and cultivation, is a resource with an extraordinary incalculable potential.Over the ages, farmers have selected plants containing few toxic metabolites such as alkaloids, saponins, tannins and other phytochemical antinutritional compounds to make them suitable for human diet. Kaplan, 1965), for example several pulses of the old and New World. The anthropic selection occurred to eliminate in some plants, like the wild artichoke (Cynara cardunculus L.), the presence of thorns and quills. Besides, plant selection also enabled crosses between different cultivated species and what we define as crop wild relatives (CWR); this form of hybridization led to the selection of new cultivated plants, often with a greater number of chromosomes (polyploid). They are often vegetal species which formed through hybridization between different species.

CWR populations contain the adaptive genes necessary to develop new varieties due to the great wealth of habitats in which they grow and the wide range of conditions to which they are adapted, therefore their genetic diversity gives a guarantee against the harmful impacts expected from climate change on biodiversity and food safety. (Magrini et al., 2016) Many of the plants cultivated today were, when agriculture began, mere weeds in wheat or spelt fields. One example is Oats or Rye, from which Avena sativa L. and Secale cereale L. were successively selected (Vaviliv, 1992). Also, other domesticated species economically interesting as the ones belonging to the genus *Vicia*, *Lathyrus*, *Sinapis* o *Brassica*. On the other hand, species which used to have a role in cultivation are now considered as garden weeds like *Portulaca oleracea* L. (Purslane), and*Borrago officinalis* L (Borage). Surely, we can affirm that the process of domestication and cultivation of new species is a continually evolving course.

1.6 Alimurgic plants and bioactive compounds

WEPs generally contain a wide range of metabolites, which makes them excellent functional products.

Recent studies based on the action of WEP extracts with in vitro human cells, have clearly shown the presence of potentially beneficial active principles and have pointed out the added value for our health. (Akram et al., 2014; Al Akeel et al., 2014; Gu et al., 2014; Liu et al., 2015; Mohammadi et al., 2013). However further research will be necessary to investigate this potential (Esco group work on botanical products and preparation, 2009; González-Castejón et al., 2012; Lozano-Baena et al., 2016; Bacchetta et al., 2016).

Beside the increasing awareness of the impact of chronic diseases, such as cardiovascular diseases (CVD), diabetes and canceron global health, many scientific studies are proving that a diet based on fruit, vegetables and cereals helps prevent these chronic diseases from developing. (Kyro et al., 2013; Mursu et al., 2014; Yamada et al., 2011).

Many traditional diets already introduced wild plants as a rule; their constant regular intake has been an important element of the Mediterranean diet. (Leonti et al., 2006). It is common knowledge that a large intake of vegetables, fresh fruit and wholegrain cereals, as well as the daily use of extra virgin olive oil ensure a huge source of minerals (e.g. calcium, magnesium, iron), essential fat acids and fiber, bioactive compounds such as carotenoids, B vitamins, a greater amount of vitamin C (Eaton e Konner, 1985), phenols and other antioxidants (Guarrera e Savo, 2016, Licata et.al, 2016, Pinela et al, 2017, Zanotti et al., 2012 Leonti et al., 2006; Heimler et al., 2007; Tabart et al., 2008),which complement and improve our diet.

Although qualitatively important, the Mediterranean diet is still poorly known and hardly correctly assessed by nutritionists and food system historians. (Łuczaj e Pieroni 2016; Pieroni et al.2005; Rivera et al.2007). Consequently, it is crucial to be aware of the nutritional composition of wild edible plants and of their processing techniques. In fact, it is as important to assess these aspects as to make a list of the species, as suggested by Jacob and Albuquerque (2020).

This protective role is ascribed to phytochemicals, defined as bioactive non nutrient compounds in fruit, vegetables, cereals and other plants. (Wang et al., 2013). So far about 10,000 phytochemicals have been identified but a large percentage is still unknown.

Identified phytochemicals include tannins, flavones, triterpenoids, steroids, saponins and alkaloids. (Barbosa et al., 2013). Their protective role may be associated to their antioxidant activity since overproduction of oxidants (oxygen reactive species and nitrogen reactive species) in the human body is involved in the pathogenesis of many chronic diseases. (Chiva-Blanch e Visioli, 2012; Visioli, 2015).

The concentration of these compounds in wild plants varies widely within the different botanical families and is also influenced by a variety of factors: growth, humidity, sun exposure, moisture balance, soil condition, plant metabolism and parts. (Camara et al., 2016).

Recent acquisitions about Mediterranean dietas regards wild edible plants, focus on the Asteraceae, which represent most of the plants consumed for their fresh tender leaves as salad greens (Petropoulos, Ntatsi, Levizou, Barros e Ferreira, 2016) or as vegetable mix. (Guarrera e Savo, 2016).

For example, *Cichorium intybus*inulin in addition to a purine rich diet pattern –which could help develop hyperuricemia, hypertriglyceridemia and abdominal obesity– has proved to decrease serum uric acid, triglycerides and excess abdominal fat deposit in a hyperuricemia quail-shaped model by altering the expression of acetyl CoA carboxylase protein and the activity of xanthine oxidase and fat acid synthase. (Lin et al., 2014).

Furthermore, *Cichorium intybus* extract has proved to protect efficiently from CC14-induced hepatic fibrosis in rats, suggesting that it could be an antifibrotic agent (Li et al., 2014).

Recent scientific acquisitions have confirmed functional activities already empirically known in popular culture broadening in some cases the range of their health beneficial activities, for example for *Plantago major* (Reina et al., 2013), *Portulaca oleracea* (Ji et al., 2015) and *Urtica dioica* (Johnson et al., 2013; Akrametal., 2014).

The crude extract of *Borago officinalis* leaves has proved to possess antispasmodic, bronchodilator, vasodilator and cardio-depressive activities (Gilani et al., 2007). Moreover, dietary supplementation with B. officinalis essential oil alters the levels of polyunsaturated fat acids 20-22 C and decreases the production of leukotrienes consistently with a reduction of inflammation (Arm et al., 2013).

The chemical composition of native species has therefore gained great interest in past decade studies thanks to the increase of demand from the food industry and from fresh bioactive compound-rich functional food consumers (Albuquerque et al., 2018; Backes et al., 2018; Giacometti et al., 2018). Among the most studied foods we find seasonal vegetables belonging to the Brassicaceae family, which includes about 4,000 species. A representative example is broccoli: apart from being “natural functional” food (because they are rich in vitamins, minerals and antioxidants), they have also been selected for the creation of cultivar enriched with glycosylates, phytochemicals with supposed anticancer properties.

1.7 The uses of WEPs in Europe

According to the Food and Agriculture Organization (FAO), over 100 million people in EU (that is 20% of the population) eat wild plants, while 65 million (14%) gather some kind of wild food (Łuczaj et al.,2012; Schulp et al.,2014). As regards how wild edible flora is used in Europe, about 1,600 wild species, representing 13% of the whole flora (Couplan 1995, 2009) have been taken into account for the Mediterranean region (Le Floch 1983; Ertug 2000, 2004; Dogan & al. 2004; Della & al. 2006; Pardo de Santayana e al. 2007; Hadjichambis & al. 2008). In the Eastern Mediterranean, on the other hand, WEPs (Rivera et al. 2006) are estimated to amount to 2,300 species. (Rivera et al. 2006, Leonti & al. 2006). However, according to EU BiodivERsA program the alimurgic flora of 17 European countries amounts to 592 WEPs. These figures show inconsistency between the number of species existing in Europe and those spread over the Mediterranean area. It is therefore necessary to census the edible flora to elucidate these discrepancies. Moreover, we need to understand whether strict criteria are applied to bring wild edible plants to their original meaning. When consulting different texts, we gather differing information, it is therefore necessary to work out whether the time frame has been selected or what is being considered to identify WEPs. Because of the great interest sparked for WEPs, several studies have been carried out on the folk tradition of different countries. (e.g. Italy, Paoletti et al., 1995, Pieroni et al., 1999, Pieroni A., 2001, Pieroni et al., 2002, Pieroni et al.,2005, Guarrera PM. 2003, Picchi et al,.2005, Guarrera et al., 2006, Ghirardini et al., 2007); (Spain, Tardio et al., 2005, Tardio et al., 2006, Bonet et al., 2002, Rivera et al.,2005, Menendez-Baceta et al., 2012); (Greece, Della et al.,2006, Forbes MHC 1976); (Poland, Łuczaj et al., 2007, Łuczaj et al., 2010, Kujawska et al.,2010); (Portugal, Pardo-de-Santayana et al.,2007, Carvalho et al.,2010); (France, Marco et al.,2006); (Bosnia-Herzegovina, Redzic S. 2006); the whole Mediterranean area (Leonti et al., 2006, Hadjichambi et al., 2008); (Austria, Christanell et al.,2010, Schunko et al., 2012); (Slovakia, Łuczaj L. 2012). Out of the WEPs utilized in traditional uses, about 2,000 are currently placed on the market; 60-70% come from Central Europe.Up to 90% of these species are still gathered in the wild. (Rodina K., et al., 2014). In many cases, ethnobotanical studies reveal a dramatic or progressive loss of knowledge and traditional practices. (Sõukand et al., 2011). Traditional knowledge about the properties and uses of many of these wild species has been lost since the mid XX century. A series of reasons, for example, the ever-changing lifestyle choices, the sprawling urbanization, a type of large-scale agriculture, a more remote contact with Nature and many others have led to a gradual decline. Furthermore, these plants are sometimes gathered in an unsustainable way, thus leading to another step backwards in wild harvest as an important source of employment and income for long-term vulnerable groups.

1.8 WEPs state of knowledge and heritage in Italy

In the past years, as regards the situation of alimurgic flora in Italy, based on recent publications (Pieroni, Picchi, 2005; Guarrera, 2006; Tomei et al., 2006) and updates (CET computerized database, Centro Etnobotanico Toscano), the number of edible species reaches 828 for dietary and aromatic uses as well as in making liqueurs including a number of cultivated plants (Caneva et al., 2013). The number of WEPs is therefore considerable, witnessing a high level of territorial biodiversity. In Sicily, for example 277 species of wild edible plants are gathered for culinary uses (Geraci et al.,2018). In Sardinia harvested WEPs amount to 10% of the regional flora (Camarda et al.,2017). In Apulia about 214 wild edible plants are used in traditional cuisine, against 204 in Northern Italy, 193 in Central Italy and 398 in Southern Italy (Biscotti et al.,2018). These data show a strong attachment of Southern Italian people to the use of wild plants in culinary tradition. Many typical dishes come from tradition, with a variety of recipes featuring wild plants in the dishes from the different Italian regions. In Friuli, *"pistic"*, a dish made of wild plants, is prepared with 56 different species. (Paoletti, Dreon, Lorenzoni,1995); while in Abruzzi, "*le fuije"*, a dish of the peasants' tradition, is prepared with plants of the *Sonchus, Picris, Crepis, Reichardia*, genus, cooked and mixed with unleavened corn or wheat dough.(Manzi 1999); In Molise, a typical traditional dish, called "*pizza e minestra*" is prepared with several wild herbs and a corn flour pizza (Di Renzo 2011); in Latium "*acquacotta*", a soup prepared with *Cichorium intybus* is quite renowned (Guarrera et al., 2004); while in Tuscany, the "*Terrana*", a herb soup, is traditionally eaten (Pieroni A. 1999). All the Italian regions appreciate omelets made with the spring shoots of different species, first of all with the spears of wild asparagus (*Aspargus acutifolius*), which can locally be replaced by the shoots of clematis (*Clematis vitalba*), hop (*Humulus lupulus*), sarsaparilla (*Smilax aspera)*, bramble (*Rubus sp.pl.)* and nettle (*Urtica sp.pl*.). Wild plants are also eaten in cities, where peasants 'markets offer a good variety of alimurgic plants gathered in the wild, to be used for cooking. The species commonly found on the markets include *Reichardia picroides*, species of the following genus: *Sonchu*s, *Cichorium intybus*, *Humulus lupulus*, *Blitum bonus-hericus*, *Muscari comosum*, and many more. These data confirm how much Italy is obviously traditionally attached to the use of wild edible plants.

1.9 A brief history of Phytoalimurgy in Italy

The use of wild plants as food in our modern western society food cultureobviously follows logics and needs which are completelydifferent from those of the rural society of the past. The alteration has occurred through a slow progressive change completed roughly in the past 150 years, as society was getting free from food shortage, but relatively fast, considering the long centuries when wild plant consumption essentially addressed the need to quell hunger and all its implications. Their use, albeit with different tones and different essentiality profiles according to place and the historical moments, was for many centuries, crucial for the survival of a great many people all'over Italy.

The consumption of wild plants has long and unanimously been considered as typical of peasant diet.This substantially true consideration does not actually lack shades, which we will, however, overlook saying only that they are relevant mainly because they have helped differentiating and enriching food cultures and local traditions; nowadays the differences lend interest to the ever wider line of investigation on residual dietary and cooking uses which have concerned all the Italian regions for the past decades.Theextremely limited number of publications which could be mentioned, especially if compared to the countless agricultural publications is per sé an example of the scarce attention the topic receives from high culture, the elite expression and practically the only one to leave written documents.It dealt simply with peasants' matters and there seemed to be no reason to take them into consideration at least until the recent past.

In every age, at least starting when agriculture became able to yield plentiful crops in relation with the population to feed, in times of plenty the use of wild plants and fruits was the exception, good for the years of famine or only for the most destitute country folk. Plants and fruits could be taken into consideration at most because they were available at no cost nor effort and only therapeutical use obviously did not make any difference between times of plenty and times of famine. In the Roman times, for example, at least in the centuries when the extension of the colonies assured Rome of daily food resources, the use of wild plants appears strictly marginal, limited to the people living in the country or on the edge of the city, even though Roman agronomists did not fail to consider wild plants, distinguishing them according to the cultivated lands on which they grew.We can reasonably hypothesize, albeit without any written proof, that this must have lasted for centuries.At the close of the Middle Ages gastronomic topics became reasoning topics no less than agricultural topics, but cookery books dating from XIII-XIV century were rare, written by cooks for other cooksin the service of various noblemen. To find a list of wild plants fit for food consumption, in raw salads, it is necessary to wait for Bartolomeo Sacchi, a humanist known as Platina, not actually a cook; in his famous *De honesta voluptate et valetudine*, printed in Rome around 1474, he explains that "mixed salad is prepared with lettuce, bugloss, mint, calamint, fennel, parsley, cress, oregano, chervil, chicory and lance dine ,-respectively called taraxacum and ribwort by doctors-morel, fennel flowers and other aromatic herbs all washed and duly drained". The culinary use of wild plants is a practice which, in the XVI and XVII century is included here and there in the works of leading scholars of herbal science like Pietro Andrea Mattioli, Castore Durante and Costanzo Felici. Elsewhere we find some other names and quite often that of Giacomo Castelvetro for his "*Briefaccount of all the roots, of all the herbs, of all the fruit, which, raw or cooked, are eaten in Italy*", published in 1624 in London, by the author, a religious exile

Not until 1767 did Giovanni Targioni-Tozzetti, a Florentine physician and naturalist, also interested in the practical aspects of botany and agriculture, and in this field a protagonist of the public life of the Grand Duchy, publish his work: "*De alimenti urgentia, that is, a way to make famines less serious, suggested for people's relief*". This treatise introduces the term "alimurgy" hence 'phytoalimurgy", a term which, to this day, refers to the study of plants for gastronomy; the origin of the word is uncertain and usually referred to three Greek words phytón (= plant), alimos (= which removes hunger) and ergon (= work, activity). (Poggio L. 2017). For a critical scrutiny of the meaning of the term and its ensuing implications, please refer to the paragraph "Clarifications on the Word 'Alimurgy' (Alimurgia)" contained in an article by Paura et al, 2021.

Although these words have different interpretations, their association means the sufficient amount of energy given off. Giovanni Targioni Tozzetti wrote this agronomic work at a disastrous time plagued by the famines which devastated a large part of Italy, from 1764 to 1767 The weather conditions of the time had a negative influence on agricultural crops, especially cereals, leading to food shortage. While staying at his Villa in Querceto (Pisa), he tasted several seeds and leaves from wild plants; as he appreciated their pleasant flavor, he came up with the idea of drawing a list suggesting new easy to grow vegetables able to provide a nutritional value the normally cultivated plants were lacking. Therefore, even though marginal in the goals of his work, the innovation G. Targioni Tozzetti supplies is to spark the interest and somehow promote the domestication o wild edible plants.

Skipping the XIX century, a period for which we have no documented information, the approach of addressing wild plants and not only those of the Italian territory–in view of their domestication was adopted by some XX century authors, like Mattirolo and Riccardo.

Not only in the country, but also in the small boroughs and in the counties around the cities, people were used to feeding also (and at times mainly) on wild vegetal food according to what the season had to offer, roots and fruit in summer and autumn, herbs mostly in winter and spring.This kind of model remained valid till relatively recent times, more or less depending on the areas of the country, which had changed from rural to modern at different times and more or less rapidly.With the XX century economic growth, in particular after WWII, which brought about a new capacity of food production and distribution as well as new daily lifestyles very different from the previous ones, the consumption of wild plants shrinks back to marginal levels, it is less and less practiced and inevitably impoverished in knowledge as it is more and more frequently considered as a remnant of history.

This change has moved really fast in the last fifty years, although in Italy, it actually dates to the first industrial revolution of the late XIX century. The very same considerations expressed about the changes which occurred in the transition to modernity are also found in one work on wild edible plants, often mentioned when dealing with our topic of interest, looking back on the past; that is the "Phytoalimurgia Pedemontana" by Oreste Mattirolo, published between 1918 and 1919, a reference text for all the following manuals on alimurgy.

In this work, Mattirolo writes about Alimurgybut wrongly attributing the word to Ottaviano Targioni Tozzetti, G. Targioni Tozzetti's son and adding the prefix phyto- (from Greek phytón = plantto the word "Alimurgy", thus specifying the vegetal implication. Mattirolo stresses the importance of WEPs as the food recommended to the people to overcome the severe famine brought about by the Great War. In fact before this historical landmark, food shortage had ceased to be a major concern for the population since trade, well endowed with means of transport, was able to supply the regionswith the food they were running out of when food was scarce, due to a series of reasons such as seasonal factors or diseases, (Mattirolo, 1918). Therefore, because of the precarious food conditions and the scarcity of cereal crops, caused in part by the lack of manpower lost to the war, Mattirolo intends this work to be a survival manual for the part of population who did not have a rural culture and consequently was not familiar with edible plants as an alternative source of livelihood. A few years later, Salvatore Riccardo (1921) published a work titled "Piante spontanee eduli della nostra Flora" (Wild edible plants in our Flora), followed by Nino Arietti (1941) with the work "La nostra flora nell'economia domestica" (Our flora in home economics). These two works point out the possibility of promoting the cultivation and use of wild species, as well as the possibility of creating new products such as substitutes; therefore they are not focused exclusively on the traditional use of wild plants, but also aim at understanding how these plants, used in a different way in different places, can be used proficuously. Among the reliable testimonies on the study of this subject, an interesting document was found: The phytoalimurgic manual (1943), devised by prof. A. Tukakov and his collaborators from Belgrade University; they field tested popular knowledge by feeding for months only on the plants they were studying. (Azzetti A. 2013).

The second post-war period and the deep fast transformation of Italian economy and society brought about the acceleration of changes in the habits linked to the use of wild edible plants, which Mattirolo had already witnessed at the beginning of the century for his native Piedmont. This is caused by the progressive abandonment of rural areas, in favor of urbanization and industrialization, a factor that has contributed to the loss of identity of rural society and its knowledge and traditions (Lucchetti et al., 2019). The few researchers of the time made an inventory of a limited number of wild plants normally gathered and eaten in the areas investigated[1] (Sella, 1964). In food culture, we witness the progressive spreading and blending of regional cuisines, so much so that the phrase "Italian cuisine" becomes commonplace. A kind of "codification" of preparations builds up, also thanks to the spread of recipe books and cooking manuals which offer typically local recipes adapted in order to be practicable anywhere.This is an evolution of Artusi's work, with the addition that, as far as we are concerned, when adapting the recipes, the authors of cooking manuals or recipe books replace, whenever possible, the wild plants used locally with herbs and/or spinach: in a society who wanted to forget peasant misery as fast as possible and felt they could do it thanks to increasing welfare, cultivated plants were used instead of wild plants.

Up till recently field studies about culinary traditions linked to wild plants were definitely scarce and considered as little more than folklore. Nowadays they are plentiful and are a relevant contribution towards increasing attention and consideration for ethnobotany and for

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Massimo Sella, for example, censused little more than a dozen used species in the valle Cervo in Piedmont, in the second post-war period.

the traditions connected to the perception of nature, a field of particular importance among those that make up the immaterial cultural heritage as a whole.

In recent years, the interest in wild plants has steadily grown, the fruit of an ever greater “need for nature” among other reasons. The word “wild” referring to the consumption of edible plants, has easily become included into a series of equivalencies starting or continuing with natural=authentic=genuine=good and so on.In the meantime, for several reasons, rediscovering popular culture has become scientific survey, as well as safeguard and enhancement of local traditions and “popular knowledge”, immaterial cultural heritage conservation, territorial promotion and marketing and much more.At the same time, however, wild plant gathering and consumption has become more and more residual, almost deprived of a reason to exist, disappearing completely from wide areas in our country. An activity which had gone on unchanged for centuries and which, in times or famine brought about by drought, cold or human devastation, had taken on vital importance all’over Italy.

With the transformation of Italian society and the twilight of rural culture, the lack or loss of some uses and traditions, of some practices, of a baggage of knowledge now variously perceived as important, was beginning to be felt all the more intensely as rural culture was definitively or totally abandoned. The severe reduction of gathering and consumption of wild plants has entailed the disappearance of knowledge about many botanic species, handed down by word of mouth and never written. Luckily the sense of loss has also elicited a strong need for conservation and a growing attention for the memory, the immaterial culture, what was being lost, with the positive consequence that the loss of this cultural heritage was actually reduced.

A direct consequence of the renewed interest in this fusion between “demand for nature” and “conservation and promotion of traditional knowledge” is not only the mighty increase in scientific publications but also of courses and meeting on “foraging” another useless neologism for alimurgic topics.

Other fields of scientific research, also less interested in immediate concrete applications, are investigating to an extent so far unknown the dietary use of wild plants.In the past decades, ethonobotanical surveys, carried out with greater and greater scientific accuracy and multidisciplinary tools, have focused mainly on the residual uses still existing.Distinct areas of the Peninsula have been involved, with attention paid to all the Italian regions, although central Italy up to high Tuscany and Liguria, as well as Sicily, have enjoyed greater consideration. Studies and research have, however, often focused on the areas where dietary uses and Phyto therapeutic uses still overlap, as evidence of a sort of continuity of the function carried out by medicine food. They involve and stimulate scientific biomedical and pharmacological surveys, often with quite interesting outcomes.

The studies about phytoalimurgy so far published are altogether numerous albeit limited to small territorial districts or at most whole regions.

To conclude this paragraph, by way of example, here follow some bibliographical references of regional monographies:

Northern Italy:

- Piemonte (Mattirolo 1918-19, Gibelli 2004, Pieroni e Giusti 2009)
- Veneto (Scortegagna 2013)
- Friuli Venezia-Giulia (Appi, Appi, Pagnucco, Pagnucco 1979; Coassini Lokar, Poldini, Angeloni Rossi, 1983)

Central Italy:

- Toscana (Corsi e Pagni 1978, Pieroni 2000, Giusti e Pieroni 2009, Signorini et al. 2007, Camangi et al. 2007; Tomei, Trimarchi 2017)
- Umbria (Ranfa, Bodesmo 2017),
- Marche (Taffetani 2019)
- Lazio (Guarrera 1994, 2006).

Southern Italy:

- Campania (Savo et al. 2011)
- Puglia (Bianco et al., 2009; Biscotti 2018),
- Basilicata (Caneva, Cutini 2009; Cassandra e Pieroni 2015; Sansanelli et al. 2017),
- Calabria (Lupia, 2018)

Italian islands:

- Sicilia (Arcidiacono 2016; Geraci et al. 2018; Pasta et al. 2020)
- Sardegna (Atzei, 2003; Camarda et al. 2017)

SECTION I AlimurgITA Database

CHAPTER I

STUDIO I

The methods and results of the discussions and conclusions related to the Alimurgita Database related to the current study, are reported in the work attached to this thesis:

Design a Database of Italian Vascular Alimurgic Flora (AlimurgITA): Preliminary Results

Citation: Paura, B.; Di Marzio, P.; Salerno, G.; Brugiapaglia, E.; Bufano A.
Plants **2021**, *10*, 743. https://doi.org/10.3390/plants10040743

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Article

Design a Database of Italian Vascular Alimurgic Flora (AlimurgITA): Preliminary Results

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Citation: Paura, B.; Di Marzio, P.; Salerno, G.; Brugiapaglia, E.; Bufano, A. Design a Database of Italian Vascular Alimurgic Flora (AlimurgITA): Preliminary Results. *Plants* **2021**, *10*, 743. https://doi.org/10.3390/plants10040743

Academic Editor: Riccardo Motti

Received: 10 March 2021
Accepted: 6 April 2021
Published: 10 April 2021

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Abstract: Despite the large number of data published in Italy on WEPs, there is no database providing a complete knowledge framework. Hence the need to design a database of the Italian alimurgic flora: AlimurgITA. Only strictly alimurgic taxa were chosen, excluding casual alien and cultivated ones. The collected data come from an archive of 358 texts (books and scientific articles) from 1918 to date, chosen with appropriate criteria. For each taxon, the part of the plant used, the method of use, the chorotype, the biological form and the regional distribution in Italy were considered. The 1103 taxa of edible flora already entered in the database equal 13.09% of Italian flora. The most widespread family is that of the Asteraceae (20.22%); the most widely used taxa are *Cichorium intybus* and *Borago officinalis*. The not homogeneous regional distribution of WEPs (maximum in the south and minimum in the north) has been interpreted. Texts published reached its peak during the 2001–2010 decade. A database for Italian WEPs is important to have a synthesis and to represent the richness and complexity of this knowledge, also in light of its potential for cultural enhancement, as well as its applications for the agri-food system.

Keywords: wild edible plants (WEPs); database; AlimurgITA; ethnobotany; Italy

1. Introduction

One of the most famous aphorisms attributed to Hippocrates of Cos ("let thy food be thy medicine and medicine be thy food") underlines the strong correlation existing between food and its curative capacities whose effects are synergic, not separable in their overall actions [1–6]. It is therefore likely that some plants, widespread in the tradition of many cuisines and which are still eaten every day, originally introduced because of their curative properties, thenover time might have become staple foods in the local cuisines.

For example, many species of the *Allium* genus, as well as many species with a bitter taste

(e.g., *Cichorium intybus*), show excellent curative properties, with their use being testified in many civilizations since ancient times (the Ebers papyrus, an Egyptian medical text dated 1550 B.C., includes long descriptive sections about the medicinal use of these plant species).

The dual value of the use of plants as foodstuff/medicine expressed today through the words "phytoceuticals" [7,8] and "nutraceutics" [9] therefore, has accompanied the history of mankind for millennia through the accurate choice of species to be gathered and domesticated [10]. As a consequence, each diet is strongly related to the environment and to what is available there, i.e., to its biodiversity.

According to [11] there are between 300,000 and 500,000 plant taxa, of which about 10% have proved to be edible. As stated by [12] there are 350,000 plant species in the world, and about 80,000 of them are edible by humans. Based on FAO data [13] there are about 6000 plant species which have been cultivated from the beginning of time to the present day for food purposes; only about 200 of them are cultivated on a significant scale, of them only eight approximately (barley, beans, peanuts, corn, potatoes, rice, sorghum, and wheat) are crops which provide more than 50% of our daily calorie intake. In Europe (Couplan, F 1989, Couplan, F.2002), the use of about 1600 wild species is known, accounting for about 13% of all its flora; on the other hand, in the eastern Mediterranean region, the list includes as many as 2300 taxa, of which 1000 are used solely at local level [Riv era et., al ,18].

The Food and Agriculture Organization (FAO), has estimated that, over 100 million people in the EU consume wild plants [19], the latter being a part of people's diet around the world and playing an important role in the Mediterranean diet.

In the case of Italy, it has been estimated that in 2013 the total number of Wild Edible Plants (or WEPs) includes 828 taxa, amounting to about 12% of the whole Italian flora; this estimate apart from wild plants includes those consumed as food, aromatic herbs, and liqueurs [20]. More recently, 276 WEPs taxa used in traditional vegetable mixtures have been analyzed also from an ethno-pharmacological relevance perspective [21]. The studies about the various regions or more limited territories thus seem to provide sufficient knowledge regarding wild edible plants.

Important international institutions (FAO, WHO, UNESCO, WWF) have taken an interest (directly or indirectly) in ethnobotany and alimurgy, attempting through the recovery of popular traditions to provide a meaningful contribution to resolving humanitarian problems such as hunger in the world [13,22], the search for new biologically active molecules for the cure of diseases [23], safeguarding minority cultures, protecting biodiversity, and taking care of the landscape [24].

In Italy, during the same period, this cultural trend has led to a significant increase in ethnobotanic studies. According to [25] this type of studies reached its peak between 1991 and 2000, then continued to grow in later years. Also the number of papers written on the subject of alimurgy as will be detailed in the following sections has shown a similar upward trend over the past 30 years.

What is the cause of such increasing interest? We consider that, to sum up, it may be associated with five reasons:

1. More attention being paid to salutogenesis also through the rediscovery of food, diets and dishes closely related to specific regions. This process is gradually helping to fill a methodology gap in the relationships between diet and use of wild plants as food [26]. For example, in the Mediterranean diet [27,28], according to the definition by

the American epidemiologist/biologist Ancel Keys [29], a fundamental component comes from plant foods, including those spontaneously available in nature. Salutogenesis, a term coined by [30], is a subject whose aim is to foster the development of health through a process of discovery and use of individual health sources, also at environmental level. The Mediterranean diet is a nutritional model inspired by food models widespread in several countries of the Mediterranean area, founded on the habitual consumption of specific foodstuffs including mainly cereals, fruit, vegetables, grains, olive oil, rather than red meat and animal fats (saturated fats), with a lower percentage of fish, white meat (poultry), legumes, eggs, dairy products, red wine, and sweets. In 2010 UNESCO acknowledged it as a protected asset and added it to the list of oral and immaterial world heritage.

2. Opportunity for sustainable agriculture [31]. The increased knowledge of WEPs could have a useful impact on cultivation in marginal areas with a low use of energy inputs, which would have a positive impact on several levels, including the complexity of agroecosystems, increasing their biodiversity. There is also a very close link between WEPs and the cereals, fruits and vegetables that are part of our diet. This link is represented by CWR (crop wild relatives) the wild ancestors of cultivated plants which are recognized as having a strategic role for the conservation and sustainable use of plant resources in agriculture [32] also within the future scenario of climate change [33–35].
3. Creation of new product ranges for the food industry, also including functional foods, fresh or processed food with beneficial and protective properties for the body which go beyond mere nutritional properties [36–43].
4. Enhancing physical and cultural specificities of a given region, in line with the concept of 'terroir'. Terroir, is an untranslatable French word which originally comes from vine growing, to define the interaction between physical factors (soil, exposure, climate), crops (vine varieties), and culture (vine cultivation), also including the product consumers.
5. Awareness of the importance of preserving and keeping the complex of ethnobotanic traditions alive; the recovery of collective knowledge, in itself, has an intrinsically high cultural value as historical memory of civilizations (farmers and shepherds) which are now lost or have undergone deep changes becoming impoverished in terms of passing on know-how. Over the past few years there has been an increasing transfer of ethnobotanical knowledge, not between elements of the same culture but

rather from one society to another, consisting essentially of experts on the subject or of enthusiasts (foragers).

Despite the large number of data published on WEPs in specialized literature, what still seems to be lacking is a synthetic and systematic framework of actual knowledge to show the actual relevance of alimurgic species as an asset, using stringent criteria and assessments over a significantly long period of time. Evidence of this is the fact that several databases have been produced available for public referencebut none of them specific for WEPs. A general list, still mostly valid, is included in Table 1.

Table 1. Partial list of relevant WEP databases

Title	Level	Link	Topic	Language
Acta Plantarum - Flora delle Regioni italiane	Italy	https://www.actaplantarum.org/	A database of the Italian flora, with information on properties and uses of plants	Italian
Cuisine sauvage	Belgium	https://cuisinesauvage.org/lesplantes/voir/	A database of wild edible plants	French
Dr. Duke's Phytochemical and Ethnobotanical Databases	United State of America	https://phytochem.nal.usda.gov/ phytochem/search	A database of wild useful plants, with information on their chemical activities	English
Edible Wild Food	Canada	https://www.ediblewildfood.com/	A blog database on wild edible plants	English
Food Plants International	World	https://foodplantsinternational.com/ (database at: https://fms.cmsvr.com/ fmi/webd/Food_Plants_World)	A database of edible plants, with information on their nutritional value	English
Foraging: what to look out for each month	United Kingdom	https://www.woodlandtrust.org.uk/ visiting-woods/things-to-do/ foraging/	A month-by-month guide to sustainable foraging, what is in season and how to eat it	English
Génial Végétal	France	https://www.genialvegetal.net/	A database of wild edible plants	French
GenResIS (Genetic Reserve Information System)	Europe	http: //www.agrobiodiversidad.org/aegro/	Information on recommended locations suited for the establishment of genetic reserves for Avena, Beta, Brassica, and Prunus across Europe	English
Native American Ethnobotany	North America	http://naeb.brit.org/	A database of foods, drugs, dyes and fibers of Native American peoples, derived from plants	English
PHYTOALIMURGIA Piante selvatiche commestibili		https://phytoalimurgia.it/	Database of wild edible plants	Italian, English
Piante innovative	Italy	https://www.pianteinnovative.it/	Information on wild edible plants, with information on the edibility of plants	Italian
Pl@ntUse	Europe	https://uses.plantnet-project.org/en/ Main_Page	An ongoing collaborative space for the exchange of information on useful plants	English, French
Plantas silvestres comestibles	Spain	https://www.vivelanaturaleza.com/ manual-de-supervivencia/plantas-comestibles/	A blog with information on wild edible plants	Spanish
Plants for A Future	World	http://www.pfaf.org/user/Default.aspx	A database of edible and otherwise useful plants	English

Despite this increase in scientific papers, the question remains open of whether knowledge of WEPs is considered sufficient for Italy and for each of its administrative regions. Hence the need to compile a database of Italian alimurgic flora aimed at providing a comprehensive knowledge framework, with a view to covering the wealth and complexity of this knowledge, also in the light of its potential for cultural enhancement, as well as of its applications for the agro-food system.

Today Italy would need a free access database which can collects comprehensively and systematically the wealth of knowledge regarding alimurgic flora in the country. Within the current limited framework, it is worth mentioning the Centro Etnobotanico Toscano (CET), established in 1999 with headquarters at the Department of Agricultural, Food, and Agro-environmental sciences at the University of Pisa, whose initial purpose was to serve as regional and national point of reference for disseminating information regarding ethnobotany. This archive, which is not accessible online for the general public, has collected, in Tuscany, more than 70 ethnobotanic publications and created an online database with all their contents [44–46]. There are currently 732 classified ethnobotanic species in Tuscany, mainly used for medicinal purposes (542 plants) and as food (366). In the same year, a paper was published announcing the establishment of a structured ethnobotany database for the Liguria region [47], which is not yet available for reference by the general public. Later on, in 2003, the Project called RUBIA [48] was started, the first ethnobotanic research work funded by the European Commission, whose purpose was to safeguard the ethnobotanic heritage in several Mediterranean countries (Albania, Algeria, Cyprus, Egypt, Italy, Morocco, and Spain), regarding the botanical aspects of the elements under investigation, as well as all related traditional items and technologies [48,49]. The main results concern a total of 985 species catalogued, of which 406 taxa have medicinal use [50] and 294 wild food plants [51] were documented. Although this work constitutes the first comparative study performed with ethnobotanical data collected by a coordinated methodology in the Mediterranean area, overall data for alimurgic species are scarce.

In in his compendium “Usi e tradizioni della flora italiana” [25] mentioned 526 taxa used as food and as aromatic plants in Italy, on a bibliographical basis. A further attempt to quantify the Italian alimurgical flora was recently made, on a limited number of texts, by [52]. The data presented here will thus refer to the AlimurgITA database which has been created at the Botanic Laboratory of the University of Molise, whose structure has been developed in order to rapidly create an interface with the major portals dedicated to Italian flora (Dryades, Acta plantarum) for user-friendly open reference. The AlimurgITA database will be available for consultation in the coming months on the website of the University of Molise. The final aim of our study is to systematically collect the large amount of data regarding plants which occupy or used to occupy a significant position in the area of Italian alimurgic botany. This database could be serve as be a tool for work and dissemination containing information which is already available literature (including both science disciplines and the humanities), which in the future could be added to those made available by research currently underway. The use of WEPs has become known in Italy under the name 'alimurgy', now of current use not only in the strictly scientific environment, but also among many enthusiasts of this subject matter. Even though the term is often quoted, its meaning is not yet sufficiently clear: it is therefore essential, in our view, to provide a few clarifications.

Clarifications on the Word 'Alimurgy' (Alimurgia)

This neologism was introduced by Giovanni Targioni-Tozzetti, author of the work by the same name dated 1767 [53]; strangely enough, the word "alimurgia" is mentioned only twice in the text, without clarifying its etymological root: the author was presumably certa that the learned audience of readers for which the work was intended would understand its hidden meaning. With an innovative editing structure and rigorous scientific method, the publication "alimurgia" was mainly focused on agriculture, ranging from the knowledge of the climate in the Tuscan region, to the choice of cereal seeds the most suitable for the various territories also including a study of wheat leaf rust, a disease which he was the first to discover and study. The use as food of wild species during famines, or of those to be introduced profitably in crops, therefore appears to be of marginal interest. Even though it was initially mentioned by Targioni-Tozzetti, this use was never dealt with later, possibly due to the work being incomplete, since it was expected to include a second volume which was actually never published [54,55] This is why there was no discussion about edible wild plants; the topic had been dealt with, only in part, in one of his earlier works [56], where several spontaneous plants are examined which added to wheat flour could be successfully used for bread-making. After one century and a half of oblivion, the word alimurgy was used again by [57], who added the prefix phyto- to the word alimurgy, then specified its area of interest, namely the use of wild species during periods of food shortage. At the same time, he provided an interpretation of the word 'alimurgia', a combination of the Latin words alimentum (food) and urgeo (to press, to urge). According to [58] the suffix urgia comes from the Greek word érgon (work). The word alimurgy was later redefined by Mattirolo who confined it from its original and broadest meaning related to practices aimed at a greater efficiency of the agricultural system, aimed at preventing or containing food shortages in the future, to the one limited to wild species alone. From the time of Mattirolo onwards, possibly also due to the confidence in this prominent author or to the limited knowledge of the work by Targioni-Tozzetti, the word "alimurgy" has taken on the meaning, which we commonly attribute to it today.

2 Materials and Methods

The setting up of the Database AlimurgITA has made it necessary to introduce a few conditions as regards the choice of data to be entered. First of all, only vascular plants have been considered, excluding from the calculation of alimurgic species fungi and lichens (e.g., Cetraria islandica used during a famine in the Veneto region in 1916) [59], a subject of limited consideration in most texts of an ethnobotanic nature. The results obtained were thus extremely partial, therefore insufficient for a comparison between plants and on an ethnobotanic basis.

In AlimurgITA database, all the data contained in the selected texts according to subsequently specified criteria, have been included, as considered valid a prioAs part of the index of taxa included in the various works published, a choice was finally made of the strictly alimurgic one, that is to say plant taxa autochthonous or alien then becoming naturalized where one or more parts was considered edible in some areas of the Italian territory studied from an ethnobotanical perspective. This means that casual alien and archaeophyte species [60] have not been considered alimurgic, i.e., those which are found only occasionally in very small parts of the territory and all the cultivated varieties which are frequently found in the lists of numerous publications on the subject of alimurgy. By the same token, according to the status defined by [60] and most recently updated according to Acta plantarum [61], the records do not include taxa reported by mistake, those which are either no longer recorded, absent or doubtfully occurring. On the other hand, the database includes species found both in their spontaneous and cultivated state (e.g., olive, chestnut, vine, hazelnut, fig, white mulberry) even though domesticated forms are widely dominant. The nomenclature of the taxa mentioned refers to the checklist by [62] and [60]. Where necessary, the binomial according to the Word Flora online [63] is shown in brackets with the exclusion of nominal subspecies. Several critical taxa from a taxonomy perspective, for example Taraxacum officinale and Rubus hirtus, have been taken into account as a group; in the case of Portulaca the choice has been made, on the contrary, to keep it as P. oleracea s.l., in view of the impossibility to refer back the records to the taxa into which it is divided. A similar criterion was applied for Thymus serpyllum. For a comparison on a national scale, an estimate has been made of the reference flora for Italy using data from the checklist of spontaneous vascular flora in Italy [62] and of alien flora in Italy [60]. More specifically, from the first list, the taxa present in Italy have been included, whereas extinct taxa have been deleted, as well as those no longer found and those reported by mistake, amounting to a total of 7582 taxa; the second list does not include casual taxa in all Italian regions, those which are extinct, no longer found and reported in error, amounting to a total of 844 taxa. On the contrary, the database still include alimurgic taxa whose presence in the region was considered uncertain, thus implicitly validating the identification completed. Starting from these 8426 taxa, moreover, a list has been compiled on the basis of species included in the database AlimurgITA, of alimurgic taxa potentially present in every Italian region, to be associated with species actually listed in the census both at regional and geographical sector level (North, Centre, South, Major islands) (Figure 1).

Figure 1. Division of Italy into sectors (North—blue, Centre—red, South—green, major islands— orange). Abbreviations of the administrative regions: AOV = Aosta Valley, PIE = Piedmont, LOM = Lombardy, TAA = Trentino-Alto Adige, VEN = Veneto, FVG = Friuli-Venezia Giulia, LIG = Liguria, EMR = Emilia Romagna, TUS = Tuscany, UMB = Umbria, MAR = Marche, ABR = Abruzzi, LAT = Latium, CAM = Campania, MOL = Molise, APU = Apulia, BAS = Basilicata, CAL = Calabria, SIC = Sicily, SAR = Sardinia.

As regards modes of consumption, the species used exclusively for herb teas, infusions and decoction have not been included, because their purpose is mainly associated with their medicinal properties rather than with the food sector [64]. On the contrary, the database includes species used for preparing liqueurs because the latter are often considered as an integral part of the meal, according also to [64]. In order to also save all data related to excluded taxa, their list is included in the Supplementary Materials Table S1. A critical discussion about the alimurgic Italian checklist is therefore postponed to the next scientific paper. A further aspect then concerned the choice of texts to be entered. Over the past few years, alongside the growing interest in WEPs, there has been a proliferation of writings, both of a scientific nature and for the general public. The chosen window of observation included the past one hundred years (1918–2021), taking as starting point the year 1918 i.e., when Phytoalimurgia pedemontana was published [57] because we consider that to be a ground-breaking text for modern botanical alimurgy. It did not seem appropriate to enter this substantial amount of data uncritically, therefore we decided to choose published texts which met the following two criteria:

1. Publications in scientific journals or books;
2. Publications also in non-scientific journals, provided that they had been compiled by authors referenced for alimurgic subjects.

These two criteria are also associated with a reference to clearly defined territories, up to the national scale; the idea was to follow a specific ethnobotanic approach, highlighting contributions which established a close relationship between WEPs uses and popular tradition.

We have expressly chosen to focus only on 'traditional uses', because our interest concentrated on collecting information about the use of WEPs, leaving aside for the time being and intentionally all 'new' food uses of plants recently acquired in the wake of new experimentations in the area of gastronomy and nutrition. This choice was also due to the need to contain as much as possible the margin for erroneous identification of taxa which, without this a priori selection would most likely have been higher [65]. Attention was thus paid to redundant work, that is to say where the same set of data had been published, by the same authors, in separate contributions for the same geographical area. Finally, scientific contributions of a methodology, conceptual, demo-anthropological or generic nature have been excluded, where no reference was made to alimurgic species e.g., [6,36,66]. In advance of this selection work, a list was compiled with a total of 358 published works (Supplementary Materials Table S2). Each taxon has been associated with the part used and with the methods through which it is consumed part of food preparations. These categories mainly refer to those listed by [25], with some changes in terms of methods, which have become more articulated in order to provide more detailed information (Table 2).

Table 2. Mode of consumption

Mode of Consumption	Description
Raw	Plant generally used raw to make salads
Cooked	Plant cooked to make soups, broths, stuffed pasta, etc.
In oil	Plant preserved in olive oil to be used later
In salt	Plant preserved in salt to be used later
In vinegar	Plant kept in vinegar (usually made from wine) to be used later
Brine	Plant kept in brine to be used later
Pickle	Plant macerated to make pickles or sauces
Roasted	Plant which is roasted to make coffee surrogates
Dried	Plant which is dried to be used later
Preserves/Jams	Plant used for confectionery products (jams, preserves, jellies, sweets, etc.)
Alcoholic/non-alcoholic beverages/Vinegar	Plant used to make alcoholic beverages through fermentation, as flavouring for alcoholic beverages (e.g., grappa, wine, rosolio), non-alcoholic beverages (e.g., syrups), or vinegar
Oil	Plant used for food oil extraction
Milled/Flours	This refers to a plant (mainly tubers, rhizomes and seeds in this case) which was boiled then dried, or it was simply dried, then it was milled and finally added to cereal flours
Flavouring	Plant used in small amounts as seasoning for cooked dishes and cheeses

As regards the parts used, reference was made to the following categories (Table 3), grouped according to the position in the plant and to the function performed:

Table 3. Function, position, and parts of the plants used

Function	Position	Part
Vegetative	Hypogeal Epigeal	Roots/tubers/rhizomes Bulbs Stem/turion/branches Bark Aerial part Leaves Young shoots/gemmas Basal rosette
Reproductive		Inflorescences Flowers/flower buds Fruits/pseudofruits Seeds
Other		Resin/sap/latex

The use of galls, recorded only for two species (*Rhododendron ferrugineum*, *R. hirsutum*) have not been considered while that of the floral nectar in *Gladiolus italicus*, *G. byzantinus* (=*G. communis*), and *Lamium orvala* has been included in flowers/flower buds in Table 3. Moreover, for WEPs, the calculation on a national and regional scale included both chorology spectrums based on the chorotypes selected by [67] and biological ones [67,68]. Further processing steps involved titles published for the purpose of highlighting the trend over the past 100 years and their contribution for each administrative region.

3 Results

3.1. Edible Plants Entered in the Database

The reference to 358 publications on alimurgy-related subjects has allowed us to select 343 papers which led to introducing 1103 taxa in the database. This value corresponds to 13.09% of the 8426 entities chosen for comparison from the checklists of Italian flora [60,62]. The latter have been divided into the following categories: *Pteridophyta* (8 taxa), *Gymnospermae* (13 taxa), *Angiospermae* (1082 taxa, of which 964 *Dicotyledones* and 118

Monocotyledones). Of the 108 families included, the most widespread appeared to be Asteraceae with 20.22% of taxa, followed by Brassicaceae (6.98%), Fabaceae and Lamiaceae (6.53%), Rosaceae (5.98%), and Apiaceae (5.08%) (Figure 2). These six families account for 51.31% of the total taxa in the database. The prevalence of Asteraceae further confirms the records in numerous publications on the subject of phyto-alimurgy [20].

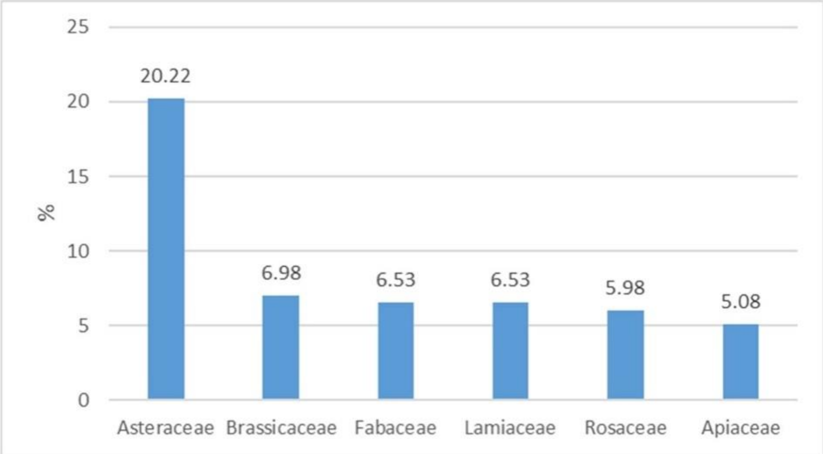


Figure 2. Percentage composition of the main families of Italian Wild Edible Plants (WEPs).

The number of WEPs recorded by family was then compared to the taxa present in the same family for Italian flora (Figure 3).

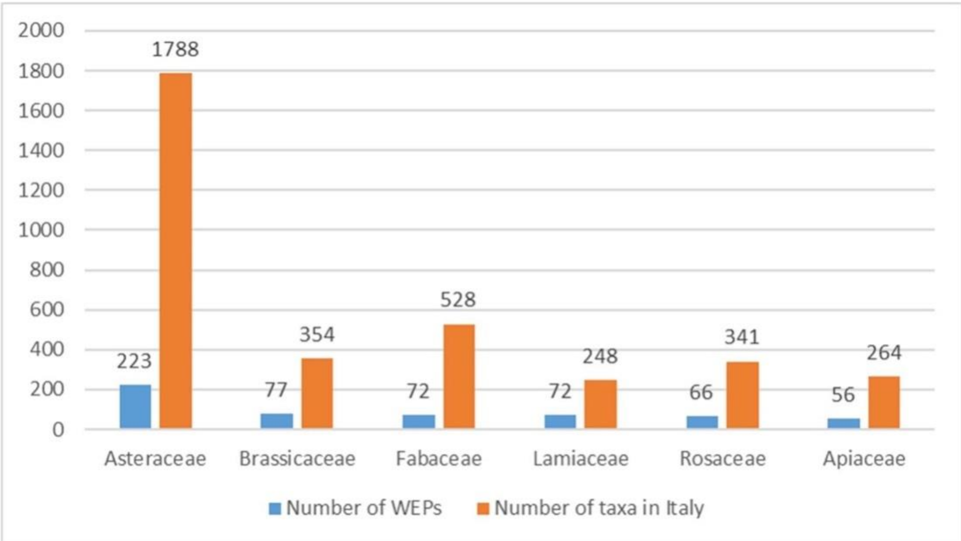
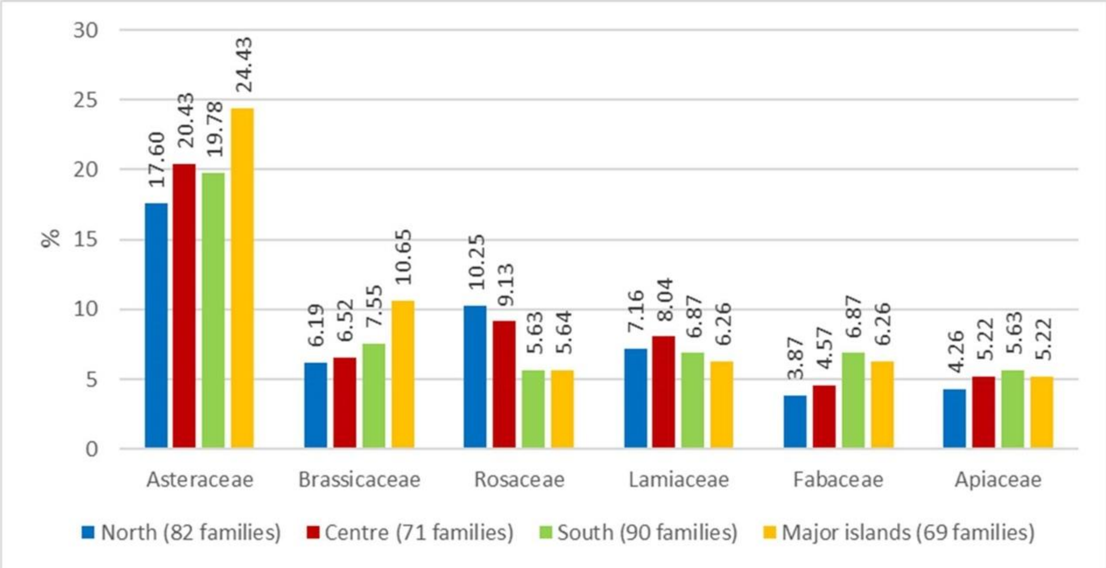


Figure 3. Number of Wild Edible Plants (WEPs) recorded (blue column) and total number of taxa in Italian flora of the most frequent families in the Database AlimurgITA.

Thirty-seven families (34.26% of the total), are represented in the database by one taxon only.

An assessment was then made of the breakdown of the most frequently found families along the geographical gradient of four geographical areas (North, Centre, South, Major islands) (Figure 4).

Figure 4. Percentage of the main families of Wild Edible Plants (WEPs) by geographical area.



Asteraceae and Brassicaceae appear to be more widely used in the islands (24.43% and 10.65% respectively), Rosaceae are dominant in the North and the Centre (10.25% and 9.13% respectively), while the use of Fabaceae is slightly lower in the North and the Centre (3.87% and 4.57% respectively). Apiaceae show a prevalence in the southern sector (5.63%). The gradual increase in the use of Asteraceae in the island area was already recorded earlier in other ethnobotanic contributions [69,70].

There are 494 genera, and those with a number of reported taxa equal to or higher than 10 are *Crepis* (19 taxa), *Allium* (18), *Lathyrus* (16), *Rumex* (15), *Prunus* (13), *Artemisia*, *Brassica*, *Carlina*, *Centaurea*, and *Malva* (10); these data confirm the close match between the most representative families and the most frequently recorded genera.

Table 4 includes a list of the 19 taxa most widely used for alimurgic purposes (from 100 records upwards). *Borago officinalis*, *Cichorium intybus*, *Foeniculum vulgare*, *Urtica dioica*, *Taraxacum officinale* (group) s.l., *Sonchus oleraceus Papaver rhoeas* subsp. *Rhoeas*, and *Asparagus acutifolius* are the most frequently recorded species (from 150 records upwards), found in more than 46% of the publications considered, and used in at least 18 Italian regions.

Table 4. List of spontaneous species most widely used for edible purposes

Taxon	**N**	**%**	**Reg.**
Borago officinalis	204	62.39	20
Cichorium intybus	204	62.39	19
Foeniculum vulgare	193	59.02	19
Urtica dioica	174	53.21	20
Taraxacum officinale	171	52.29	20
Sonchus oleraceus	168	51.38	20
Papaver rhoeas subsp. *rhoeas*	158	48.32	20
Asparagus acutifolius	151	46.18	18
Clematis vitalba	145	44.34	18
Laurus nobilis	133	40.67	16
Reichardia picroides	129	39.45	15
Silene vulgaris	126	38.53	20
Portulaca oleracea	126	38.53	19
Sambucus nigra	123	37.61	19
Nasturtium officinale	122	37.31	20
Malva sylvestris	117	35.78	20
Ruscus aculeatus	108	33.03	17
Rubus ulmifolius	106	32.42	19
Helminthotheca echioides	105	32.11	15

N = number of records, % = ratio between number of records and reference texts, Reg. = number of administrative Regions where the species is recorded.

As many as 234 taxa (21.21%) are recorded only once, and 410 taxa (37.17%) are mentioned only for one region (Figure 5). In the figure the value of 0 is due to the absence for 11 taxa (1.00%), of any specific regional reference, so the information refers to Italy in general. These 11 entities (*Ambrosia artemisiifolia*, *Argentina anserina* subsp. *anserina* (=*Potentilla* *anserina*), *Apios americana*, *Bassia scoparia*, *Butomus umbellatus*, *Chaerophyllum bulbosum* subsp. *bulbosum*, *Cynomorium coccineum* subsp. *coccineum* (=*Cynomorium coccineum*), *Nelumbo nucifera*, *Nuphar lutea*, *Sagittaria sagittifolia*, *Triglochin maritimum*) all come from [71] (apart from *Apios americana*, also cited by [72], and *Sagittaria sagittifolia*, also cited by [73]) and it is strange that these citations have never been found in any Italian region.

3.2. Italian Wild Edible Plants Divided by Region and by Geographical Area

The analysis of results involved calculating the number of edible spontaneous taxa used for each Italian region. It is worth noting (Figure 6) that the region with the largest number of recorded taxa is Apulia (569), followed by Sicily (387) and Tuscany (341). On the other hand, the regions with the lowest use of WEPs are Trentino-Alto Adige, Aosta Valley, Umbria, and Molise with 86, 110, 112, and 143 taxa respectively. Among the four geographical areas considered, the one with the most taxa mentioned (728) is the South, followed by the North (517), Major islands (479), and Centre (460), even though compared to regional flora the WEPs percentage is higher to the South then the Major island (Figure 7).

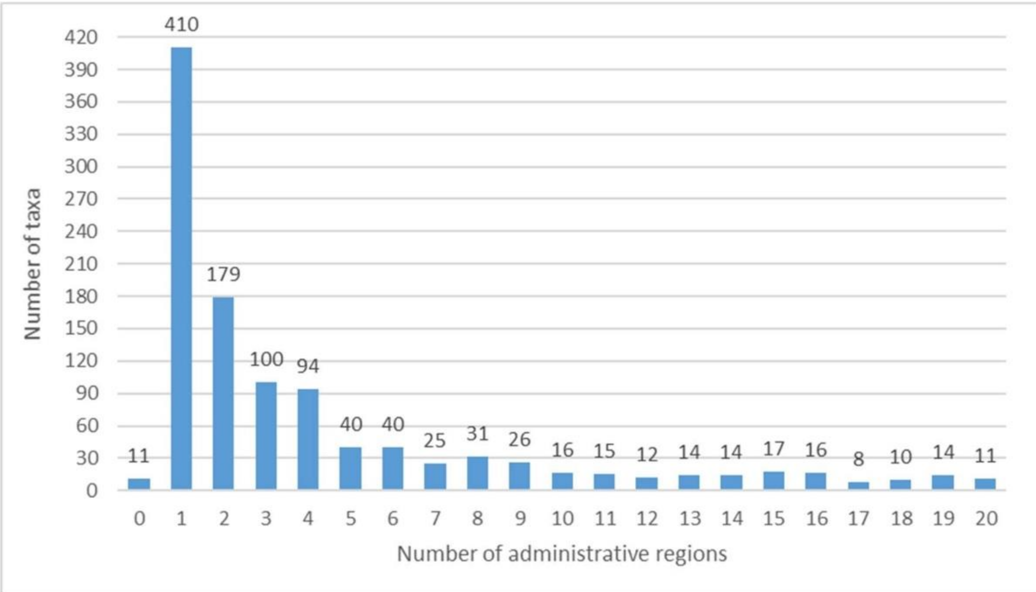


Figure 5. Number of administrative regions where the taxa have been cited.

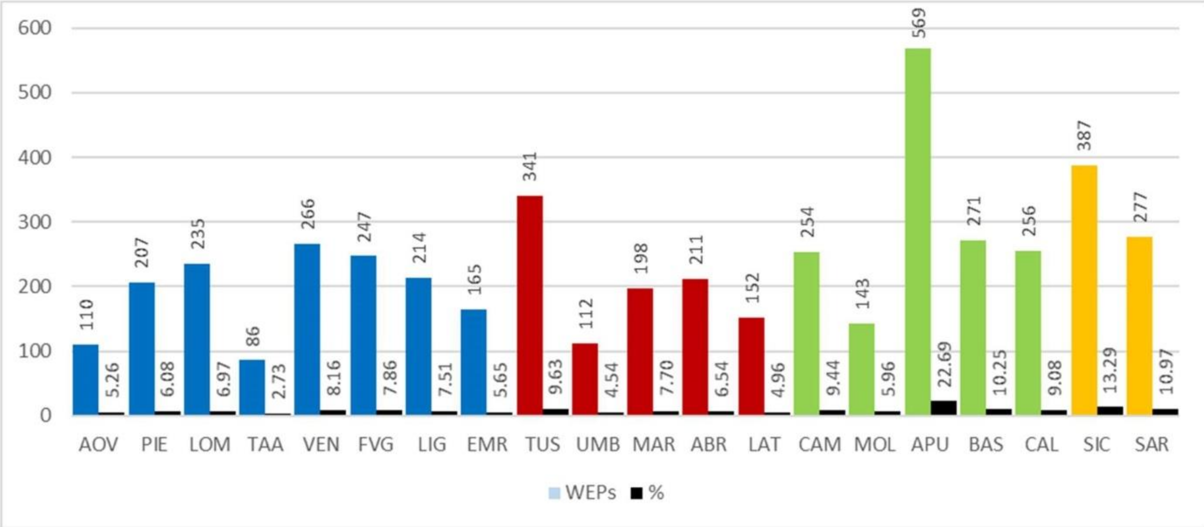


Figure 6. Number of Wild Edible Plants (WEPs) by region in respect of the percentage composition of taxa present in the regional flora. Abbreviations of the administrative regions are shown in Figure 1.

The taxa excluded from the calculation, according to the status defined by [60] (casual alien, absent, doubtfully occurring, reported by mistake, no longer recorded) and updated to date according to [61] are reported, region by region, in Table 5.

Table 5. Number of taxa excluded from the calculation of WEPs and reason for exclusion

Reason for Exclusion	AOV	PIE	LOM	TAA	VEN	FVG	LIG	EMR	TUS	UMB	MAR	ABR	LAT	CAM	MOL	PUG	BAS	CAL	SIC	SAR
Casual alien/archaeophyte	2	13	12	3	38	14	16	14	39	2	14	9	12	15	11	9	23	15	11	34
Absent	7	9	1	2	17	9	17	6	12	1	5	2	4	5	9	11	20	19	15	16
Reported by mistake	.	1	.	.	2	2	3	2	2	2	.	2	.	2	.	4	3	3	3	2
Doubtfully occurring	.	.	.	1	1	.	.	.	3	2	.	1	.	1	.	8	4	3	2	.
No longer recorded	.	1	.	.	1	1	.	.	.	.	.	.	.	1	.	9	.	2	1	.
Total number of species	8	24	13	6	59	26	36	22	56	7	19	14	16	24	20	41	50	42	32	52

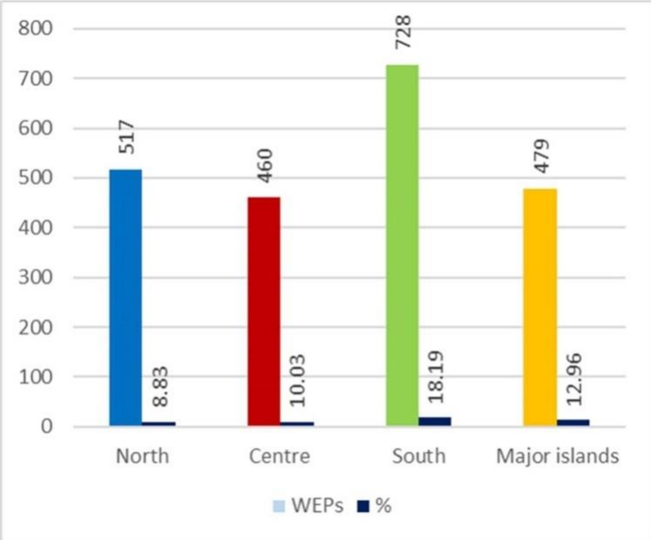
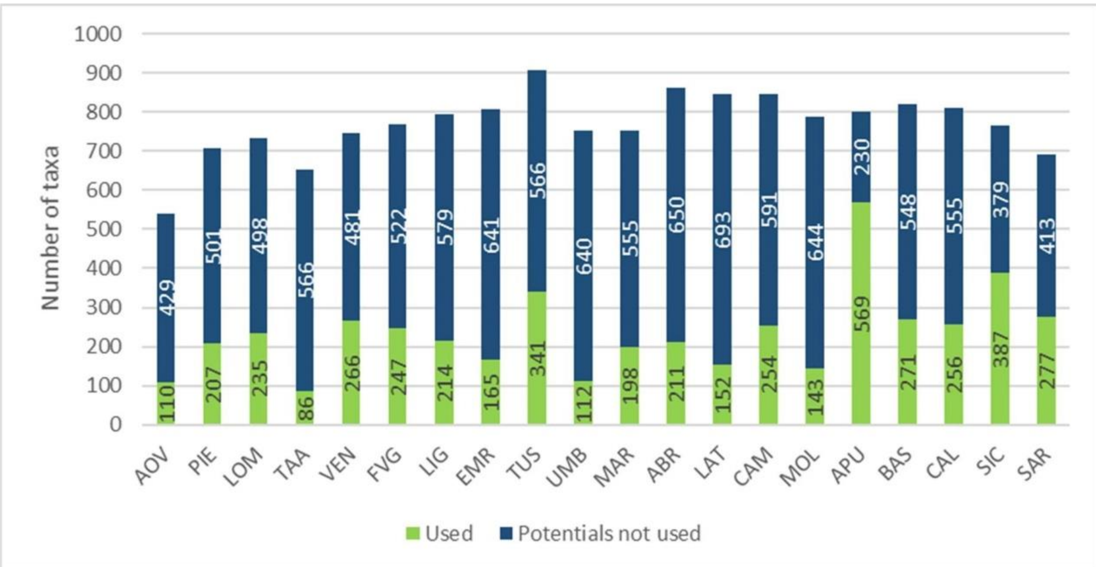


Figure 7. Number of recorded Wild Edible Plants (WEPs) by geographical sector and percentage comparison with regional flora.

3.3. Relationship between Edible Plants Recorded by Region and Those Potentially Present

Regional spontaneous edible flora has been linked with the species which could be found in the same areas but which are not used. These latter data have been derived by selecting the alimurgic species found in the region, based on local flora [60,62], from the total recorded in the AlimurgITA Database (1103 taxa). Figure 8 shows that WEPs actually account for a small percentage in respect of the potential regional edible flora, ranging from 13.19% (Trentino-Alto Adige) to 71.21% (Apulia).

Figure 8. Regional comparison based on the number of recorded and potential alimurgic taxa. Abbreviations of the administrative regions are shown in Figure 1.



In order to provide an overview, the regional data have then been aggregated by geographical area (Figure 9).

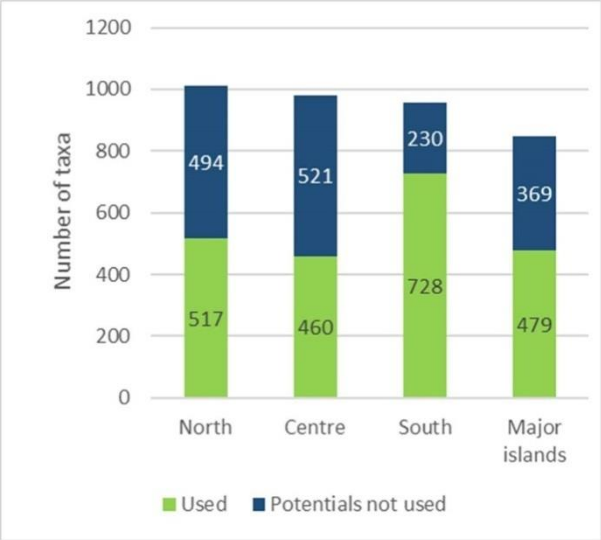


Figure 9. Comparison by geographical area between the number of recorded and potential alimurgic taxa.

This comparison serves the purpose of making assumptions regarding the overall situation of alimurgic knowledge, which in turn can be associated with the level of erosion of traditional knowledge (*TK*) [64], due to socio-economic transformation or to the degree of ethnobotanic exploration, highly variable from region to region.

3.4. Parts of WEPs Used

In Italy, as regards the most widely used edible parts in the culinary tradition, these include leaves (616 records), new shoots/gemmae (210), roots/tubers/rhizomes (152), fruits/pseudofruits (157), and flowers/flower buds (145) (Figure 10). There are only eight records of resin/sap/latex (0.75%).

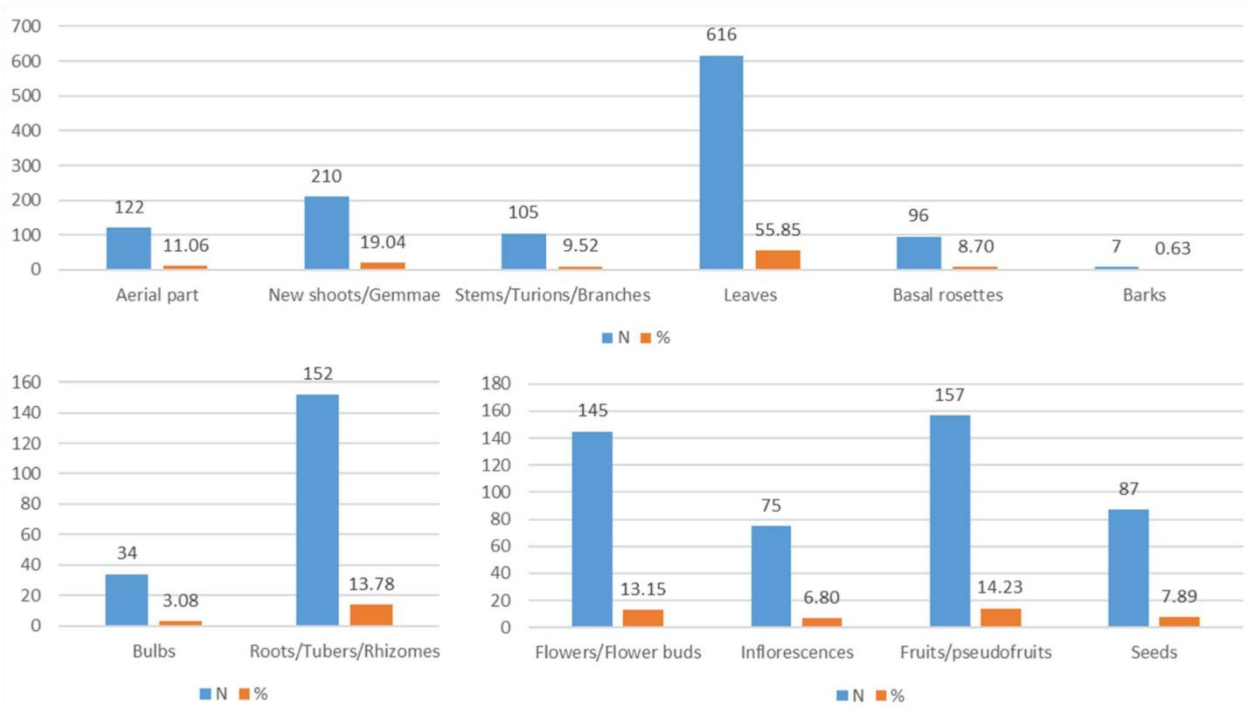


Figure 10. Parts of the plant used and their frequency in the whole database

3.5. Methods for Use of WEPs

Further analysis has led to processing data related to the number of records for each of the methods of use (Figure 11). This assessment has shown that the most widespread modes of consumption are, in this order, cooked (737 records, amounting to 66.82%), raw (559 records, 50.68%), flavouring (215 records, 19.49%), and beverages/vinegar (169 records, 15.32%).

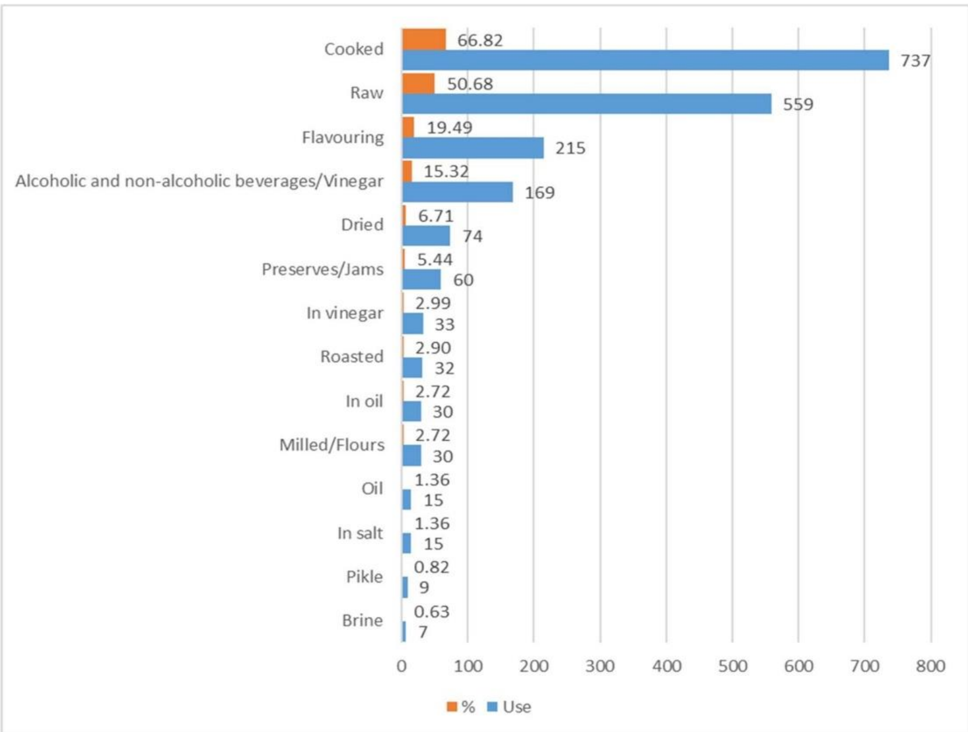


Figure 11. Methods for use of edible species and their frequency in the whole database.

The cooking of WEPs follows articulated local recipes, and is extremely varied (boiled, stewed, in omelettes, fried, to make vegetable broths, risotto, soups, stuffed pasta, savoury pies, etc.). As regards the most widespread use, it is worth noting that today there are many spontaneous species which are eaten raw in a salad, either on their own or mixed with other herbs. This latter type of use is advantageous compared to the former because there is no loss in terms of nutritional value [74], on the other hand it is potentially risky. It is worth remembering that when food is eaten raw, there is no alteration of any toxic or dangerous substances present. Finally, they are frequently used for beverages (alcoholic and otherwise) derived from fermentation or infusion in water or alcohol, mainly using fruits and flowers as a base, which also become part of local tradition. Wide and well-documented use is made of edible wild fruit: loquats, raspberries, wild strawberries, blackberries, blackcurrants are eaten fresh, in fruit salads, jams, desserts, biscuits, syrups, and the like. Several species are used to prepare hot beverages such as herb teas (e.g., *Mentha* sp.pl., *Melissa officinalis*).

3.6. Potentially Toxic Species

A fairly large number of taxa, which in literature appear to be consumed as food, can be considered in some way toxic. Many of them are species which apart from being widespread across the country are largely used and closely connected to the Italian culinary tradition; they include for example *Borago officinalis* and *Dioscorea communis*; in other instances, they are species whose use as food is really sporadic, and in any case limited to extremely small areas, for example *Polygonatum multiflorum* and *Lonicera etrusca*, with very few records in literature. In all cases they are species which contain several categories of chemical compounds (active ingredients, phyto-complexes) whose toxic effects range from high to bland. An example of these highly toxic species, whose use is clearly documented, is *Conium maculatum*; taken in certain doses the latter is considered deadly due to the presence of the alkaloid coniine, even though in some parts of Sardinia the stems of young plants without the bark are eaten [75]. Among the highly toxic species it is also worth mentioning *Lactuca virosa*, whose young leaves are sometimes eaten as salad [75,76] and *Euphorbia lathyris* whose buds were used in Veneto instead of capers [77]. Species with medium or low toxicity include those which can prove dangerous only in cases of excessive and prolonged consumption, for example those in the genus *Rumex* and *Oxalis* due to the presence of oxalates, or of *Amaranthus*, which can accumulate nitrates. In other species, toxic substances are concentrated only in some organs, possibly absent or in any case found only in amounts which are not significant in the parts used. This is the case, for example of

Clematis vitalba which contains ranuncholine, a glucoside which, by hydrolysis, releases protoanemonine, with a strong irritant and blistering effect [21,25,78, 79]; however only the buds of this plant are eaten (where the concentration of ranuncholine is smaller), always cooked (protoanemonine is thermally unstable). Also the type of preparation, therefore, can make a difference: in order to make some bulbs edible, for example *Cyclamen hederifolium*, *C. repandum*, *Bellevalia romana*, prolonged cooking was followed by macerating in cold water [80–82] to eliminate any excess of both bitter and toxic substances (saponins, cyclamins, and histamines). As can be seen in Figure 12, it appears that in some families most WEPs are toxic in one way or another; in other cases, practically all of them are, for example Boraginaceae such as *Borago officinalis*, *Symphytum officinale*, and *S. tuberosum* which contain unsaturated pyrrolizidine alkaloids [83,84]; if used frequently these plants have a hepatotoxic and blandly mutagenic action [74]; moreover, experiments on animals have shown their carcinogenic action, through a genotoxic mechanism [85].

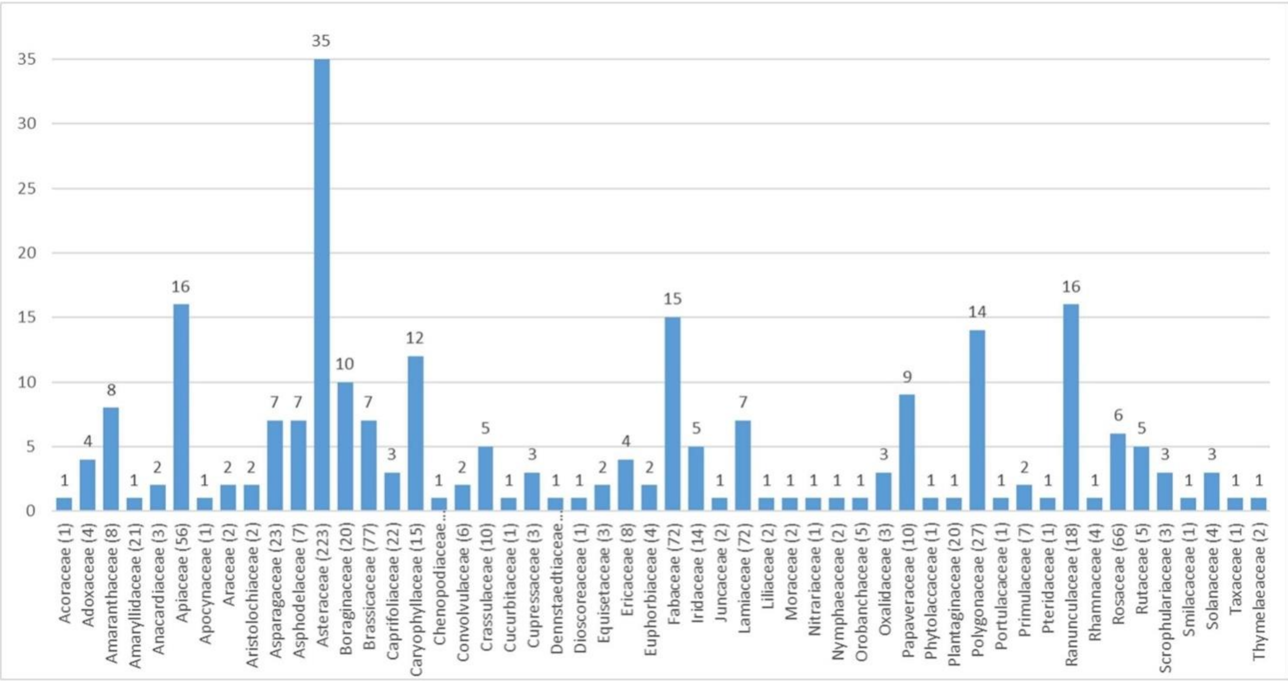


Figure 12. Distribution of toxic taxa of Italian alimurgic flora included in the database AlimurgITA.

3.7. Biological Spectrum

Examining life forms, out of the 1103 taxa recorded, it has been shown that the most widely represented can be divided as follows, in decreasing order: emicryptophytes (39%), therophytes (25%), geophytes (12%), phanerophytes (15%), chamaephytes (8%), hydrophytes (1%), and helophytes (0.09%) (Figure 13). Table S2 of the Supplementary Materials shows a breakdown by subforms.

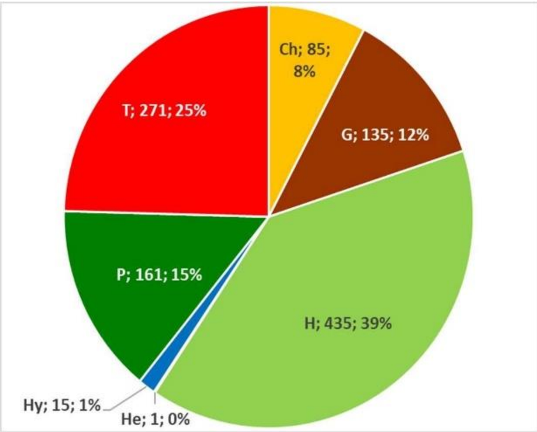


Figure 13. Composition in absolute and percentage value of the Italian edible spontaneous taxa biological spectrum. Ch = Chamaephytes; G = Geophytes; H = Emicryptophytes; He = Helophytes; Hy = Hydrophytes; P = Phanerophytes; and T = Therophytes.

The widespread presence of Hemicryptophytes is mainly due to their habitus, because they be either biannual (*Crepis vesicaria*, *Daucus carota*) or perennial species (*Cichorium intybus*, *Plantago lanceolata*, *Foeniculum vulgare*). Among the various sub-forms, the most relevant in percentage terms include scapose plants (H scap), accounting for 22.48%, of which mainly the basal rosettes and leaves are used (e.g., *Cichorium intybus*). As regards Therophytes, consisting almost exclusively of scapose plants (T scap 22.39%), it is their tender leaves that are generally eaten (*Chenopodium album*, *Portulaca oleracea*, *Borago officinalis*), then possibly their aerial part.

As for Phanerophytes, which are mainly represented by scapose plants (P scap 4.35%), it is their fruits that are mainly used, both fresh and dried (e.g., *Sambucus nigra*, *Juniperus communis*, *Ceratonia siliqua*). The group of phanerophytes and nano-phanerophytes (P and NP), trees and small shrubs, provide fruits and wild seeds; on the other hand, new shoots are mostly collected from liana phanerophytes (P lian). Geophytes, both bulbous (G bulb 5.80%) and rhizomatous (G rhiz 5.80%) are mainly used for their underground part (tubers, roots, bulbs) (e.g., *Ficaria verna*, *Helianthus tuberosus*, and *Muscari comosum* (=*Leopoldia comosa*). The most widely used parts of Chamaephytes, especially aromatic suffruticose plants (CH suffr 3.90%) rich in essential oils used to flavour dishes (e.g., *Thymus vulgaris*, *Satureja montana*) are branches and leaves. Hydrophytes (*Trapa natans*, *Acorus calamus*, *Glyceria fluitans*, *Posidonia oceanica*), mainly rooting plants (I rad 1.27%), are scarcely represented and not associated with the use of specific parts of the plant. Their consumption is limited to four regions (Lombardy, Veneto, Liguria, Apulia). The only helophyte found (*Phragmites australis*) is used just in the Apulia region; the parts used of the latter are rhizomes, tender leaves and top shoots, either raw in salads and cooked/stewed or in omelettes.

3.8. Chorology Spectrum

From a phyto-geographical perspective, it is interesting to note that most of the food flora comes from the Mediterranean region, with a strong presence of Euri-Mediterranean (18.98%) and of Steno-Mediterranean plants (16.35%); this highlights in the gastronomic field the connection between the various cultures in the Mediterranean area [15,16,69,70] (Figures 14 and 15). In fact, some plants are used in different parts of Italy and the Mediterranean, for example *Papaver rhoeas* subsp. *rhoeas*, *Sonchus asper*, or *Reichardia picroides* [71,86–91].

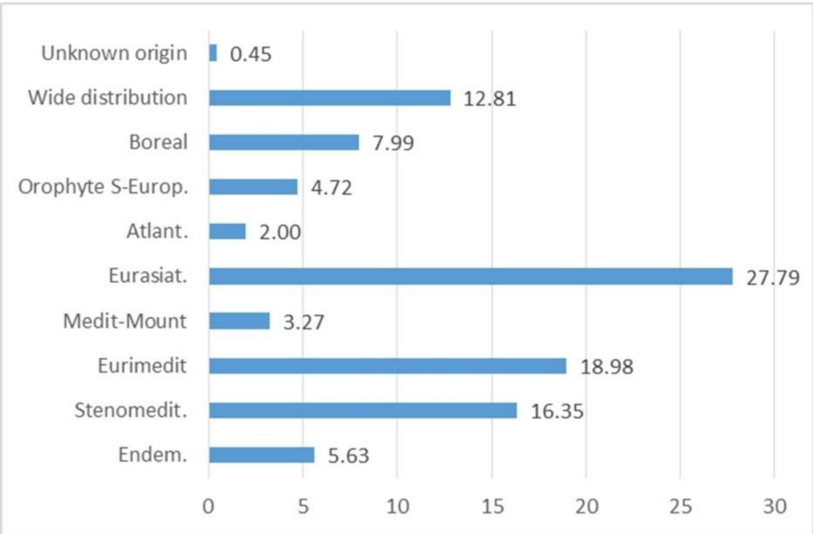


Figure 14. Percentage composition of the chorologic spectrum of Italian of Wild Edible Plants (WEPs).

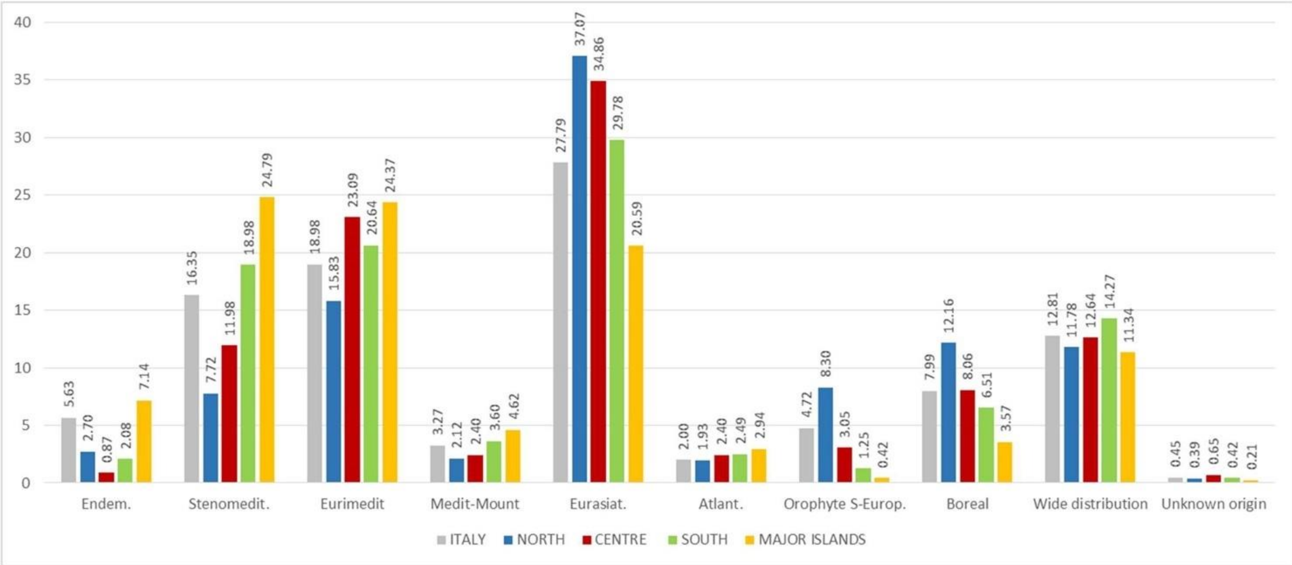


Figure 15. Percentage composition of the chorologic spectrum of Italian edible spontaneous taxa by geographical region.

The high incidence of Eurasian species, about 27.79%, is due to strong bio-geographical connections between the flora contingent in the Italian Apennine region and areas belonging to Eurasia. Boreal species connected with Northern Europe or mountain environments account for 7.99% (Euro-Siberian and Circumboreal species). There is a limited amount of both SE-European Orophytes (4.72%) distributed along the mountain strip of Balkan areas, and Atlantic (2.00%) species whose distribution area is focused on the Atlantic coast of Europe. Only 5.63% of the total alimurgic flora is represented by endemic species, divided in an extremely discontinuous way, with low values in the central sector (0.87%), and on the other hand a strong accentuation in the island area (7.14%).

Further significant data resulting from the chorology analysis are related to species with a wide distribution present in Italy accounting for 12.81%, a value which is fairly similar in the various geographical sectors. Within this chorotype, specific consideration has been given in this case to ‘adventitious’ plants, i.e., alien species, now naturalized, which over the centuries have found a phytoalimurgic collocation, fully entitled to fit within the multi-faceted framework of traditional regional cuisines. From an ecology perspective, adventitious plants canbe considered in most cases species with a pioneering approach and a marked colonizing activity, often invasive, in synanthropic nitrophyle or ruderal habitats [92]. This set of characteristics has allowed them to establish themselves rapidly also on large surfaces. It therefore seemed appropriate to further divide this chorotype into its sub-categories for the purpose of attempting to historically connect and reconnect, although in an approximated form, the beginning of the use of some species in the Italian culinary tradition. In this regard, Table 6 shows that the main flora supplies of alimurgic species, with the exception of Cosmopolitan and Subcosmopolitan plants, come from the American and Asian continent and from desert areas from the Mediterranean to central Asian region (Mediterraneo-Turanian species).

Table 6. Chorology spectrum of wide distribution species, divided by chorotypes

Chorotype	N	%
Africa	3	2.13
America	17	12.06
Asia	17	12.06
Oceania	2	1.42
Adventitia	4	2.84
Cosmopolitan	19	13.48
Mediterraneo-turanian	28	19.86
Paleosubtropical	2	1.42
Paleotropical	4	2.84
Pantropical	2	1.42
Saharo-sindic	2	1.42
Subcosmopolite	38	26.95
Subtropical	3	2.13

3.9. Bibliography Contributions from 1918 to 2020

Considering the state of our knowledge regarding wild edible plants, further analysis has been focused on how this knowledge has become more in-depth over time proportionally to the degree of interest shown in them by the audience of specialists in this discipline. Starting from the first modern publication by [57] to the present day, the overall bibliography trend has been outlined with a 10-year interval division. From Figure 16 it appears clearly that the increase in texts published started to become significant during the 1991–2000 decade, reaching its peak in the next decade, then dropping in the 2011–2020 decade. There have been 289 publications on WEPs (accounting for 80.73% of the total) produced between 1991 and 2021, which is evidence of the growing interest in the subject of alimurgy.

3.10. Bibliography Contributions for Each Italian Region

Considering the amount of bibliography contributions published for each region, according to the criteria established in the methodology section, the available data show very clearly (Figure 17) that the three regions with the largest number of published specialized texts are Tuscany (63), followed by Sicily (50) and Apulia (24). There are numerous regions with limited bibliography contributions: Aosta Valley (2), Trentino Alto-Adige (3), Umbria (4), and Emilia Romagna (6). Tuscany, with its abundant production, accounts for 17.26% of Italian literature overall, while Sicily accounts for 13.70%.

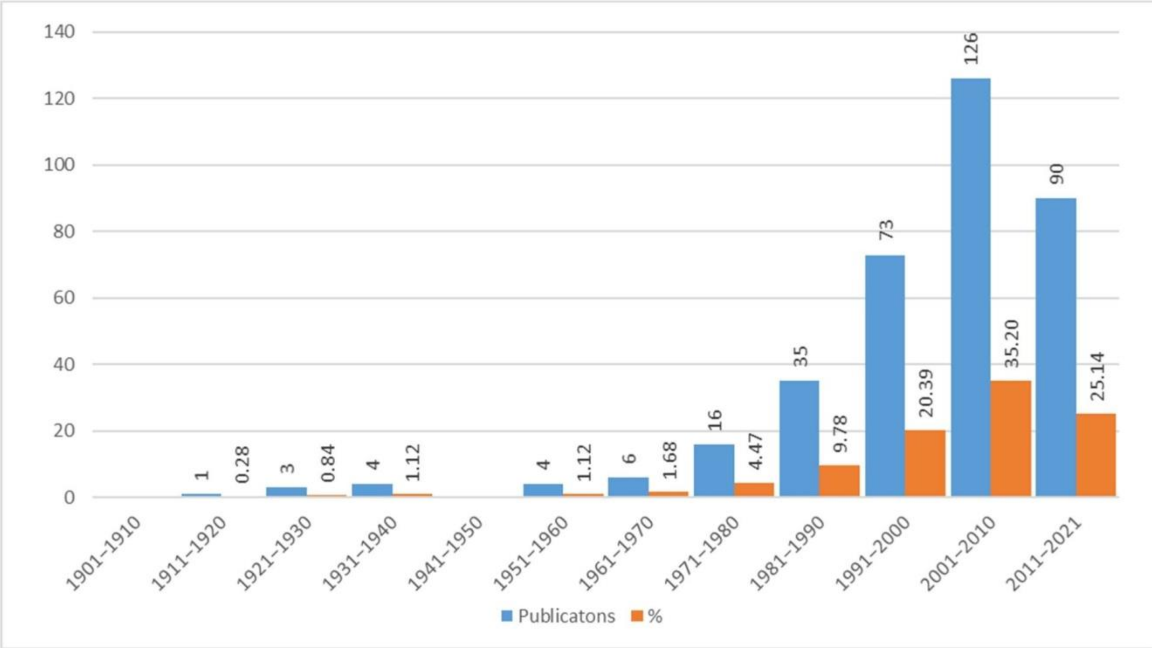


Figure 16. Publications (358) on the alimurgic theme per decade, expressed in absolute and percentage figures.

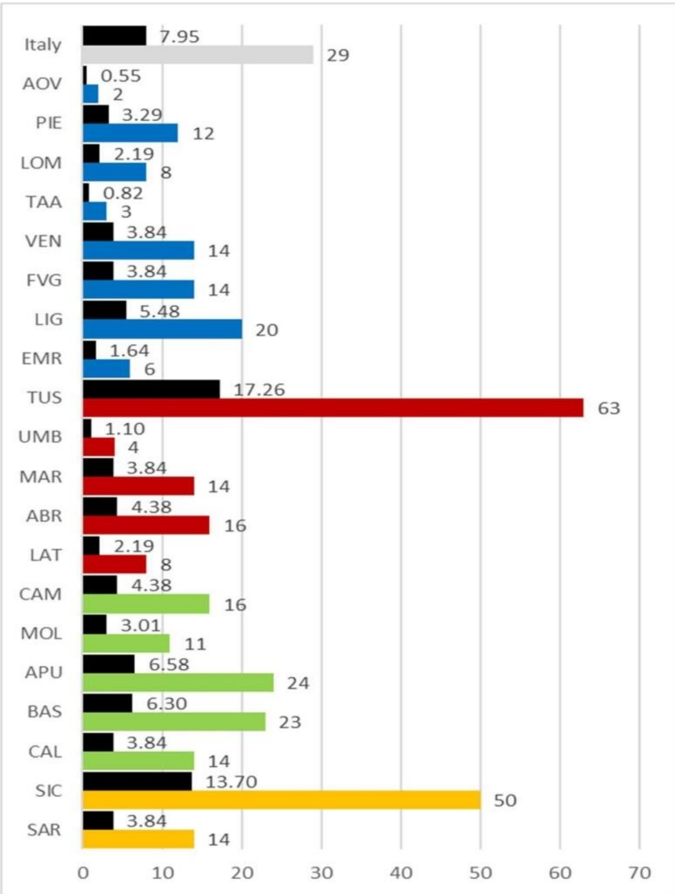


Figure 17. Number of texts published by region or in Italy based on absolute (colored columns) and percentage (black columns) values. Abbreviations of the administrative regions are shown in Figure 1.

In total, the taxa which should be considered somehow toxic are 242, accounting for 21.94% of WEPs in Italy.

In any case, despite the presence of active ingredients potentially harmful for human health, their consumption for centuries [93,94] is evidence that they are essentially harmless if ingested. Of course, the limit between the two categories (toxic/non toxic) is arbitrary, because it is difficult to establish: as always the following concept applies: "All things are poison and nothing is without poison; only the dose makes a thing not a poison" according to the famous sentence by Paracelsus.

4. Discussion

The 1103 taxa of edible flora entered in the database AlimurgITA account for 13.09% of Italian flora. There has thus been an increase by 275 taxa compared to the 828 recorded in the database of CET (Centro Etnobotanico Toscano) which also includes several cultivated plants [20]. A further 177 taxa listed in the bibliography consulted, and considered for this project, have been excluded from the total number of alimurgic plants because they are cultivated or considered occasional Adventitious (for a definition, please refer to Materials and Methods). The high frequency of edible Asteraceae, accounting for 20.22% of total WEPs, is apparently associated with the high number of taxa in Italian flora, to their palatability which is combined with their large availability in several seasons. The basal rosette, the most widely consumed part, is available even during the autumn-winter. It is also worth mentioning the low toxicity of this family, mainly with regard to the subfamily of *Cichorioideae* to which most of the recorded WEPs belong. The fact that Asteraceae are more representative has also become apparent in a number of studies, therefore it is confirmed to be one of the most widely used in Italy [20,74,95], especially in insular regions of the country [69,70]. The regional distribution of WEPs is far from homogeneous, ranging from a minimum of 86 taxa recorded in Trentino-Alto Adige to the maximum of Apulia, with 569 taxa. The data from Apulia derives mainly from the contribution by Bianco who, in one publication alone [96], reported as many as 564 taxa (of which 156 not reported in previous papers); all this has also affected the distribution of aggregated data by sector in southern Italy, the area with the largest number of taxa. Trentino Alto-Adige, Emilia-Romagna, and Umbria show the lowest numbers of WEPs in Italy. In some cases (e.g., Veneto, Tuscany, Sicily) the number of taxa mentioned in the database AlimurgITA appears to differ, although just by a few units, from the one recorded in summary publications of a regional nature [70,77,97,98]. The difference is due to the different criterion for choosing

WEPs, to the different nomenclature system and to any updates of lists with the acquisition of new data. The large number of alimurgic taxa by region can be interpreted in various ways. A first theory is associated with the assessment of the time span during which the alimurgic studies have taken place: the more distant they are from the current time, the higher the probability that it might be possible to have access to cultural heritages which are richer and even more strongly rooted to traditional used. The time span is also related to another element (which is often neglected), namely the continuity of recording within the same territorial framework, which has made it possible to monitor the persistence in the use of some species. On a national scale, for example, the 32 taxa listed in the publication by [57], then entered in the database (*Achillea millefolium*, *Asparagus acutifolius*, *A. officinalis* subsp. *officinalis*, *Bellis perennis*, *Bistorta officinalis* (=*Persicaria bistorta*), *Bunias erucago*, *Campanula rapunculus*, *Capsella bursa-pastoris* subsp. *bursa-pastoris*, *Diplotaxis tenuifolia*, *Eruca vesicaria*, *Humulus lupulus*, *Hypochaeris radicata*, *Lapsana communis*, *Loncomelos pyrenaicum* (=*Ornithogalum pyrenaicum*), *Melissa officinalis*, *Nasturtium officinale*, *Papaver rhoeas* subsp. *rhoeas*, *Parietaria officinalis*, *Plantago lanceolata*, *P. media*, *Portulaca oleracea*, *Poterium sanguisorba* (=*Sanguisorba minor*), *Salvia rosmarinus* (=*Rosmarinus officinalis*), *Sinapis arvensis* subsp. *arvensis*, *Sisymbrium officinale*, *Sonchus arvensis*, *S. asper*, *S. oleraceus*, *Symphytum tuberosum*, *Taraxacum officinale* group, *Tragopogon pratensis*, *Urtica dioica*), have been mentioned in various ways over time by several authors and in publications both as bibliographic compendium and territorial ethnobotanic census (Figure 18).

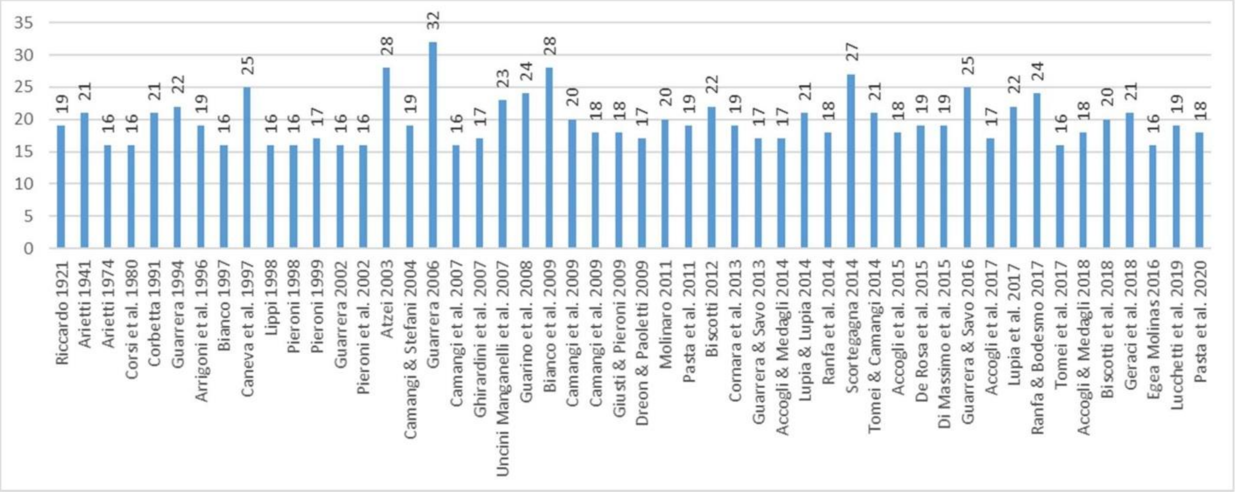


Figure 18. Number of taxa cited by [57] and also reported in publications of subsequent years.

Among these taxa, those which are no longer mentioned include Loncomelos pyrenaicum (=Ornithogalum pyrenaicum), since 2017, Plantago media and Bistorta officinalis (=Persicaria bistorta), since 2018, Lapsana communis, Sisymbrium officinale, and Symphytum tuberosum subsp. angustifolium since 2019. A second theory is related to floral and coenological diversity, which in turn is associated with the geographical extension and complexity of the regions surveyed, large sections of which may not be explored in the absence of regional overviews.

There is a third theory related to the latter, connected with the number of publications, even though this element cannot always be correlated to the degree of knowledge. For example, Tuscany, the region which provided the largest number of publications on the subject of alimurgy (sometimes redundant in terms of information) shows similar levels of knowledge compared to Veneto, Calabria, and Sardinia, characterized by few but substantial synthesis works [16,75,77,99]. A last theory refers to the use of the territory and to its impact in terms of erosion in traditional culture. The limited number of WEPs in Emilia-Romagna, for example, could also be due to agricultural practices on an industrial scale which over the past few decades have radically changed the farming society, leading to a rapid reduction of ethnobotanic knowledge (and therefore of WEPs). The remarkable differences in the number of species recorded from region to region can thus be associated also with the level of erosion in the transmission of culture. Attempting to estimate, even hypothetically, the entity of this loss, was one of the objectives of this project. This is why we calculated the ratio between edible plants recorded by region and the species potentially present. The results, in percentage terms on a national scale, have shown a use of alimurgic flora accounting for 7.6% compared to the potential value; as regards regional flora, WEPs account for 2.73% in Trentino Alto-Adige and 22.69% in Apulia. As for southern regions and major islands, the values remain high, which is evidence of on-going and capillary ethnobotanic explorations, complemented by traditional culture legacies which are still present, vital, and can therefore be detected. In this area there are some specific cultural provisions of ancient races, which are also important in order to establish the ethnichistorical connection, which sometimes still exists, with eastern Adriatic countries (Greece, Albania, Croatia) [80,100–104]. An example of this is the influence of Greek communities in Calabria, developed as a consequence of the historical migrations which occurred in Greece. More than half of the plant species from the Graecanic area (58%) are also used as edible plants in Greece [105,106] and there are some species (*Chrysanthemum segetum*, *Hedypnois cretica*, and *Lotus edulis*) commonly used in Greece and in the Graecanic area, but not in other parts of Italy [107]. It is finally worth noting the substantial contribution of publications from the past 20 years for the southern and insular areas as further evidence of the persistent vitality of cultures related to farming and shepherding. Their availability for most of the year, their palatable taste, territorial frequency, specific biomass, ease of recognition and therapeutic virtues are all factors which taken together lead to the success in the use of a given species. This is the case of *Borago officinalis*, *Urtica dioica*, *Sonchus oleraceus*, *Taraxacum officinale* group, *Papaver rhoeas* subsp. *rhoeas* which are widely eaten and present in all recipe books of traditional cuisine in every Italian region, as evidence of still existing ethnobotanic connections. Nevertheless, some differences have been detected in the gathering and consumption of wild plants between the various Italian regions. In terms of families recorded, in the North and Centre there is a prevalence of Rosaceae, in the South of Brassicaceae and on the islands of Asteraceae. These data match what was in part recorded by [20,64].

As a matter of fact, the use of each species on the Italian territory is related not just to its area distribution but also to frequency, that is to say its availability in the region, a factor which would explain the anomalies in the failed reporting of its use. Species which are widely used in Italy such as *Clematis vitalba* and *Asparagus acutifolius*, for example do not appear to be used in Aosta Valley and in Trentino-Alto Adige due to their rarity, even though they are present in regional flora [60,62]. Nevertheless, other taxa show anomalies related to discontinuity in distribution with geographical sector leaps which are difficult to interpret. Reference can be made, for example to the absence of *Sambucus nigra* in Umbria, of *Laurus nobilis* in Aosta Valley and Umbria, of *Rosa canina* in Umbria alone, of *Plantago major* in Latium *Clinopodium nepeta* subsp. *nepeta* in most regions in the north, and of *Hypochaeris radicata* which shows gaps in every region. The current lack of reference to the use of a given plant in a specific region could be due to its limited availability, to the decline in its use of time, to its absence in tradition, or simply to the fact that it has not been intercepted by ethnobotanic studies. At the moment we believe that it is not possible to establish which of these theories (ecological and cultural) is more sensible. It is also worth mentioning that the most accentuated and deeply-rooted preference of taste in some regions, for example for the bitter flavour, which is more appreciated in southern Italy than in the North [64,102,103]. Generally speaking, when talking of ‘traditional’ use of a given species, collective imagination places it many centuries before the modern age. This is not always true because the use of some species (and of recipes) which are undisputedly considered as belonging to the cultural heritage of one area, may date back just one or two centuries. In some circumstances, the beginning of the use of WEPs can be placed within a specific time frame:

this is the case of adventitious species from the New World which have gained ground and later become widespread in Italy thanks to their presence in seeds of other crops (e.g., tomato, potato, corn). Nor can it be ruled out that some of these adventitious plants might have been grown on purpose to be abandoned later if they should no longer prove convenient or palatable, as for example in the case of *Lepidium sativum* and *Satureja hortensis*. Specific attention should be paid to endemic or rare species. Excessive gathering of these species for edible use could lead to contraction phenomenon in populations, with risks in terms of preservation in nature of the latter. The precautionary principle also applies when there are two species which are morphologically very similar, one of which rare and the other frequent which can be mistaken one from the other, leading to the disappearance or reduction of population of the rarest species. This is the case of several endemic regional plants which are found and eaten only in one Region, such as *Anchusa capellii* (=*Anchusa crispa*) in Sardinia [75] and *Urtica rupestris* in the Sicily [108] whose use is questioned by [98].

It would therefore be appropriate if, for this category of alimurgic species (or of medicinal species), authors could mention the appropriateness of gathering them in moderation, making reference if applicable to regional or national regulations. The most extensively collected parts of WEPs are leaves, especially if joined into basal rosettes (H ros) which, being easy to collect, guarantee, in rapid times, the acquisition of a satisfactory amount of biomass. Moreover, these parts are tender, very palatable, and versatile in their use. From a nutritional perspective, the fact that leaves are the most widely used part in almost all species should be attributed to their ability to collect fundamental substances, such as mineral salts and vitamins.

More limited use is made of new shoots, gemmae, and flower buds because they are related to very short phenology periods (e.g., *Asparagus* sp. pl., *Capparis* sp. pl, etc.).

The underground systems (roots, bulbs and rhizomes) have a variety of uses because they can be used either as flavouring (gentian, horseradish, liquorice, etc.), or as nutrient reserves (first and foremost starch), given that they can be kept for a relatively long period of time (e.g., garlic, potatoes, onions). Such a widespread use of fruits, due to their high palatability, is attributable in part to nutritional features: rich in sugar and calories, they are eaten also during famine periods in order to alleviate hunger. The high number of records, in any case, is related also the diversified use which was made of them; their fruits were eaten not only fresh, they were also dried or used to flavour wines and liqueurs. As regards flowers, their use is mainly associated with preparing miscellaneous beverages and liqueurs. Within the current culinary framework, flowers due to their pleasant appearance are mainly used for garnishing dishes. Even though raw consumption is the easiest and most straightforward, cooking appears to the most widespread because it makes food more digestible, reduces the pathogenic load and allows for eliminating unwelcome characteristics (e.g., toxicity). It is also worth mentioning that, in some cases, cooking enhances the sensorial properties of herbs, mitigating any excessively bitter characteristics. On the other hand, thermal treatments may lead to a series of modifications involving consistency, color, and texture of plant tissues associated with phenomena related to thermal degradation, oxidation, and leaching with a subsequent loss of nutrients and anti-oxidant compounds [109,110]. The method of use, also related to preservation and thus to deferred consumption of species over time, also involves complex and multiple preparations (e.g., roasting as pre-requisite for preparing flours or beverages).

5. Conclusions

The gastronomic geography of Italy is rich in culinary variants compliant with the morphology of its territories, the climatology of physical environments, the structuring of production activities and the series of historical-cultural and socio-demographic events. This is the setting for the rich floral diversity of the WEPs used in the national gastronomy tradition. Over the last century, however, great social upheavals especially in Europe have led to a simultaneous trend towards urbanization and depopulation of our inland areas, which are considered the main causes for the disappearance of most of the traditional knowledge and practice as regards wild edible plants [111]. The use of WEPs still thrives, mainly in several small communities, the last strongholds of our farming and shepherding heritage, also thanks to the increased opportunities of being in touch on an on-going basis with the natural environment, compared to urban dwellers. The results of this work have shown that the regions where WEPs are most widely used are those where there is still a strong territorial connection which encourages the population and researchers to keep knowledge and skills alive. This phenomenon, with the exception of Tuscany, seems to be concentrated in southern Italian regions (Apulia) and on the islands (Sicily and Sardinia) [70,75,96]. On the contrary, in other Italian regions, the diversity of alimurgic flora shows the lack of knowledge as a whole, considering its extraordinary basic potential. In this regard, our study can be expected to encourage the in-depth study of alimurgy and more in general of ethnobotany in Italian territories where knowledge appears to be insufficient, not to say scarce. The wealth and diversification of uses is also due to the impacts of cultures from several ethnic groups, often limited to community minorities found mainly in southern regions and in Sicily (e.g., Slava language communities in Molise, Albanian communities in Molise, Lucania and Calabria, as well as Graecanic communities in Apulia and Calabria) which have created specificities [80,100–106].

The long list of WEPs in this work, also related to the high floral diversity in Italy, includes all taxa recorded to date in Italian tradition. Unfortunately, it is not possible to establish how many of these taxa are still used or how many are no longer eaten, and therefore should be considered mere ‘historical’ testimonies. The gradual erosion of traditional knowledge of WEPs, especially in the last generations [64], is counterbalanced by a widespread phenomenon related to the “craving for nature” and “neo-rurality” which have become something more than a passing trend of our time. Evidence of this is the thriving of numerous texts and recipe books which, over the past 20 years, have been published based on the local tradition and experimenting with alternative uses thanks to a gastronomy culture which is very lively and strongly felt in Italy.

What is the significance of alimurgic plants today?

It is first of all a way of keeping alive a millenary tradition which will be able to survive, as long as it remains functional, without being limited to mere folklore or museum exhibitions. Even though WEPs in Italy are not a staple food, they are often a key element in cultural representations, in identification processes of a community. An example of this is the cross-border identity which is founded on the phrase ‘Mediterranean diet’, even though it appears to be highly diversified in terms of local recipe books. The use of WEPs, to sum up, implicitly means accepting as part of one’s diet the tenets of a traditional model to be followed which is consistent with the characteristics of the territories. The large variety of plant products available spontaneously (complementary to those from the fields and from the orchard), apart from meeting taste requirements is an important nutraceutical product which can prove advantageous in terms of psycho-physical well-being.

In conclusion, studying the socio-psychological components of food, ref. [112] highlights and sums up the above with an insightful sentence: “Whether we are aware of it or not, when we eat we are ingesting not just a specific food, but also the concept (i.e., the culture and territory) associated with it”.

The use of WEPs, furthermore, is also a way of reformulating some paradigms related to production in the farming world. Most of the current agricultural production systems cause environmental pollution because large amounts of fertilizers, pesticides, and herbicides are used. The profound alteration of habitats caused by agriculture is considered the main cause of the loss of biodiversity [13,113,114] with an impact also in terms of reduced connectivity in the landscape. The expected human population growth to nine billion by 2050 will require an even more significant increase in agricultural production. Over the next few decades, the epochal challenge will be to maintain these productive rhythms in the face of biotic and abiotic threats attributed to climate change [33–35]. Within this forthcoming scenario, CWRs and WEPs, which are closely linked, can provide a significant and growing contribution to the security of food supplies. Given that they have not crossed the domestication bottleneck [115], WEPs and CWRs maintain a high inherent genetic diversity which allows for their effective adaptation to a wide variety of habitats [116]. WEPs are still a largely unexplored area for farming with a low energy input (including water consumption), as well as for an extension of the availability for humanity of food, vitamins, and nutrients from sustainable sources [117], also including preparations based on herbs, traditional medicine formulas, or new bio-drugs [118,119]. Therefore, an overall knowledge of WEPs and of their traditional use in a large territory such as Italy, offers far-reaching prospects in terms of domesticating wild species whose use has already been 'tested' by the relevant populations, encouraging their subsequent introduction into production and consumption systems, for example creating demand for species and regulating their gathering in nature, or possibly encouraging their cultivation. As rightly pointed out by [120], the COVID-19 crisis has dramatically highlighted the frailty of a trade system based on the globalization of procurement and distribution of food products. The pandemic is leading us towards a new paradigm of the food system consisting of short food chains, or even self-sufficiency. Domestic and community vegetable patches, the traditional agro-ecosystems and farmers' markets are shaping up as increasingly essential services [118,121]. Within this socio-economic framework, WEPs could constitute a crucial element, as a model of salutogenesis: systemically generating health both in those who practice it and in the environment.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/ 10.3390/plants10040743/s1, Table S1: List of taxa excluded from the AlimurgITA database region by region: A = Absent; CA = Casual alien/archaeophyte; NR = No longer recorded; D = Doubtfully occurring; RM = Reported by mistake; P = Present. The cultivated species are marked with an asterisk; Table S2: List of the 358 selected texts; Table S3: Biological Spectrum of subforms.

Author Contributions: B.P., P.D.M., and A.B. designed the database. B.P. and P.D.M. analyzed the data. B.P., P.D.M., G.S., E.B., and A.B. wrote the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by PhD grants in Agriculture Technologies and Biotechnologies, Department of Agricultural, Environmental and Food Sciences, University of Molise.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data will be available when the AlimurgITA website is published

Acknowledgments: There are many people to whom we must thank for their collaboration and for the time they have given us. We list them in alphabetical order. Stefano Armiraglio, Andrea Bertacchi, Adelina Chierchia, Federica Gironi, Paolo Maria Guarrera, Carmine Lupia, Aurelio Manzi,
Eleonora Matarrese, Giovanni Rendina, Silvio Scortegagna; Professors Riccardo Guarino, Pietro Minissale, Angela Stanisci and Fernando Tammaro. Our gratitude is also addressed to Mariassunta Libertucci, Antonella Zappone of the University of Molise, and to the AIF (Associazione Italiana Fitoalimurgica) which unites experts and proposes activities in the national field in alimurgical issues. Finally, I should like to say special thanks to Serena Trimarchi of the University of Pisa, precious in her advice and generous in the bibliographic material made available.

Conflicts of Interest: The authors declare no conflict of interest.

References

1.Arnason, T.; Hedba, R.J.; Johns, T. Use of plants for food and medicine by Native Peoples of eastern Canada. Can. J. Bot. 1981, 59, 2189–2325. [CrossRef]

2.Gispert, M.; Gonzalez, C. Plantas comestibles–plantas medicinales ¿matrimonio en concordia? Antropologicas 1993, 7, 58–64.

3.Etkin, N. Medicinal cuisines: Diet and ethnopharmacology. Int. J. Pharm. 1996, 34, 313–326. [CrossRef]

4.Etkin, N.; Johns, T. ‘Pharmafoods’ and ‘nutraceuticals’: Paradigm shifts in biotherapeutics. In Plants for Food and Medicine; Prendergast, H.D.V., Etkin, N.L., Harris, D.R., Houghton, P.J., Eds.; Royal Botanic Gardens, Kew: London, UK, 1998; pp. 3–16.

5.Pieroni, A. Medicinal plants and food medicines in the folk traditions of the upper Lucca Province, Italy. J. Ethnopharmacol. 2000, 70, 235–273. [CrossRef]

6.Pieroni, A.; Price, L.L. Eating and Healing: Traditional Food as Medicine; Food Products Press: Binghamton, NY, USA, 2005.

7.Goldman, I.L. Forgotten and Future Vegetable Phytoceuticals. In Trends in New Crops and New Uses, Proceedings of the Fifth National Symposium, Atlanta, GA, USA, 10–13 November 2001; Janick, J., Whipkey, A., Eds.; ASHS Press: Alexandria, VA, USA, 2002; pp. 484–490.

8.Khanuja, S.P.S. The power of plant metabolome: Secondary metabolites as high value bioactive phytoceuticals. Proc. Natl. Acad. Sci. India Sect. B Biol. Sci. 2009, 79, 7–14.

9.Wildman, R.E.C. (Ed.) Handbook of Nutraceuticals and FUNCTIONAL foods; CRC Press—Taylor & Francis Group: London, UK, 2016.

10.Zohary, D.; Hopf, M. Domestication of Plants in the Old World: The Origin and Spread of Cultivated Plants in West Asia, Europe and the Nile Valley, 3rd ed.; Oxford University Press: Oxford, UK, 2000.

11.Garn, S.M.; Leonard, W.R. What did our ancestors eat? Nutr. Rev. 1989, 47, 337–345. [CrossRef] [PubMed]

12. Fuleky, G. Cultivated Plants, Primarily as Food Sources. In Cultivated Plants, Primarily as Food Sources; Fuleky, G., Ed.; EOLSS Publishers Co Ltd: Oxford, UK, 2009; Volume 1.

13. FAO. The State of the World's Biodiversity for Food and Agriculture; Bélanger, J., Pilling, D., Eds.; FAO Commission on Genetic Resources for Food and Agriculture Assessments: Rome, Italy, 2019. [CrossRef]

14. Couplan, F. Le Régal Végétal, Plantes Sauvages Comestibles; Éditions Équilibres: Flers, France, 1989.

15. Couplan, F. Les Plantes Sauvages Comestibles, 2nd ed.; Editions Sang de la Terre: Paris, France, 1995.

16. Couplan, F. Guide des Plantes Sauvages Comestibles et Toxiques; Delachaux & Niestle: Paris, France, 2002.

17. Rivera, D.; Obón, C.; Heinrich, M.; Inocencio, C.; Verde, A.; Fajardo, J. Gathered mediterranean food plants. Ethnobotanical investigations and historical development. In Local Mediterranean Food Plants and Nutraceuticals; Forum of Nutrition 59; Heinrich,

M., Müller, W.E., Galli, C., Eds.; Karger: Basel, Switzerland, 2006; pp. 18–74. [CrossRef]

18. Leonti, M.; Nebel, S.; Rivera, D.; Heinrich, M. Wild gathered food plants in the European Mediterranean: A comparative analysis. Econ. Bot. 2006, 60, 130–142. [CrossRef]

19. FAO Committee on Forestry State of the World's Forests 2020—Key Messages; Twenty-Fifth Session, 5–9 October 2020. Available online: http://www.fao.org/3/nd452en/nd452en.pdf (accessed on 15 February 2021).

20. Camangi, F.; Guarrera, P.M.; Camarda, I.; Tomei, P.E.; Lentini, F.; Stefani, A.; Leporatti, M.L.; Pieroni, A. Usi alimentari. In Etnobotanica. Conservazione di un Patrimonio Culturale Come Risorsa per uno Sviluppo Sostenibile; Caneva, G., Pieroni, A., Guarrera, P.M., Eds.; Edipuglia: Santo Spirito (Ba), Italy, 2013; pp. 113–142.

21. Guarrera, P.M.; Savo, V. Wild food plants used in traditional vegetable mixtures in Italy. J. Ethnopharmacol. 2016, 185, 202–234. [CrossRef]

22. Fleurentin, J. Ethnopharmacologie et aliments: Introduction au sujet et réflexions sur l'efficacité biologique. In Médicaments et Aliments: Approche Ethnopharmacologique; Schoeder, E., Balansard, G., Caballon, P., Fleurentin, J., Mazars, G., Eds.; ORTOM Edit.: Paris, France, 1993; pp. 1–7.

23. Cox, P.A.; Balick, M.J. The ethnobotanical approach to drug discovery. Sci. Am. 1994, 270, 82–87. [CrossRef]

24. Camangi, F. Etnobotanica: Ricadute applicative. In Atti del Workshop. Le Piante Spontanee Come Risorsa per il Florovivaismo e la Valorizzazione del Paesaggio (Pisa, 18 maggio 2007); Pardossi, A., Malorgio, F., Pezzarossa, B., Bretzel, F., Eds.; Aracne: Roma, Italy, 2008; pp. 79–92.

25. Guarrera, P.M. Usi e Tradizioni della Flora Italiana. Medicina, Popolare ed Etnobotanica; Aracne Editrice: Roma, Italy, 2006.

26. Etkin, N. The cull of the wild. In Eating on the Wild Side: The Pharmacologic, Ecologic, and Social Implications of Using Noncultigens; Etkin, N.L., Ed.; University of Arizona Press: Tucson, Arizona, 1994; pp. 1–21.

27. Brill, J.B. The Mediterranean Diet and Your Health. Am. J. Lifestyle Med. 2009, 3, 44–56. [CrossRef]

28. Motti, R.; Bonanomi, G.; Lanzotti, V.; Sacchi, R. The Contribution of Wild Edible Plants to the Mediterranean Diet: An Ethnobotanical Case Study Along the Coast of Campania (Southern Italy). Econ. Bot. 2020, 74, 249–272. [CrossRef]

29. Keys, A.B.; Keys, M. How to Eat Well and Stay Well the Mediterranean Way; Doubleday: Garden City, NY, USA, 1975.

30. Antonovsky, A. The salutogenic model as a theory to guide health promotion. Health Promot. Int. 1996, 11, 11–18. [CrossRef]

31. Ulian, T.; Diazgranados, M.; Pironon, S.; Padulosi, S.; Liu, U.; Davies, L.; Howes, M.-J.R.; Borrell, J.S.; Ondo, I.; Pérez-Escobar, O.A.; et al. See fewer authorsUnlocking plant resources to support food security and promote sustainable agriculture. PlantsPeoplePlanet 2020, 2, 421–445. [CrossRef]

32. Maxted, N.; Ford-Lloyd, B.V.; Jury, S.L.; Kell, S.P.; Scholten, M.A. Towards a definition of a crop wild relative. Biodiv. Conserv. 2006, 15, 2673–2685. [CrossRef]

33. Feuillet, C.; Langridge, P.; Waugh, R. Cereal breeding takes a walk on the wild side. Trends Genet. 2008, 24, 24–32. [CrossRef] [PubMed]

34. Maxted, N.; Kell, S.; Brehm, J.M.; Jackson, M.; Ford-Lloyd, B.; Parry, M. Crop wild relatives and climate change. In Plant Genetic Resources and Climate Change; Jackson, M., Ford-Lloyd, B., Parry, M., Eds.; CABI: Wallingford, UK, 2013.

35. Redden, R.J.; Yadav, S.S.; Maxted, N.; Dulloo, M.E.; Guarino, L.; Smith, P. (Eds.) Crop Wild Relatives and Climate Change; John Wiley & Son: Hoboken, NY, USA, 2015.

36. Heinrich, M.; Kufer, J.; Leonti, M.; Pardo-de-Santayana, M. Ethnobotany and ethnopharmacology-Interdisciplinary links with the historical sciences. J. Ethnopharmacol. 2006, 107, 157–160. [CrossRef]

37. Morales, P.; Ferreira, I.C.F.R.; Carvalho, A.M.; Sánchez-Mata, M.C.; Cámara, M.; Fernández-Ruiz, V.; de Santayana, M.P.; Tardío, J. Mediterranean non-cultivated vegetables as dietary sources of compounds with antioxidant and biological activity. Lwt-Food Sci. Technol. 2014, 55, 389–396. [CrossRef]

38. Schunko, C.; Vogl, C.R. Factors determining organic consumers' knowledge and practices with respect to wild plant foods: A countrywide study in Austria. Food Qual. Prefer. 2020, 85, 103960. [CrossRef]

39. Tardio, J.; Pardo-De-Santayana, M.; Morales, R. Ethnobotanical review of wild edible plants in Spain. J. Linn. Soc. Bot. 2006, 152, 27–71. [CrossRef]

40. Guarrera, P.M.; Nicoletti, M.; Cingolani, M.L.; Camangi, F.; Culicelli, V.; Lentini, F.; Pieroni, A.; Tomei, P.E.; Sarandrea, M.; Stefani,A.; et al. L'etnobotanica e nuove prospettive in campo farmacologico ed erboristico. In Etnobotanica. Conservazione di un Patrimonio Culturale Come Risorsa per uno Sviluppo Sostenibile; Caneva, G., Pieroni, A., Guarrera, P.M., Eds.; Edipuglia: Santo Spirito (Ba), Italy, 2013; pp. 284–301.

41. Sánchez-Mata, M.C.; Loera, R.C.; Morales, P.; Fernández-Ruiz, V.; Cámara, M.; Marqués, C.D.; Pardo-de-Santayana, M.; Tardío, J. Wild vegetables of the Mediterranean area as valuable sources of bioactive compounds. Genet. Resour. Crop. Evol. 2012, 59, 431–443. [CrossRef]

42. Sánchez-Mata, M.D.C.; Tardío, J. Mediterranean Wild Edible Plants; Springer: New York, NY, USA, 2016.

43. Panfili, G.; Niro, S.; Bufano, A.; D'Agostino, A.; Fratianni, A.; Paura, B.; Falasca, L.; Cinquanta, L. Bioactive Compounds in Wild Asteraceae Edible Plants Consumed in the Mediterranean Diet. Plant Foods Hum. Nutr. 2020, 75, 540–546. [CrossRef]

44. Uncini Manganelli, R.E.; Tomei, P.E. L'etnobotanica in Toscana: Stato attuale e prospettive future. Inf. Bot. Ital. 1999, 31, 164–165.

45. Tomei, P.E.; Uncini Manganelli, R.E.; Trimarchi, S.; Camangi, F. Ethnopharmacobotany in Italy: State of knowledge and prospect in the future. In Proceedings of the Fourth International Congress of Ethnobotany (ICEB 2005), Istanbul, Turkey, 21–26 August 2005; Ege Yayinlari: Istanbul, Turkey, 2006; pp. 123–127.

46. Camangi, F.; Stefani, A.; Sebastiani, L. Etnobotanica in val di Vara. L'uso Delle Piante Nella Tradizione Popolare; Biolabs Libri: Pisa, Italy, 2009.

47. Giacomini, M.; Bisio, A.; Minuto, L.; Profumo, P.; Ruggiero, C. Strutturazione della conoscenza per un database di etnobotanica ligure. Inform. Bot. Ital. 1999, 31, 156–160.

48. Giusti, M.E. Programmi europei e salvaguardia dei patrimoni. Il progetto RUBIA. Lares 2004, 70, 257–267. Available online: https://www.jstor.org/stable/26233873 (accessed on 15 February 2021).

49. Pieroni, A.; Giusti, M.E.; de Pasquale, C.; Lenzarini, C.; Censorii, E.; Gonzáles-Tejero, M.R.; Sánchez-Rojas, C.P.; Ramiro-Gutiérrez, J.M.; Skoula, M.; Johnson, C.; et al. Circum-Mediterranean cultural heritage and medicinal plant uses in traditional animal healthcare: A field survey in eight selected areas within the RUBIA project. J. Ethnobiol. Ethnomed. 2006, 2, 1–12. [CrossRef] [PubMed]

50. Gonzalez-Tejero, M.R.; Casares-Porcel, M.; Sanchez-Rojas, C.P.; Ramiro-Gutierrez, J.M.; Molero-Mesa, J.; Pieroni, A.; Giusti, M.E.;

Censorii, E.; de Pasquale, C.; Della, A.; et al. Medicinal plants in the Mediterranean area: Synthesis of the results of the project Rubia. J. Ethnopharmacol. 2008, 116, 341–357. [CrossRef] [PubMed]

51. Hadjichambis, A.C.H.; Paraskeva-Hadjichambi, D.; Della, A.; Giusti, M.E.; De Pasquale, C.; Lenzarini, C.; Censorii, E.; GonzalesTejero, M.R.; Sanchez-Rojas, C.P.; Ramiro-Gutierrez, J.M.; et al. Wild and semi-domesticated food plant consumption in seven circum-Mediterranean areas. Int. J. Food Sci. Nutr. 2008, 59, 383–414. [CrossRef] [PubMed]

52. Biscotti, N.; Bonsanto, D.; Del Viscio, G. The traditional food use of wild vegetables in Apulia (Italy) in the light of Italian ethnobotanical literature. Ital. Bot. 2018, 5, 1–24. [CrossRef]

53. Targioni-Tozzetti, G. Alimurgia Ossia Modo di Render Meno Gravi le Carestie Proposto per Sollievo dei Poveri; Tip. Moucke: Firenze, Italy, 1767.

54. Arrigoni, T. Uno Scienziato Nella Toscana del Settecento. Giovanni Targioni Tozzetti; Editrice Gonnelli: Firenze, Italy, 1987.

55. Vergari, D. Giovanni Targioni Tozzetti georgofilo e agronomo. Uno scienziato al servizio della comunità. Atti Georg. 2012, 9, 881–894.

56. Targioni-Tozzetti, G. Breve Istruzione circ'ai Modi di Accrescere il Pane col Mescuglio D'alcune Sostanze Vegetabili alla Quale si Sono Aggiunte Certe nuove e Più Sicure Regole per ben Scegliere i Semi del Grano da Seminarsi nel Corrente Autunno del 1766; Firenze, Italy, 1766.

57. Mattirolo, O. Phytoalimurgia Pedemontana (ossia Censimento delle specie vegetali alimentari della flora spontanea del Piemonte); Bona: Torino, Italy, 1918.

58. Camangi, F.; Stefani, A. Tradizioni Phytoalimurgiche in Toscana: Le piante selvatiche nella preparazione delle zuppe. Paralleli E Meridiani Riv. Preist. Etnogr. E Sci. Nat. 2004, 2, 1–5.

59. Zampiva, F. Erbario veneto: Cultura, Usi e Tradizioni Delle Piante e Delle Erbe Più Note; Egida Ed.: Vicenza, Italy, 1999.

60. Galasso, G.; Conti, F.; Peruzzi, L.; Ardenghi, N.M.G.; Banfi, E.; Celesti-Grapow, L.; Albano, A.; Alessandrini, A.; Bacchetta, G.; Ballelli, S.; et al. An updated checklist of the vascular flora alien to Italy. Plant Biosyst. 2018, 152, 556–592. [CrossRef]

61. Acta Plantarum, from 2007 on "IPFI: Index Plantarum". Available online: https://www.actaplantarum.org/flora/flora.php (accessed on 27 February 2021).

62. Bartolucci, F.; Peruzzi, L.; Galasso, G.; Albano, A.; Alessandrini, A.; Ardenghi, N.M.G.; Astuti, G.; Bacchetta, G.; Ballelli, S.; Banfi, E.; et al. An updated checklist of the vascular flora native to Italy. Plant Biosyst. 2018, 152, 179–303. [CrossRef] 63. WFO (2021) World Flora Online. Available online: http://www.worldfloraonline.org (accessed on 4 April 2021).

64. Ghirardini, M.P.; Carli, M.; Del Vecchio, N.; Rovati, A.; Cova, O.; Valigi, F.; Agnetti, G.; Macconi, M.; Adamo, D.; Traina, M.; et al. The importance of a taste. A comparative study on wild food plant consumption in twenty-one local communities in Italy. J. Ethnobiol. Ethnomed. 2007, 3, 22. [CrossRef]

65. Łuczaj, Ł.J. Plant identification credibility in ethnobotany: A closer look at Polish ethnographic studies. J. Ethnobiol. Ethnomed. 2010, 6, 36. [CrossRef] [PubMed]

66. Bacchetta, L.; Visioli, F.; Cappelli, G.; Caruso, E.; Martin, G.; Nemeth, E.; Bacchetta, G.; Bedini, G.; Wezel, A.; Asseldonk, T.; et al. Eatwild Consortium. A manifesto for the valorization of wild edible plants. J. Ethnopharmacol. 2016, 191, 180–187. [CrossRef]

67. Pignatti, S.; Guarino, R.; La Rosa, M. Flora d’Italia, 2nd ed.; Edagricole: Bologna, Italy, 2017–2019; Volumes 1–4.

68. Raunkiaer, C. The Life Forms of Plants and Statistical Plant Geography; The Clarendon Press: Oxford, UK, 1934.

69. Camarda, I.; Carta, L.; Vacca, G.; Brunu, A. Les plantes alimentaires de la Sardaigne: Un patrimoine ethnobotanique et culturel d’ancienne origine. Flora Mediterr. 2017, 27, 77–90. [CrossRef]

70. Geraci, A.; Amato, F.; Di Noto, G.; Bazan, G.; Schicchi, R. The wild taxa utilized as vegetables in Sicily (Italy): A traditional component of the Mediterranean diet. J. Ethnobiol. Ethnomed. 2018, 14, 14. [CrossRef]

71. Aliotta, G. Edible Wild Plants in Italy. Inform. Bot. Ital. 1987, 19, 17–30.

72. Corbetta, F. 99 Modeste, Umili, Saporosissime erbe Spontanee Mangerecce; Edagricole: Milano, Italy, 1991.

73. Riccardo, S. Le Piante Spontanee Eduli; Ed. Battiato: Catania, Italy, 1921.

74. Guarrera, P.M.; Savo, V. Perceived health properties of wild and cultivated food plants in local and popular traditions of Italy: A review. J. Ethnopharmacol. 2013, 146, 659–680. [CrossRef] [PubMed]

75. Atzei, A.D. Le Piante Nella Tradizione Popolare Della Sardegna; C. Delfino Editore: Sassari, Italy, 2003.

76. Bulgarelli, G.; Flamigni, S. Le Piante Tossiche e Velenose; Hoepli Editore: Milano, Italy, 2010.

77. Scortegagna, S. Flora Popolare Veneta—Nomi e Usi Tradizionali Delle Piante nel Veneto; WBA Peoject: Verona, Italy, 2016.

78. Demarque, D.; Jovanny, J.; Poitevin, B. Farmacología e Materia Medica Omeopatica; Tecniche Nuove Spa: Milano, Italy, 1999.

79. Duke, J. Handbook of Medicinal Herbs; CRC Press: Boca Raton, FL, USA, 1985.

80. Pieroni, A.; Quave, C.L. Functional food or food medicine? On the consumption of wild plants among Albanians and Southern italians in Lucania. In Eating and Healing: Traditional Food as Medicine; Pieroni, A., Price, L.L., Eds.; Haworth Press: Binghamton, NY, USA, 2006; pp. 101–129.

81. Savo, V.; Salomone, F.; Bartoli, F.; Caneva, G. When the local cuisine still incorporates wild food plants: The unknown traditions of the Monti Picentini Regional Park (Southern Italy). Econ. Bot. 2019, 73, 28–46. [CrossRef]

82. Lupia, C.; (Sersale CZ, Italy). Personal communication, 2020.

83. Firenzuoli, F. Le Insidie del Naturale. Guida All'impiego Sicuro e Corretto Delle Piante Medicinali; Tecniche nuove Spa: Milano, Italy, 1996.

84. Campanini, E. Dizionario di Fitoterapia e Piante Medicinali; Tecniche nuove Spa: Milano, Italy, 2004.

85. Galliano Raspino, M. Refit. Repertorio Fitoterapico, 3rd ed.; Accademia Naz. Sci. Igien. G. Galilei: Trento, Italy, 2016.

86. Corsi, G.; Pagni, A.M. Studi sulla flora e vegetazione del Monte Pisano (Toscana Nord-Occidentale). V. Le piante spontanee nella alimentazione popolare. Atti Soc. Tosc. Sci. Nat. Mem. 1979, 86, 79–101.

87. Paoletti, M.G.; Dreon, A.L.; Lorenzoni, G.G. Pistic, traditional food from western Friuli, NE Italy. Econ. Bot. 1995, 49, 26–30. [CrossRef]

88. Bonet, M.A.; Valles, J. Use of Non-crop Food Vascular Plants in Montseny Biosphere Reserve (Catalonia, Iberian Peninsula). Int. J. Food Sci. Nutr. 2002, 53, 225–248. [CrossRef] [PubMed]

89. Guarrera, P.M. Food Medicine and Minor Nourishment in the Folk Traditions of Central Italy (Marche, Abruzzo and Latium). Fitoterapia 2003, 74, 515–544. [CrossRef]

90. Zeghichi, S.; Kallithraka, S.; Simopoulos, A.P.; Kypriotakis, Z. Nutritional Composition of Selected Wild Plants in the Diet of Crete. In Plants in Human Health and Nutrition Policy; Simopoulos, A.P., Gopalan, C., Eds.; S. Karger AG: Basel, Switzerland, 2003; pp. 22–40.

91. Scherrer, A.M.; Motti, R.; Weckerle, C.S. Traditional Plant Use in the Areas of Monte Vesole and Ascea, Cilento National Park (Campania, Southern Italy). J. Ethnopharmacol. 2005, 97, 129–143. [CrossRef] [PubMed]

92. Lazzaro, L.; Bolpagni, R.; Buffa, G.; Gentili, R.; Lonati, M.; Stinca, A.; Acosta, A.T.R.; Adorni, M.; Aleffi, M.; Allegrezza, M.; et al. Impact of invasive alien plants on native plant communities and Natura 2000 habitats: State of the art, gap analysis and perspectives in Italy. J. Environ. Manag. 2020, 274, 111140. [CrossRef] [PubMed]

93. Mattioli, P.A. I Discorsi di M.P. Matthioli Senese, Nelli sei Libri di Pedacio Dioscoride Anzarbeo Della Materiamedicinale; Vincenzo Valgrifi: Venezia, Italy, 1568.

94. Massonio, S. Archidipno, Ovvero Dell'insalata e Dell'uso di Essa; Paleari Henssler, M., Ferrero, C.S., Eds.; Edi. Artes: Milano, Italy, 1990.

95. Cornara, L.; La Rocca, A.; Marsili, S.; Mariotti, M.G. Traditional uses of plants in the Eastern Riviera (Liguria, Italy). J. Ethnopharmacol. 2009, 125, 16–30. [CrossRef]

96. Bianco, V.; Mariani, R.; Santamaria, P. Piante Spontanee Nella Cucina Tradizionale Molese. Storie, Curiosità e Ricette; Edizioni Levante:

Bari, Italy, 2009.

97. Tomei, P.E.; Trimarchi, S. Piante D'uso Etnobotanico in Toscana; Ed. Maria Pacini Fazzi: Lucca, Italy, 2017.

98. Pasta, S.; La Rosa, A.; Garfì, G.; Marcenò, C.; Gristina, A.S.; Carimi, F.; Guarino, R. An Updated Checklist of the Sicilian Native Edible Plants: Preserving the Traditional Ecological Knowledge of Century-Old Agro-Pastoral Landscapes. Front. Plant Sci. 2020,11, 388. [CrossRef]

99. Lupia, A.; Lupia, C.; Lupia, R. Etnobotanica in Calabria. Viaggio alla Scoperta di Antichi Saperi Intorno al Mondo Delle Piante; Ed. Rubbettino: Soveria Mannelli (CZ), Italy, 2017.

100. Di Tizio, A.; Łuczaj, Ł.J.; Quave, C.L.; Redžic´, S.; Pieroni, A. Traditional food and herbal uses of wild plants in the ancient South-Slavic diaspora of Mundimitar/Montemitro (Southern Italy). J. Ethnobiol. Ethnomed. 2012, 8, 21. [CrossRef]

101. Quave, C.L.; Pieroni, A. Healing with sacred and medicinal plants in three Arbereshe Communities of Southern Italy. In Proceedings of the 3rd International Congress of Ethnobotany, Naples, Italy, 22–30 September 2001; Volume 43, p. 63.

102. Pieroni, A.; Nebel, S.; Quave, C.; Munz, H.; Heinrich, M. Ethnopharmacology of liakra: Traditional weedy vegetables of the Arbereshe of the Vulture area in southern Italy. J. Ethnopharmacol. 2002, 81, 165–185. [CrossRef]

103. Pieroni, A.; Nebel, S.; Quave, C.; Munz, H.; Heinrich, M. Ethnopharmacy of the ethnic Albanians of northern Basilicata, Italy. Fitoterapia 2002, 73, 217–241. [CrossRef]

104. Quave, C.L.; Pieroni, A. Traditional health care and food and medicinal plant use among historic Albanian migrants and Italians in Lucania, Southern Italy. In Traveling Cultures and Plants. The Ethnobiology and Ethnopharmacy of Human Migrations; Pieroni, A., Vandebroek, I., Eds.; Berghahn Books: Oxford, NY, USA, 2007; pp. 204–227.

105. Nebel, S.; Pieroni, A.; Heinrich, M. Ta chorta: Wild edible greens used in the Graecanic area in Calabria, southern Italy. Appetite 2006, 47, 333–342. [CrossRef] [PubMed]

106. Nebel, S.; Heinrich, M. The Use of Wild Edible Plants in the Graecanic Area in Calabria, Southern Italy. In Ethnobotany in the New Europe: People, Health and Wild Plant Resources; Pardo-de-santayana, M., Pieroni, A., Puri, R.K., Eds.; Berghahn Books: Oxford, NY, USA, 2010; pp. 172–188.

107. Picchi, G.; Pieroni, A. Atlante dei prodotti Tipici. Le Erbe; AGRA: Rome, Italy, 2005.

108. Licata, M.; Tuttolomondo, T.; Leto, C.; Virga, G.; Bonsangue, G.; Cammalleri, I.; Gennaro, M.C.; La Bella, S. A survey of wild plant species for food use in Sicily (Italy)—Results of a 3-year study in four Regional Parks. J. Ethnobiol. Ethnomed. 2016, 12, 12. [CrossRef]

109. Jiménez-Monreal, A.M.; García-Diz, L.; Martínez-Tomé, M.; Mariscal, M.M.M.A.; Murcia, M.A. Influence of cooking methods on antioxidant activity of vegetables. J. Food Sci. 2009, 74, H97–H103. [CrossRef] [PubMed]

110. Nayak, B.; Liu, R.H.; Tang, J. Effect of processing on phenolic antioxidants of fruits, vegetables, and grains A review. Crit. Rev. Food Sci. Nutr. 2015, 55, 887–918. [CrossRef] [PubMed]

111. Łuczaj, Ł.; Pieroni, A.; Tardío, J.; Pardo de Santayana, M.; Sõukand, R.; Svanberg, I.; Kalle, R. Wild food plant use in 21st century

Europe: The disappearance of old traditions and the search for new cuisines involving wild edibles. Acta Soc. Bot. Pol. 2012, 81, 359–370. [CrossRef]

112. Rappoport, L. Come Mangiamo: Appetito, Cultura e Psicologia del Cibo; Ponte alle Grazie: Milan, Italy, 2003.

113. IPBES. Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental

Science-Policy Platform on Biodiversity and Ecosystem Services; Díaz, S., Settele, J., Brondízio, E.S., Ngo, H.T., Guèze, M., Agard, J., Arneth, A., Balvanera, P., Brauman, K.A., Butchart, S.H.M., et al., Eds.; IPBES secretariat: Bonn, Germany, 2019. [CrossRef]

114. Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S.; Garnett, T.; Tilman, D.; DeClerck, F.; Wood, A.; et al. Food in the anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. Lancet 2019, 393, 447–492. [CrossRef]

115. Vollbrecht, E.; Sigmon, B. Amazing grass: Developmental genetics of maize domestication. Biochem. Soc. Trans. 2005, 33, 1502–1506. [CrossRef]

116. Maxted, N.; Kell, S.P.; Ford-Lloyd, B.V.; Dulloo, M.E.; Toledo, A. Toward the systematic conservation of global crop wild relative diversity. Crop Sci. 2012, 52, 774–785. [CrossRef]

117. Demand for Indigenous Vegetables Soar as Residents Grapple with COVID-19 Economic Shocks. Available online: https://www.

kenyanews.go.ke/demand-for-indigenous-vegetables-soar-as-residents-grapple-with-covid-19-economic-shocks/ (accessed on 13 July 2020).

118. Vandebroek, I.; Pieroni, A.; Stepp, J.R.; Hanazaki, N.; Ladio, A.; Alves, R.R.N.; Picking, D.; Delgoda, R.; Maroyi, A.; van Andel, T.; et al. Reshaping the future of ethnobiology research after the COVID-19 pandemic. Nat. Plants 2020, 6, 723–730. [CrossRef] [PubMed]

119. COVID-19—The Role of Wild Plants in Health Treatment and Why Sustainability of Their Trade Matters. Available online: https://www.tra:https://www.trac.org/news/covid-19-the-role-ofwild-plants-in-health-treatment/ (accessed on 13 July 2020). 120. Borelli, T.; Hunter, D.; Powell,

B.; Ulian, T.; Mattana, E.; Termote, C.; Pawera, L.; Beltrame, D.; Penafiel, D.; Tan, A.; et al. Born to Eat Wild: An Integrated Conservation Approach to Secure Wild Food Plants for Food Security and Nutrition. Plants 2020, 9, 1299. [CrossRef] [PubMed]

121. IPES-Food. COVID-19 and the Crisis in Food Systems: Symptoms, Causes, and Potential Solutions; IPES-Food: Brussels,

CHAPTER II

WEB SITE

2 Introduction

Alimurgical plants have been subjected to numerous studies on their therapeutic and nutritional properties (Pieroni, 1999; Etkin, et al.,1982; Etkin, 1994;Moreno-Black, et al.,1996;Vitalini, et al., 2006;Pardo de Santayana, et al., 2007) and the beneficial effects of the Mediterranean diet on human health are well documented due to the high fiber content, antioxidant vitamins, total polyphenols, vitamins and minerals (Cao, et al., 1993;Guerrero Guil, et al., 1999;Grivetti, et al., 2000;Schaffer et al., 2005;Ranfa et al., 2011,Vanzani et al.,2011). A renewed interest in the use of edible wild plants is closely related to the rediscovery of local traditions, (Hadjichambis2008) the eating habits and the role these species have played in different cultures or ethnic groups. (Leonti et al., 2006) The rediscovery of popular culture has become a scientific investigation, but also a preservation and an enhancement of the local traditions and of the "popular knowledge". This cultural context, arisen in the last decade, has exponentially increased the interest in food consumption of Wild Edible Plants (WEP). The high consumption of fruit and vegetables, as a characteristic of the Mediterranean diet, has traditionally included wild fruits but especially wild vegetables, as reported by many ethnobotanical studies. (Leonti et al., 2006, Rivera et al., 2006, The Local Food-Nutraceutical Consortium 2005)

These WEP, also known as alimurgical plants, have in the past played an important historical role in integrating and enriching the diet based on basic agricultural food, (Pieroni et al., 2002, Tardio et al., 2005) considered an integral part of the Mediterranean basin diet. (Vanzaniet al.,2011, Zeghichi et al., 2003)

Although many species considered alimurgic are widespread throughout the Mediterranean basin, only few species (about 30) are currently used in the human food comsuption. (Rivera et al., 2006)

For this reason, the following work has been focused on the creation of a database and website of Italian alimurgical flora (called AlimurgITA) (Fig. 1), with the aim of systematizing the extensive knowledge (and often disorderly) on the WEP acquired in Italy in the last 100 years, creating an easy to read tool not only for purely speculative but also for practical purposes.

2.1Materials and methods

2.1.1 Alimurgical Plant website in Italy

AlimurgITA is a set of data and digital artifacts useful to publish and share alimurgical plant data to the target scientific community.

We can classify materials used for building AlimurgITA as a) Content Data, the original dataset collected by botanists and used as the input of the website publication workflow, and b) Digital Artifacts, that encompasses 1) a database, where content data have been normalized and enriched for the website building objective, 2) a transformation system developed for automating the workflow that transforms, Alimurgical Content Data into Web Pages/Resources.

The structure of the spreadsheet file has been changed several time in order to match the knowledge needs of botanical domain, and its relationships to other knowledge domains like agriculture, nutrition, food preservation.

The construction of the Alimurgita database has been designed to optimize the storage and consultation of data, making them usable both for purely scientific and application purposes.

The spreadsheet file collects data collected by means of the discovery and the analysis of bibliographic resources from 358 ethnobotanical and phytoalimurgical works published in Italy since 1918 to these days. For each of the 1103 alimurgic entities considered and reported in the database, 95 fields related to taxonomic, morphological, geographical and food use characteristics were considered.

Specifically, the following fields were assessed:

- Scientific name;
- Family;
- Bibliography;
- Region;
- Vegetable part used (Roots/tubers/rhizomes, Bulbs, Stem/turion/branches, Bark, Aerial part, Leaves, Young shoots/gemmas Basal rosette, Inflorescences, Flowers/flower buds, Fruits/pseudofruits Seeds, Resin/sap/latex);

- How to use (Raw, Cooked, In oil, In salt, In vinegar, Brine, Pickle, Roasted, Dried, Preserves/Jams, Alcoholic/non-alcoholic beverages/Vinegar, Oil, Milled/Flours, Flavouring);
- Food use.

The nomenclature follows Bartolucci et al. (2018) while the dialectal names are those reported in the Portal for the Flora of Italy (http://dryades.units.it)

The workflow steps are detailed as follows:

• Design of the AlimurgITA Database schema collecting spreadsheet metadata of the relevant fields, creating data controlled vocabularies, extending metadata for the normalization of data.

• Development of the automation process for importing data against the designed schema. The import process performs different tasks that aim to privilege the data quality, like the URL identification of each plant record, consistency data checking, standardization and normalization of bibliography, data enrichment for future data integration.

In the end of the process, the alimurgical plant data are ready for being extracted and used for the website user interface of AlimurgITA.

The point of interest of the users, landing on the website, is considered the page of descriptive information about each alimurgical plant collected. The page is dynamically created from the database by recalling the internet address (URL) of the page, or by selecting the page link resulting from a user search or from a browsing action.

The website is equipped with two main data retrieval features: a faceted browsing, based on the data classification method adopted for the spreadsheet, and a local search engine allowing to perform simple and advanced search.

Figure 2 shows the advanced search page, where, end-users can perform text search, based on the scientific or dialect name, or filter, alphabetically, the names. End-users can also trigger data queries, shows the advanced search page, where, end-users can trigger data queries, based on the following main filters already mentioned. The bibliography collected, and referring to a specific alimurgical plant, can also be used as a cross-referencing filter by means of the author’s name or the publication year of bibliographic items, mentioning alimurgical plants.

The website will be published at the end of 2021, further enrichments to data, will allow to connect data to other scientific plant databases and bibliographic datasets. The data integration with global relevant data sources will allow AlimurgITA to enlarge its reference community, and to assist botanical investigations in retrieving locations of relevant bibliographic resources.

2.2 Discussion of the results

Following the necessary preliminary collection of data for the functionality of the portal, the same are ready to be extracted and used for the user interface of the Alimurgita website as shown in Figure 1. The page of descriptive information of each Weps in the database, is considered the point of interest of users who reach the website.

Figure1. AlimurgITA portal Home Page

The page is dynamically created by the database by calling the Internet address (URL) of the page or selecting the page, through the link that is returned by a user search or browsing through the different classification systems.The website, in fact, has two main data recovery features: a layered navigation, based on the different types of data classification, adopted in the spreadsheet and a local search engine that allows you to perform simple and advanced searches.Figure 2 shows the advanced search page, where end-users can perform precise searches, based on the scientific or dialectal name, or filter, in alphabetical order, the names.While in Figure 3 it is possible to observe the descriptive data of an example of WEP.In addition, end users can also query the database, based on the main filters already mentioned. The collected bibliography, and referring to alimurgic plants, can also be used to filter alimurgic plants based on citations by author or by year of publication of the bibliographic unit. The website, once made public will be supported by the portal of Unimol. The data will be linked to other scientific equipment databases and bibliographic datasets. The subsequent integration with globally relevant data sources will allow Alimurgita to expand its reference community and assist botanical surveys in the recovery of relevant bibliographical resource locations.

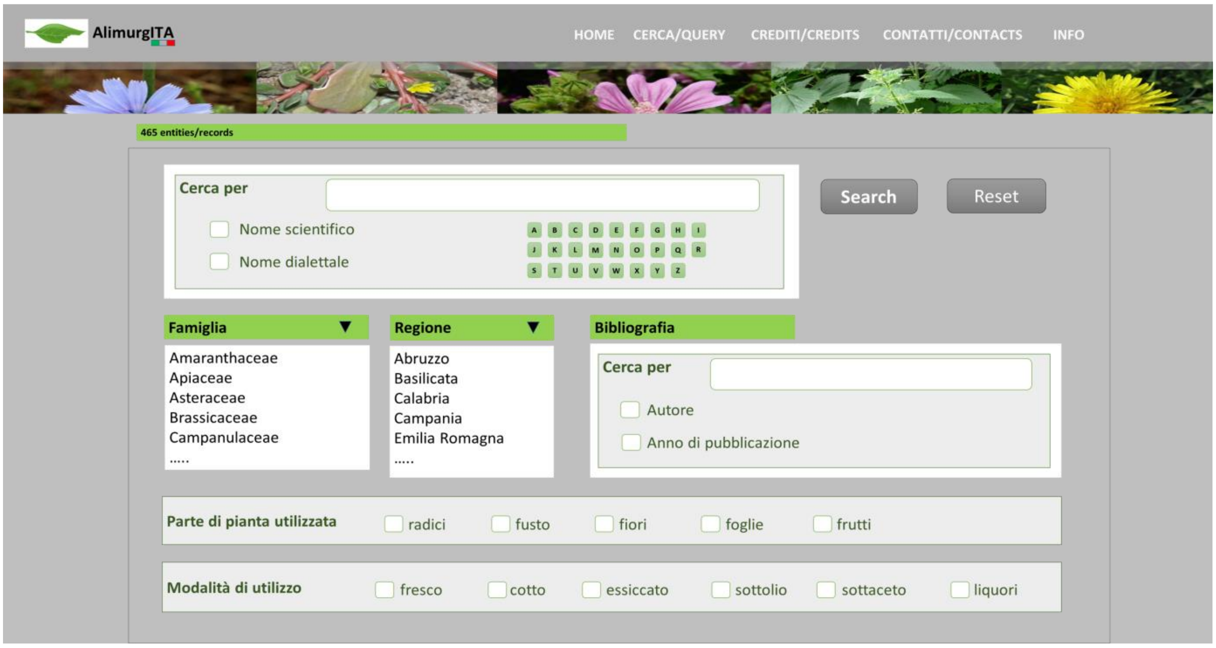


Figure 2. Advanced search page

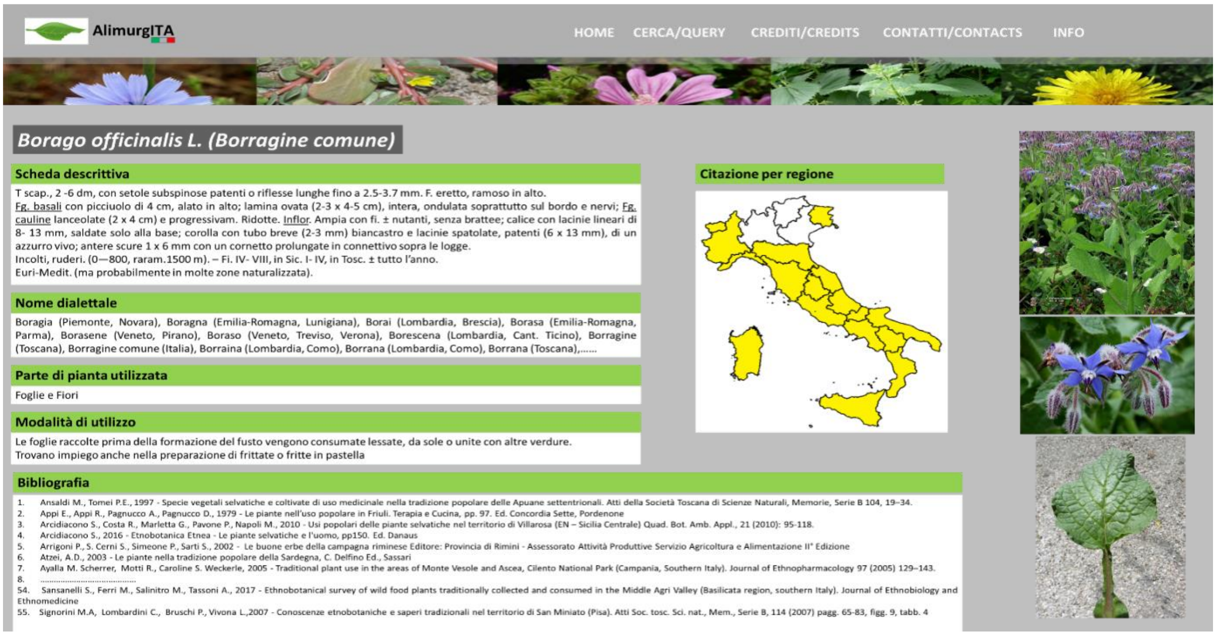


Figure 3. Descriptive data page: example of WEP

SECTION II Functional Properties of Weps

CHAPTER III
DESCRIPTION OF ANALYZED SPECIES

After an accurate survey of the AlimurgITA Database, five alimurgic species have been selected and hereafter listed through descriptive cards; they are considered as an integral part of the traditional alimurgic heritage of all the different zones in the Apennine area.

Sonchus spp.

Species belonging to the Asteraceae family are afferent to the ***Sonchus*** genus. About a hundred species belong to this genus, including (*Sonchus oleraceus, Sonchus asper*), which number among the Italian wild edible plants. These plants were already known in Ancient Ages; in fact, Pliny the Elder described how the Romans used them in their diet.

3.1.1 ***Sonchus asper* L.**

Figure 4. *Sonchus asper, adult plant*

Figure 5. Leaf detail

Botanical Description: Annual or biannual herbaceous plant, growing 3 to 10 dm; its stalks are strong, hollow, streaked, sometimes reddish and poorly ramified. The basal leaves are gathered into a rosette in the first months of growth, from whole to pinnatifid, and later appear rigid, ± leathery, glabrous, bright green on the upper side; the stem leaves are sparse, amplexicaul with snail like winding auricles; with small thorns on the margins. Capitula inflorescences, 3-4 cm in Ø gathered in irregular umbellifer heads with pear-shaped casings 10-15 mm long. The flowers are all ligulate, yellow, sometimes reddish on the outer surface. The fruit are obovate-elliptic with three longitudinal ribs, fairly smooth, without transversal streaks, with a white sessile pappus.

Habitat: This species is found in settings where the soil has been disturbed by man. Commonly considered as a weed in gardens, vegetable gardens, wasteland, cultivated fields and along the roadsides. It is often found in urban areas, in parks and city gardens. Another characteristic of the species is that it is able to keep its seeds fertile and dormant for up to 10 years; moreover, it thrives in nutrient rich grounds, especially nitrogen rich soils.

Diffusion of alimurgic use in Italy: Figure 6 shows the diffusion of the use of the species all over the country according to the data stored in Database AlimurgITA, Paura et al.,2021).

Nutritional qualities: It contains a good number of mineral salts, iron, calcium and phosphorus, vitamins and fiber; it is purifying, refreshing, diuretic and hepatoprotective

Figure 6. Diffusion of alimurgic use of *Sonchus asper* in Italy

Culinary uses:

The culinary uses are quite like those of wild chicory. The leaves of the basal rosette are used mainly in salads while tender leaves and even adult leaves (despite their bitter taste) are used to prepare omelets or soups such as "minestra ' ‘Terrana’ or the pistic from Friuli. The shoots are cooked and eaten as vegetables, often mixed with dandelion to temper its bitter taste, or they can be fried with oil and garlic. (Paura et al., 2021)

3.1.2 ***Sonchus oleraceus* L.**

Botanical description: An annual or biannual wild herbaceous plant. Its basal leaves are at first gathered as a rosette and are quite limp, dull and varying in shape. The flowers are gathered in capitulum inflorescences, bright yellow in the center; the outer ligulae are paler and open in the early morning but close again after a few hours as they cannot bear the heat.

Figure 7 Rosetta basale di *Sonchus oleraceus* L.

Habitat: a common plant all over the country; in some regions it is available all year round except in the coldest months. It grows in proximity of cultivated lands, ruins, vineyards, in the median strips, along the roadside; it is found also in residential areas, (in the cracks in sidewalks, near old walls). This plant lives between 0 and 1,700 m above sea level, in any kind of soil, especially disturbed soils.

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Diffusion of alimurgic use in Italy: Figure 8 shows the diffusion of the use of the species all over the country according to the data stored in Database AlimurgITA, Paura et al.,2021).

Figure 8. Diffusion of the alimurgic use of *Sonchus oleraceus* in Italy

Nutritional qualities: The leaves are particularly rich in water, which is actually the main component. It is also rich in mineral salts such as iron, calcium, phosphorus and potassium, vitamins, especially Vitamin C, and fibers. The macromolecules have a higher concentration of carbohydrates, followed by proteins. It is deemed to have purifying properties, especially for the liver, hepatoprotective, diuretic properties (therefore the water used to boil them is commonly drunk) and it also has remineralizing properties.

Culinary uses: *Sonchus oleraceus* has delicate organoleptic features. It is used in much the same way as wild chicory. We eat the tender leaves of the basal rosette or the tender leafy stem in mixed salads. These parts can be cooked and used to prepare omelets, risotto, fillings, soups and pasta. In Sardinia, if harvested before the stalk develops, it is cooked in soups or eaten in jam fillings. (Atzei 2003) It can also be boiled in water and sauteed with smoked ricotta. In Liguria *Sonchus oleraceus* is part of the herb mixture (so-called "prebuggiùn") used to prepare savoury pies, "pansoti" or “gattafin”, big ravioli filled with herbs and fried, typical of Levanto (SP). The leaves were used in Ischia (Campania) to prepare "menesta salvaggioia" (joy saver soup) made of a dozen more herbs. The aerial part of the plant is cooked together with other herbs to prepare "minestra maritata" in Campania. The numerous uses of this species are confirmed by (Guarrera et al.,2016) This large use has caused *Sonchus oleraceus* to be the fourth most cited alimurgic plant in dedicated bibliography, with 156 citations.

Crepis spp.

The *Crepis* genus belongs to the *Asteraceae* family. The term is derived from Greek "krepis" meaning footwear, sandal, due to the look of the basal leaves, leaning on the soil. Nowadays, this genus is generally known as "knotgrass" accompanied by different adjectives to identify the species.

3.1.3 *Crepis vesicaria* L.

Botanical description: It is an annual or biannual herbaceous plant. The stalk appears more or less lignified, reddish-purple at the basis, upright, ramose and bristly. The rosette basal leaves are rather pressed down on the ground. sometimes whole or lobed, but more frequently pinnatisect; the caulis leaves are smaller and smaller, sessile, auriculate and amplexicaul. The young plant features a series of self-enclosed buds. The flowers are 2 cm capitula with yellow ligulate corollas often featuring numerous reddish streaks; they tend to form a terminal umbel or gather as a corymbiform raceme. The inflorescence has a cylindrical casing with paper-like outer bracts

and bristly scales. The fruits are achenes with 10-12 thin ribs; the pappus protrudes for over half its length from the casing scales.

Figure 9. adult *Crepis vesicaria*

Figure 10. Diffusion of the alimurgic use di *Crepis vesicaria* in Italy

***Habitat*:** it is found in wasteland, cultivated lands, along vineyards, along country cart tracks, on the banks of canals and rivers. It thrives on solid limy grounds and is found up to 1,200 m.a.s.l.

Diffusion of alimurgic use in Italy: Figure 10 shows the diffusion of the use of the species all over the country according to the data stored in Database AlimurgITA, (Paura et al.,2021).

Nutritional qualities: This species possesses the same properties as many bitter herbs; therefore, it is detoxifying and purifies the blood, it is diuretic and hypoglycemic

The phenolic substances contained in wild plants act as antioxidants of free radicals and help prevent cardiovascular diseases and tumor diseases.

Culinary uses: The tender leaves of *Crepis vesicaria*, commonly known as knot grass, are used boiled and sauteed, to prepare soups, omelets, risotto or as filling for ravioli and savory pies. The tender shoots are kept in salt. In Sardinia ground toasted roots were used as a coffee substitute. (Paura et al., 2021)

3.1.4 ***Blitum bonus–henricus*** **L.**

Botanical description: A perennial herbaceous plant, it looks chalky and sticky, due to the presence of numerous vesicular hairs. It has a thick rhizome. The stem is erect or ascending, streaked and leafy, ramified from the base, it is between 20 and 70 cm tall. The basal leaves have a long petiole (10 - 20 cm), they are triangular, hastate at the base with two downward corners; the margin is entire and slightly undulated; the upper surface is dark green while the underside is light and chalky. The inflorescence is an elongated terminal spike, with basal bracts and ramifications, sometimes folded, brownish red when fruiting, made of glomeruli of inconspicuous greenish brown flowers. The fruits are achenes with black shiny seeds

Figure 11. Adult plant of *Blitum bonus-henricus*; detail of the inflorescence

Habitat: It grows in proximity of meadows, where cattle generally linger, among ruins, near cowsheds, in proximity of dwellings and alpine pastures, from the hills to the mountains, from 500 to 2,100 m. a.s.l.

Diffusion of alimurgic use in Italy: Figure 12 shows the diffusion of the use of the species all over the country according to the data stored in Database AlimurgITA, (Paura et al., 2021).

Figure 12. Diffusion of alimurgic use of *Blitum bonus-henricus* in Italy

Nutritional qualities: Thanks to the high content of iron, other salts and vitamins, it has an excellent remineralizing action; it is therefore a valuable tonic, antianemia, laxative and purifying; however, because it contains oxalic acid, it is unadvisable for people suffering from stones, arthritis and rheumatism. The leaves are emollient and are suitable to mature pimples and abscesses. When briefly cooked in olive oil, they can be used as poultices on burns and sores. Oxalate is not an essential nutrient and, if taken in great quantity, it leads to an increase of oxalate concentration in urine and to the creation of kidney stones. (Wanying e Geoffrey, 2015).

Culinary uses: the shoots and tender leaves, which can be picked from adult plants too, are boiled as vegetables or used in soups (for example the pistic in Friuli), pottages, risotto, omelets or as a filling for ravioli and savory pies. In Venetia, the orapi, which taste like spinach, were the basis of an herb mixture known as kraut or mehlkraut. At Revine (TV, Venetia) they were sauteed and served with two fried eggs. Tender shoots are traditionally kept in salt, floral shoots are eaten, and the leaves are traditionally used to color homemade pasta. It is used in Molise to prepare some traditional dishes such as “m’baniccia” (Fig. 13), which is baked corn flour pizza mixed with alimurgic plants (Guarrera e Savo, 2016). *Blitum bonus-henricus* is used mainly in Abruzzi where the Orapi Festival still exists, the typical dish in this area is “orap e fasciul” (orapi and beans). The tender leaves are however rarely used in mixed salads, probably because when raw, they do not taste too good. In the Aosta Valley, the seeds were ground into flour and cooked like semolina. The cooking water was drained because it was rich in saponins.

Figure 13. Typical Molise dish
“*m’baniccia molisana*”

3.1.5 *Tragopogon porrifolius* L.

Botanical description: A biannual or annual herbaceous plant, 20-60 cm tall (-120); it is glaucous and glabrous; its taproot is vertical and woody. The stem is erect, simple or scarcely ramified, generally glabrous but sometimes with sparse flaky down; it is clavate under the capitulum. The basal leaves are linear, alternate, entire, penninerved, with undulated margin; they are 5 mm wide and 10 - 15 cm long; cauline leaves are shorter (4-10 cm). The inflorescence is a single capitulum, 6-7 cm in Ø, carried by a long peduncle, enlarged at the apex; the flowers are all ligulate, 2,3-2,6 cm, with five teeth; they are violet-brown or dark purple, rarely white or lilac colored. The fruit is a dark brown achene with spinulescent ribs, which thin into a long beak, 14-24 mm, topped by a 25-35 mm pappus of feathery bristles

Figure 14. Adult *Tragopogon porrifolius*; Root detail

Diffusion of alimurgic use in Italy: Figure 15 shows the diffusion of the use of the species all over the country according to the data stored in Database AlimurgITA, (Paura et al., 2021).

Figure 15. Diffusion of the alimurgic use of *Tragopogon porrifolis* in Italy

Nutritional qualities: The main components are glucids, protids and lipids, which give the plant diuretic, sweat and expectorant properties. Moreover, the root, rich in "inuline", a polysaccharide, is used to produce sugar for diabeticsdepurative
.

Culinary uses: The peeled stem has a pleasant taste and can be eaten raw, or in salads; it can be cooked together with other composites and seasoned with a little oil. The tender root is eaten as a vegetable and used to prepare soups. In Tuscany the young leaves are cooked and seasoned with olive oil and vinegar or are sauteed. The young shoots are eaten raw. (Paura et al., 2021)

CHAPTER IV
VITAMINS

4.1.1 CAROTENOIDS

General features

Carotenoids are named after carotene, first found in the root of the *Daucus carota* in 1831. They are important both for their wide distribution and their structural diversity, as well as their different functions. A number of epidemiological studies have shown that a greater consumption of fruit and vegetables reduces the risk of developing several diseases and some types of cancer. (Stahl and Sies, 2005).

Carotenoids are widespread in flora and are found in the plant chloroplasts and chromoplasts; they are also found in photosynthetic organisms such as algae and in some bacterial species; vertebrates, however, are not able to synthesise them and must, therefore, take them in essentially through their diet.

Carotenoids are fat soluble pigments which give many fruits and flowers their colour from yellow to orange, from red to purple, according to the type of carotene; they are often blended into lipid droplets or protein-bound inside chromoplasts. (Takyi, 2001).

In leafy greens they take part in photosynthesis together with chlorophyll, as they are part of the photosystem within chloroplasts, where they act as accessory pigments, since they contribute to absorb light, thus increasing the efficacy of the system and favouring the transport of energy. Moreover, they have other important functions as antioxidant and protect the reaction centre from photoxidative damage. In general, the green colour of plants depends on a high chlorophyll concentration which screens the presence of carotenoids. These become visible only with leaf senescence, when chlorophyll decays and is replaced by yellow and red pigments, which are carotenoid residue.

Colour intensity in edible vegetables therefore depends on which carotenoids they contain and how much, as well as their physical state. (Takyi, 2001).

Chemical structure of carotenoids

From a chemical point of view, carotenoids are molecules made of a long central chain consisting of about 40 carbon atoms (tetra terpenes); these feature an alternation of double bonds and two terminal units with different functions (e.g. alcoholic, ketonic, epoxide).

The carbon-carbon double bonds are deemed to be an important structural feature of carotenoids; this part of molecule makes up the chromophore, which accounts for carotenoids to be able to absorb light in the visible region of the spectrum. (Takyi, 2001).

The chromophore is responsible for determining colour by absorbing light, (Rodriguez-Amaya and Kimura, 2004) therefore, as the number of conjugated double bonds increases colour becomes more intense, from light yellow to orange and red. For example, lycopene, which has 11 double bonds, is red.

Some limitations are due to the cyclization of the terminal portions; in fact, even though β-carotene and α-carotene have the same number of conjugated double bonds they are respectively orange and reddish orange.

Apart from colour, electron motion capability within conjugated double bonds yields particular features; one of these is the capability to bind free radicals; they are therefore particularly important as antioxidants.

Apart from colour, the chromophore system is also responsible for the great instability of carotenes; they easily oxidise on contact with air and light.

Depending on the presence of oxygen in the molecule, carotenoids can be divided into:

- CAROTENES, which have a dienic hydrocarbon structure, made of carbon and hydrogen but lacking in oxygen; examples are: β-carotene, α-carotene and lycopene;
- XANTOPHYLLS, which are oxygenated derivatives of carotenes; they include β-cryptoxanthin, canthaxanthin, violaxanthin, zeaxanthin, lutein.

Because they are lipophilic substances, carotenoids dissolve in fats and solvents such as alcohol, diethyl ether, acetone and chloroform. In fact, they dissolve rapidly in petroleum, ether and hexane; on the other hand, xantophylls, which are the most polar better dissolve in methanol and ethanol (Takyi, 2001).

Furthermore, carotenoids easily crystallize and, in solution, with light, oxygen, high temperature and acids, they oxidize and isomerise, turning into colourless compounds; on the other hand, they are highly stable when oxygen pressure is low, when there is no light and at low temperatures.

The terminal units can be acyclic, as in lycopene or both of them cyclic as in α and β-carotene, or one cyclic and the other acyclic as in γ-carotene. Cyclic terminal units can be rings of 5 or 6 atoms (Stahl e Sies, 1999) and can feature a large variety of groups, for instance, alcoholic, ketonic, epoxide, benzene etc.

The combination of these terminal groups, together with oxygen containing functional groups and the variation of hydrogenation level, gives rise to most carotenoid structures (Fig. 16).

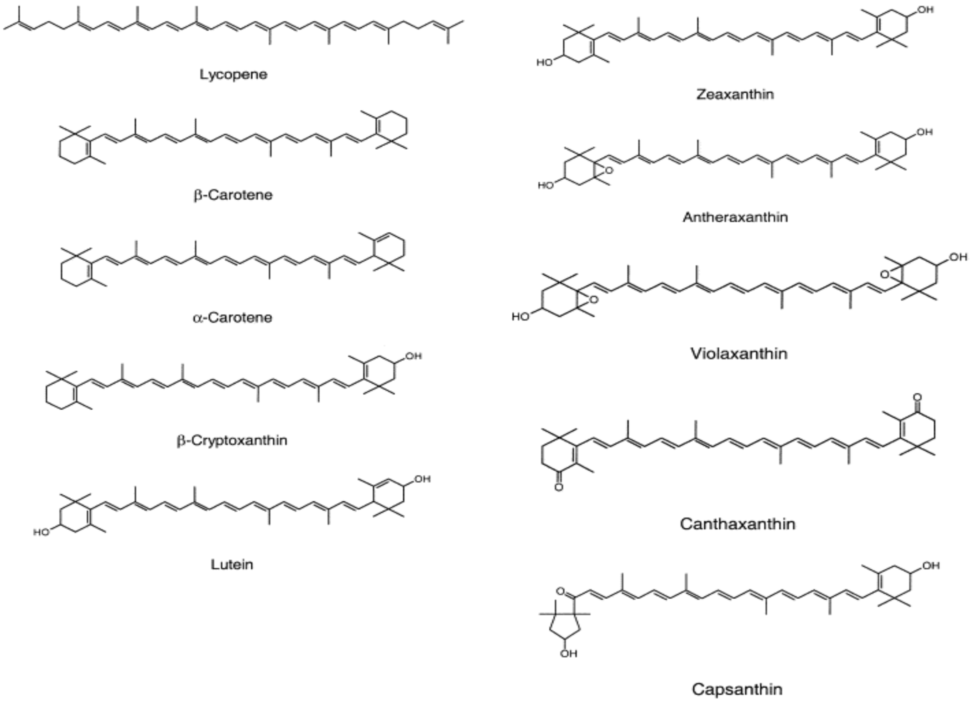

Figure 16. Examples of carotenoid structure (Oliver and Palou, 2000)

In nature they are found mainly in the *trans isomeric pattern,* which is the most thermodynamically stable (Stahl e Sies, 2005), but trans structures can yield *cis* isomeric products during processing.

Antioxidant activity of carotenoids

Antioxidants counteract oxidation in two different ways and can therefore be divided into two categories: "preventive or secondary" and "chain-breaking or primary".

- Preventive or secondary antioxidants react with radicals and turn them into more stable products. In this case, the antioxidant can rapidly donate an H atom or an electron to a radical, turning into a stable radical;
- "Chain breaking" or primary antioxidants act on the initiation stage of the chain reaction through different modes of action such as binding metal ions, capturing oxygen, breaking hydroperoxides and forming non radical species which absorb UV radiations thus deactivating singlet oxygen (Laguerre et al., 2007).

The “antioxidant” function of carotenoids in biological systems consists in their acting as “quenchers” for singlet oxygen and per-oxygen radicals (Stahl e Sies, 2005). Oxygen in its singlet state is one of the most reactive among oxygen free radicals (OFR). Carotenoids absorb the energy that is freed from a singlet oxygen molecule when passing from the above mentioned state to the fundamental one and dissipate the excess energy in their environment (Stahl e Sies, 2003).

An excess production of OFR and/or reduced antioxidant capacity shift the balance between pro-oxidants and anti-oxidants in favour of the former. This condition known as oxidative stress can entail massive damage (Pisoschi e Pop, 2015) to DNA, lipids, proteins, enzymes and carbohydrates causing functional and structural alterations of the cell.

Moreover, since carotenoids are not modified during this reaction, they remain available for further “quenching” cycles (Stahl and Sies, 2003).

The efficacy of carotenoids as quenchers is linked to the number of conjugated double bonds; this enables them to readily accept electrons and therefore to act as scavengers of free radicals. Consequently, zeaxanthin, cryptoxanthin, α-carotene and especially lycopene are particularly active molecules. However, it is important to point out that the antioxidant activity of carotenoids depends on the presence of other antioxidant species such as vitamins E and C. (Stahl e Sies, 2003)

The role of carotenoids in the human body

For man, the transformation of α, β and γ-carotenes plays an important role; especially the transformation of β-carotene, into vitamin A, within the intestinal mucosa, which makes it possible to capture this molecule, which is crucial for the human body. Because the human body is unable to synthesize these compounds, it makes up for the lack by consuming vegetables. (Stahl e Sies, 2005).

Other carotenoids, such as lutein, lycopene and zeaxanthin have been shown to possess, in greater quantity, equally important properties. (Rodriguez-Amaya and Kimura, 2004).

To sum up, we can claim that carotenoids carry out a number of biological functions in our body, namely:

- ✓ some are metabolised at intestinal level to produce vitamin A;
- ✓ they have an antioxidant activity against reactive oxygen species (ROS);
- ✓ they act as skin protective barrier, preventing damage from ultraviolet light.;

- ✓ they contribute to reduce the risk of macular degeneration and cataract;
- ✓ they contribute to reduce the risk of certain tumours and cardiovascular diseases,
- ✓ they boost the immune system (Institute of Medicine, 2000).

Absorption

The intestinal absorption of dietary carotenoids is facilitated by the presence of fat in the small intestine, which stimulates bile acid secretion by the gallbladder and improves carotenoid absorption. Due to their fat solubility, carotenoids are incorporated into micelles made of cholesterol, fat acids, phospholipids and bile salts. These micelles are characterised by a hydrophobic kernel where carotenes are located and by a hydrophilous ring where xantophylls are located. (Saini et al., 2015).

Micelles are absorbed at intestinal level through passive diffusion; carotenoids can be absorbed whole and those with provitamin A activity can be split to form vitamin A and subsequently incorporated into chylomicrons, thus entering the lymphatic and blood circulation in the cells of the intestinal mucosa (Rao e Rao, 2007).

Vitamin A activity

Vitamin A is a fat soluble vitamin obtained from the diet as retinol and retinyl in animal foods or as carotenoids in plant foods (a limited number have provitamin A activity such as β-carotene, α-carotene and β-cryptoxanthin).

Although carotenes have been acknowledged as beneficial for human health, they are sadly not defined as essential nutrients as such, which is why they are not assigned a value for daily reference intakes. (Rao e Rao, 2007).

Vitamin A is an essential nutrient, as it is a bioactive compound involved in the visual cycle of the retina, in the continued growth and integrity of the cells in body tissues. Unfortunately, the human body is unable to synthesize compounds with vitamin A activity.

The biological value of substances with vitamin A activity is expressed as retinol equivalent (RE) (EFSA, 2015). In the assessment of this value reference is made to the conversion factors suggested by EFSA, namely 1 μg RE is tantamount to 1 μg retinol, 6 μg β-carotene and 12 μg other provitamin A activity carotenoidssuch as α-carotene, β–cryptoxanthina and cis isomers of β-carotene with lower vitamin activity (EFSA, 2015).

The demand for Vitamin A can be satisfied with any mixture supplying a quantity of vitamin A equivalent to the reference value expressed in µg RE per day, corresponding to 800 µg according to EU Reg n. 1169/2011.

4.2.1 TOCOLS

According to the number and position of the substituent methyl groups in the chromanic ring distinction is made between α, β, γ, δ tocopherol and α, β, γ, δ tocotrienol (Fig. 17).

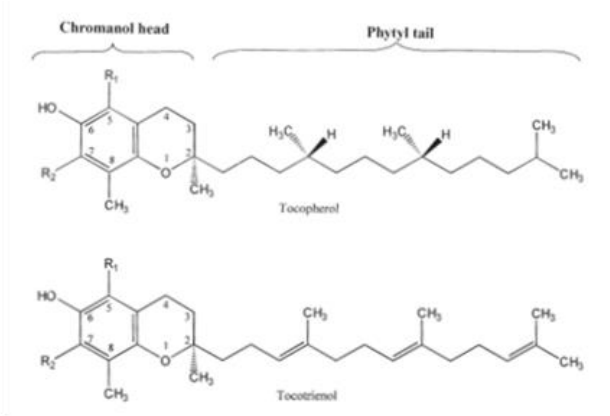

Figure 17. chemical structure of tocopherols and tocotrienols (Herrera e Barbas, 2001)

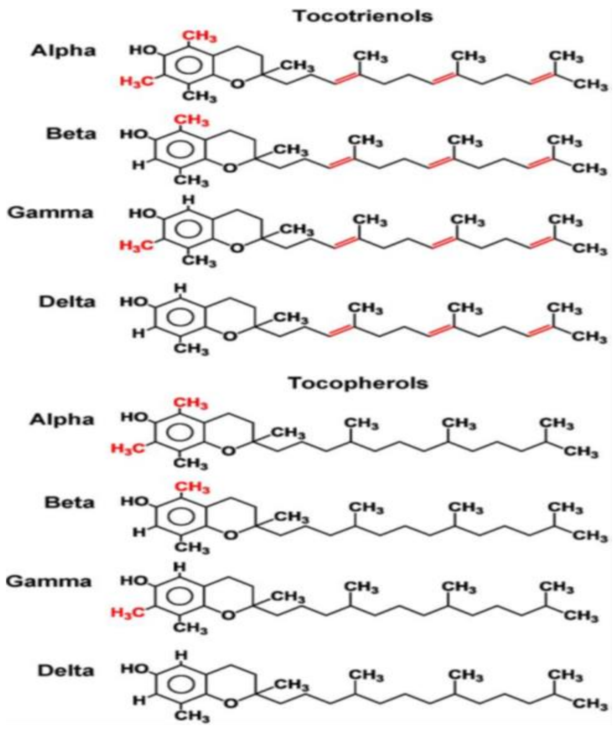

Figure 18. Structures and common names of tocopherols and tocotrienols

The presence of the hydroxyl group (-OH) in position 6 and of a methyl group in position 2 characteristically features in all vitamin E vitamers, which are therefore 2-methyl-6-chromanol derivatives.

In nature tocopherols and tocotrienols are found in association with the lipid component since the long isoprenoid chain makes them lipophilic compounds.

Antioxidant function

Vitamin activity and antioxidant function do not coincide within the different chemical forms (Herrera e Barbas, 2001). In particular antioxidant activity varies as follows: $\delta<\gamma<\beta<\alpha$ (Ingold et al.,1990).

The hydroxyl group linked to the chromanic ring is crucial for antioxidant activity in tocols, since it can donate a hydrogen atom; thus there remains a resonance stabilized scarcely reactive unpaired electron which tends to form non-radical products such as tocopherylchinons; this activity, therefore, blocks radical propagation reactions. Methyl groups too are important for the antioxidant activity of these compounds. α-tocopherol, with three methyl groups is the biologically most active form.

Link between health and vitamin E

One feature worth considering concerns tocopherols, which are always present in plants, while tocotrienols appear only in seeds and fruits (Falk et al., 2010). Moreover, in foods, the main sources of vitamin E are fats and vegetable oils but it is also present in cereals, meat and by-products.

In the past, the scientific world focused mainly on α-tocopherol, considered to be the constituent with the highest vitamin activity (100%), but recent studies have shown that other homologues carry out important functions for human health. In fact, a mixture of α-, γ- and δ- tocopherol has proved to have a higher antioxidant and anti-inflammatory power on biological systems than α-tocopherol alone.

Moreover, tocotrienols, which are plentiful in vegetable oils (eg. Palm oil), despite a lower vitamin activity than α-tocopherol, have a significantly higher antioxidant capacity compared to tocopherols. Tocotrienols show further promising healthy effects, compared to tocopherols, such as lowering plasma cholesterol levels and triggering immune system response. Several *in vitro* studies point out that tocotrienols feature anticancer, cardioprotective and neuroprotective effects (Aggarwal, Sundaram et al., 2010).

Consequently, an adequate supply of all eight homologues making up vitamin E can contribute to counteract oxidative stress within cell membranes (D'Evoli, Tufi, Gabrielli et al., 2013).

In the past, the biological activity of Vitamin E was defined in terms of International Units (IU), while nowadays it is defined in terms of Tocopherol Equivalent (TE) where 1TE corresponds to 1mg α-tocopherol, the biologically most active form of vitamin E. The different tocols feature a wide variety of bioactivity, which lessens dramatically as follows: α-T>β-T>α-T3>γ-T>βT3>δT (Panfili et al., 2008).

According to EU Regulation n° 1169/2011 dealing with the nutritional labelling of food products, the recommended daily allowance (RDA) of vitamin E is 12 mg.

Absorption

The benefits of vitamin E on human health are well-known, but research on the impact of factors influencing the bioavailability of vitamin E is limited. Vitamin E absorption from food can be influenced by a number of factors, including food matrix, cooking methods, diet, lipids and interaction with digestive enzymes or with other foods. (Kim, Ferruzzi e Campbell, 2016).

Vitamin E is a fat soluble nutrient, therefore absorption is strictly linked to the processes regulating digestion and edible fat absorption. Following ingestion, emulsified fats in the intestine blend with pancreatic and bile juices; pancreatic esterases together with bile acids make up micelles which contain tocols and other hydrophobic molecules. Vitaminic compounds are integrated within chylomicrons and absorbed in the vicinity of the small intestine through passive diffusion. The absorption of α- and γ-tocopherolo does not show great differences, while other tocopherols are scarcely absorbed (Herrera e Barbas, 2001). Chylomicrons play a crucial role in vitamin E transport. They are lipoproteins rich in triglycerides, cholesterol, proteins, fat soluble vitamins (vitamin E) and carotenoids, these particles are released into the intestinal lymph and carried along the lymphatic vessels before flowing into the main veins and sticking to the endothelium of the skeletal muscle and adipose tissue. The surface components of chylomicrons, including tocopherols, are transferred directly to the high density lipoproteins (HDL). The greatest quantity of vitamin E in the human body is found in the adipose tissue and in the adrenal glands.

A number of studies have shown that vitamin E absorption is limited. In fact, vitamin E concentration in the human plasma following integration has not shown an important increase (2-3 times more) regardless of the quantity administered, of the duration and frequency of administration leading to the conclusion that the vitamin E taken replaces that already present in the lipoproteins, thus limiting overall concentration.

4.3.1 WATER-SOLUBLE VITAMINS

Thiamine

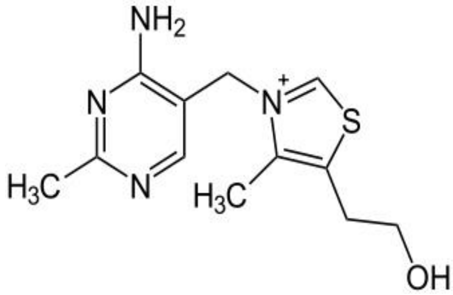

Figure 19. Chemical structure of thiamine

The vitamin B complex is a group of eight compounds all acting as enzyme cofactors essential in metabolism. (B1, B2, B3, B5, B6, B8, B9 and B12). Apart from vitamin B 12, plants can synthesize all group B vitamins. (Fitzpatrick et al., 2012).

Thiamine, also known as **vitamin B1** (Fig. 19), is a water-soluble vitamin made of a pyrimidine ring and a thiazole ring linked together by a methylene bridge (EFSA, 2016) The biologically active form of vitamin B1 is thiamine pyrophosphate (TPP) or thiamine diphosphate which form following the transfer of a pyrophosphoric group from ATP to thiamine.

Thiamine is a coenzyme of the pentose phosphate pathway, involved in the process of synthesis of fat acids, steroids, nucleic acids and other bioactive compounds essential to the brain function (Kerns et al., 2015). It is specifically involved in the neuro modulation of acetylcholine and contributes to the structure and functions of cell membranes, including neurons. (Bâ, 2008)

Thiamine nutritional sources

Thiamine is widespread both in vegetable foods (as free thiamine) and in animal foods (in its phosphorylated form). The main dietary sources are whole grains, pulses and, most of all, beer yeast. In grains the aleurone layer and the germ are the richest in thiamine but they are removed during the refining process. (Fitzpatrick et al., 2012).

Food processing (alkaline pH, high temperatures, sulphite exposure) entails a significant loss of thiamine (Bentreud, 1977; Clydesdale et al., 1991; Ball, 2005; Damodaran et al., 2007). Therefore, most thiamine is lost in the production of refined flours and glazed rice.

For example100 g whole wheat flour contain 0,55 mg thiamine whereas 100 g white flour only contain 0,06 mg (Fitzpatrick et al., 2012).

Deficiency

Thiamine deficiency is associated mainly to carbohydrate metabolism alterations. Healthy subjects rapidly absorb thiamine, mostly in the small intestine.

The human body produces hardly any thiamine therefore it must be supplemented through the diet. Moreover, the human body is unable to store it meaning that even short periods of insufficient intake can bring about a high risk of deficiency.

Chronic vitamin B1 deficiency leads to a disease characterised by alterations of the nervous system, of the cardiovascular system and of the gastroenteric system; this disease is known as beriberi. The disease is still widespread in some Far Eastern areas, where part of the population relies on a single basic crop as they cannot afford a diversified diet. Their diet consists mainly of poor sources of thiamine, such as milled cereals including glazed rice and white flour; this unfailingly determines a deficiency of many essential micronutrients. (Fitzpatrick et al., 2012).

In this respect, according to UE Regulation n°1169/2011 about the nutritional labelling of food products, the recommended daily allowance (RDA) for vitamin B_1 is 11 mg daily.

Thiamine deficiency can also depend on diets rich in thiaminasis, an enzyme which breaks natural thiamine and abounds in some raw or fermented fish eaten mostly in Africa and Asia. (WHO, 1999).

Riboflavin

Riboflavin (vitamin B2) was first isolated in 1927 b. Paul Gyorgy. It is the result of the combination of a flavin (a heterocyclic nitrogen compound with three hexagonal rings), namely isoalloxazine and a ribose sugar. (Fidanza et al., 1988).

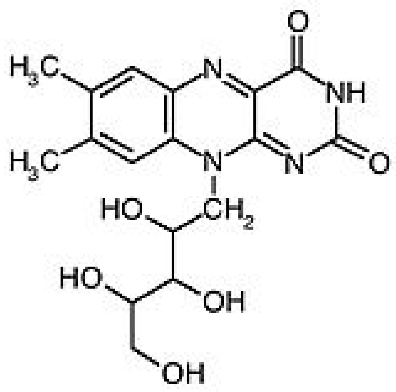

Figure 20. Chemical structure of riboflavin

Riboflavin (Fig. 20) is part of the functional group of flavin adenine dinucleotide (FAD) and flavin mononucleotide (FMN) cofactors.

A large number of enzymes require these flavin cofactors, including those involved in electron transport at mitochondrial level, in photosynthesis and in fatty acid oxidation. Man cannot synthesise it but can produce FMN and FAD from riboflavin.

Nutrient sources

Greens such as broccoli, turnip greens, asparagus and spinach are good sources of riboflavin. In fact, in vegetables, the leafy parts contain plenty of riboflavin, which decreases as the vegetable ripens, whereas cereals, for example contain little riboflavin (National Academy of Sciences, 1989).

Deficiency

Riboflavin deficiency brings about hyporiboflavinosis; one of the main causes is low dietary intake, sometimes worsened by unsatisfactory food keeping or processing. This disease is widespread especially in developing countries. In humans, a relationship has been found between riboflavin deficit and a number of conditions including cancer, cardiovascular diseases, anaemia and a number of neurological and developmental disorders (Powers, 2003). Deficiency symptomatology also includes stunting and skin alterations (seborrhoeic dermatitis), alterations of the lip mucosa (angular stomatitis) and of the eye (corneal vascularization, conjunctivitis and lens opacity) (www.docente.unicas.it). Pure deficiency is rare; it usually comes with a lack of other group B vitamins. In food, riboflavin is found mostly in its phosphorylated form. Reduced riboflavin assimilation may also be the result of digestion abnormalities, for example in the case of lactose intolerance or coeliac disease. (FAO, 2001).

Recommended intake levels naturally vary depending on age, sex and physiological condition. In this respect, according to UE Regulation n°1169/2011 about the nutritional labelling of food products, the recommended daily allowance (RDA) for vitamin B_1 is 1.4 mg daily.

CHAPTER V

5.1 NUTRIENT COMPOSITION OF THE STUDIED SPECIES

Nutrient composition of Sonchus spp.

Over the past years, the species related to the *Sonchus* genus have been investigated for their nutritional, medical and biological properties, due to their high concentration of nutrients. (Guerrero-Guil et al., 1998).

As regards the percentage chemical composition of ***Sonchus oleraceus*** the data reported in Table.1 refer to 100g of edible part, taken from a collection of bibliographic sources cited in the work of Tardio et al., 2016.

Table 1. PercentageComposition **(g/100g out of t.q**) of ***Sonchus oleraceus*** species (Tardio et al., 2016)

Percentage compostion	Average (g/100g t.q.)	Range
Moisture	87,6	83,0 - 91,9
Fats	0,60	0,20 - 1,28
Proteins	2,22	1,11 - 3,48
Available carbohydrates	2,29	0,94 - 4,20
Fibre	3,37	2,60 - 5,57
Ashes	2,17	1,58 - 3,00

Moisture is the main component with an average of 87.6 g/100g; proteins have an average content of about 2.22g/100g, a lower value compared to the other species, *Sonchus asper*. The fat content is low at 0.60 g/100g; while fibre value reaches3.00 g /100g on average; therefore, this species is regarded as a source of fibre. As for the content of bioactive compounds, Morales et al., 2014 report the tocopherol (Tab. 2). In literature, only Guerrero-Guil et al., 1998 report the total carotenoid content for *Sonchus oleraceus* amounting to 15.8 mg/100g t.q.

Table 2. Tocopherol content for *Sonchus oleraceus* (Morales et al., 2014)

	Average ± DS (mg /100g t.q.)
α-tocopherol	1,7 ± 0,05
β-tocopherol	0,04 ± 0,01
γ-tocopherol	0,47 ± 0,03
δ-tocopherol	0,01 ± 0,00
Total Tocopherol	2,22 ± 0,06

As regards the percentage composition of ***Sonchus asper*** Table 3 reports the following values according to Guerrero-Guil et al., 1998

Table 3. Percentage Composition (g/100g t.q.) for Sonchus asper (Guerrero-Guil et al., 1998, modified).

Percentage Composition	Media (g/100g t.q.)
Moisture	86,4
Fats	0,7
Proteins	3,2
Available carbohydrates	2,0
Fibre	3,6
Ashes	3,0

Speaking of nutrient composition, the moisture content is consistent with the most common vegetal species. The protein content found is unusual, over 3,10 g/100g and the fibre content is high as well, around 3,5 g/100g. Recent studies have shown that the *Sonchus genus,* in particular, could be a good vitamin source (Hussain et al., 2010). According to Guerrero-Guil et al., 1998 vitamin C amounts to about 62,8 mg/100 g while carotenoid content is 8,0 mg/100g.

Table 4 shows the mineral salt levels of *Sonchus asper*. High levels were found especially for potassium, sodium and calcium. The quantities of phosphorus, zinc, copper and manganese are similar to those found in common leafy greens. (Xiu-Mei Li e Pei-Long Yang, 2018).

Table 4. Mineral salt contents (mg/kg t.q.) of *Sonchus asper,* (Guerrero-Guil et al., 1998; modified).

Mineral composition	Average (mg/kg)
Na	1903
K	5839
Ca	990
Mg	289
P	493
Fe	29,8
Cu	3,1
Zn	8,8
Mn	9,0

As regards *Crepis vesicaria*, there are no bibliographical studies in literature about nutrient composition and bioactive compound contents.

Bioactive compound content in Blitum bonus-henricus

Literature is lacking in studies about the percentage composition of this plant. However, there exists one work on the carotenoid content expressed on dry matter (d.m.). (Hanganu et al., 2012), reported in the following table (Tab.5)

Table 5. carotenoid content in *Blitum bonus-henricus* (mg/100g son dry matter), (Hanganu et al., 2012).

Compound	**100g s.s.**
neoxanthin	30,41
violaxanthin	36,14
cis-lutein	23,62
trans-lutein	150,96
zeaxanthin	0,44
β-cryptoxanthin	3,07
α-carotene	4,52
β-carotene	70,37
cis-β-carotene	*14,01*
Tot. carotenoids	336,54

Blitum bonus-henricus appears to be a good source of carotenoids with a relevant presence of xanthophylls (neoxanthin, violaxanthin, lutein, zeaxanthin e β-cryptoxanthin) and carotenes (α and β-carotene). Data stress that trans-lutein is the highest present compound (150.96 mg/100 g d.m.), followed by β-carotene (70.37 mg/100 g d.m.).

As regards *Tragopogon porrifolius L.*, literature does not report proven studies regarding vitamin component.

CHAPTER VI

6.1 EFFECTS OF DOMESTIC COOKING TREATMENTS ON THE CONTENT OF BIOACTIVE COMPOUNDS

Since ancient times, foods have undergone processing processes as a way to protect and improve their nutritional and organoleptic properties. Nevertheless, these processes can also cause some undesirable consequences such as loss of nutrients and formation of toxic compounds with adverse effects on consistency, taste or color (Friedman, 2015; Mogol & Gokmen, 2016; Zamora, León e Hidalgo, 2015). Although, the benefits of food processing, such as ensuring food safety, cannot be underestimated, but also obtain a greater nutritional value for the release of natural phytochemicals that have antioxidant or antimicrobial properties (Nayak, Liu, e Tang, 2015; Van Boeckel et al., 2010). As far as food processing is concerned, much depends on the culinary traditions of the various countries for domestic consumption. If for example we consider hot cooking methods, these involve a very wide variety of processes, including boiling, steaming, frying, baking and roasting and the use of microwave ovens (Palermo, Pellegrini e Fogliano, 2014). Domestic processing and cooking methods are presumably considered to be one of the most important factors influencing the daily intake of carotenoids and tocols (Van den Berg et al.2000). On the content of bioactive compounds in vegetables, and on those that promote health, the cooking process has shown a considerable effect

(Moreno et al., 2007; Zhao et al., 2019; Shonte et al., 2020; Hailemariam e Wudineh, 2020).Therefore, the most recent knowledge on the effects of two specific domestic cooking conditions (conventional boiling and steam) on the bioactive content of vegetables is presented below.Like all transformation treatments, even hot processes can determine, at different degrees, tissue softening, colour change, formation of aromas and inactivation of compounds considered to be anti-nutrient, but they can be responsible for creating a damage to color, taste and nutritional value.The boiling treatment, in particular, can produce changes in cell structure and cell composition, the breaking of the food matrix (formed mainly by dietary fiber) which can cause the release of low molecular weight compounds into water and solid losses (Southon et al., 2002).Studies on processed foods have shown that processed foods have a better bioavailability of carotenoids than their raw materials (G¨artner et al., 1997; Hedren et al., 2002; Stahl e Sies, 1992). In fact, carotenoids and tocols, being fat soluble, are not significantly lost in water-soluble media during processing.In any case, domestic cooking processes in different ways, can significantly condition their content in vegetables(Zhao et al., 2019, Ruiz-Rodriguez et al.,2008).In some cases there has been a decrease in their thermal lability and their sensitivity to oxidation.The extent of degradation depends on temperature, light, the presence of oxygen, pH, water activity and interactions with other antioxidants (Fratianni et al., 2020, Penicaud et al., 2011). In a study conducted by Chang et al. (2013), a significant increase of β-carotene was observed in selected vegetables during boiling for 8 min. Nevertheless, they observed retention of β-carotene in Chinese cabbage and spinach with boiling for 4 minutes, while lutein shows good stability during boiling. While, studies conducted on steaming mode, have shown that this treatment, improves the digestibility of food, the extraction and bioavailability of nutrients softening the food matrix (Palermo et al., 2014). However, the final effect of the heat treatment depends mainly on the processing parameters and the structure of the food matrix (Palermo et al., 2014). This thermal process is considered a safer method in terms of retention of the bioavailability of the contents of vegetables. For example, in the study conducted by Wachtel-Galor et al. (2008) It has been found that the antioxidant content of the investigated Brassica species was high during the steaming process compared to microwave or boiling methods. In fact, during steaming, the investigated species maintain a better consistency quality. In addition, even the total antioxidant capacity remains stable after steaming Mazzeo et al. (2011). The content of polyphenols after steaming is significantly increased, and it is also noted that this treatment preserves better the content of carotenoids (Pellegrini et al., 2010). Therefore it can be said that this process is safe in preserving the content in bioactive compounds. It is further demonstrated by dos Reis et al. (2015b) that the lutein and β-carotene content of broccoli is increased after steaming.

CHAPTER VII

MATERIALS AND METHODS

7.1 Sampling of the studied species

The study focuses on five species*: Crepis vesicaria* L. (s.l.*), Sonchus asper (*L.) Hill s.l., *and Sonchus oleraceus* L. (Asteraceae), *Blitum bonus henricus* L. (Chenopodiaceae) and *Tragopogon porrifolius* L. (Asteraceae). For the first four species the samples used in the experimental testing were collected from two different sites in the Molise region, Italy. In particular, the samples of *C. vesicaria* were collected in spring in two consecutive years, namely 2018 and 2019, in the fields of Ripalimosani (altitude 600 m a.s.l., coordinates: Lat. 41 ° 36′41.25 ″ N, Long. 14 ° 39′59.58 ″ E) while *S. asper, S. oleraceus e Blitum bonus henricus* L were sampled in the pastures of San Massimo, Matese Massif (altitude 709 m a.s.l., coordinates Lat. 41 ° 29′19,09 ″ N; Long. 14 ° 23′29,28 E) in their stage of basal rosette. For *Sonchus spp*. samples were first gathered in autumn 2018 and the second harvest occurred in spring 2019. *Blitum bonus-henricus* L. samples were first collected in spring 2018, the second harvest occurred in 2019. Samples of *Tragopogon porrifolius* L. (Asteraceae) leaves and roots were collected solely in spring 2019, within the Comunità montana of Guilmi Medio Vastese in Abruzzi (altitude 674 m a.s.l. corrdinates Lat. 42° 01′N, Long. 14°33′E). The best season to gather wild plants is spring, when up to 56% species are available, followed by summer (29%), autumn (9%) and winter (6%) (Gonzalez et al., 2011). Table. 6 reports a synthesis of the data concerning the studied species, harvest sites, years and seasons when samples were collected. With specific reference to these last two criteria it is important to point out that the decision of analysing samples gathered in different years arises from the necessity to assess possible variations in data depending on the seasonal component. Unfortunately, due to Covid-19 impediments, a further sampling planned for spring 2020 for *Tragopogon porrifolius L*. could not be carried out. Sample determination of gathered plants was based on their morphological characters, according to the classification of Bartolucci et al. 2018.

Table 6. Synthesis of sampling operations

SPECIES	FAMILIES	PLACE OF COLLECTION	YEAR OF HARVEST
Sonchus asper L. Hill	Asteraceae	Region Molise Fields near Ripalimosani Pastures near S. Massimo - Matese massif	autumn 2018 spring 2019
Sonchus oleraceus L.	Asteraceae	Fields near Ripalimosani Pastures near S. Massimo - Matese massif	autumn 2018 spring 2019
Crepis vesicaria L.	Asteraceae	Fields near Ripalimosani Pastures near S. Massimo - Matese massif	spring 2018 2019
Tragopogon porrifolius L.	Asteraceae	Region Abruzzo Guilmi Medio Vastese mountain community	spring 2019
Blitum bonus henricus L.	Chenopodiaceae	Region Molise Pastures near S. Massimo - Matese massif	spring 2018 2019

All samples were prepared with at least twenty randomly chosen specimens for each species. About 500g of edible part were collected for each species After harvest, the vegetable material was taken to the laboratory of the Department of Agriculture, Environment and Food Science of the University of Molise, and was accurately cleaned. For each sample, a part of the vegetable material harvested was cut into small portions to carry out the moisture analysis on fresh sample. Then the vegetable material was lyophilized. This operation was carried out with the Genesis 25ES lyophilizer (Vir Tis Co., Gardiner, New York), Fig.21

consisting in a freezing and sublimation chamber, equipped with 4 cooling/warming plates, a condensation chamber and a vacuum pump. The system is equipped with 4 probes which can be inserted into the product before lyophilization for constant monitoring of the product temperature. The whole system is driven by a Data Center Wizard 2.0. programme. Through the management program, the freeze-drying system was set up with the following recipe:

• Initial vacuum 500 mPa

• Heat treatment step -40 ° C for 120 min (time and temperature to which the chamber plates are brought);

• Freezing temperature -35 ° C (temperature that the product must reach);

• Condenser temperature -40 °C Subsequently the lyophilised samples were ground with a refrigerated laboratory grinder (IKA A10, Staufen, Germany). All samples were stored at -20°C until analysis. To carry out the tests, all samples were analyzed in triplicate.

Figure 21. Samples of Sonchus oleraceus Sonchus asper before being lyophilized. Genesis 25ES freeze dryer model (Vir Tis Co., Gardiner, New York)

7.2 Methods

The lyophilized samples were subjected to the assessment of moisture, ashes, proteins, fats, dietary fibres and eventually the contents of carotenoids, tocols and B1 and B2 vitamins were analyzed.

7.2.1 *Centesimal composition*

The compostion in moisture, ashes, proteins and fats was determined following the AOAC, 2000. methods.

Moisture

Moisture was assessed by weighing 10 g (fresh) and1 g (lyophilised) sample then desiccated at 105°C in a stove for 4 hours.

Ashes

0.2 grams of finely ground lyophilised sample were charred in a furnace at 525°C till white ashes were obtained.

Proteins

The assessment of protein content was carried out on 0.2 grams of sample lyophilised with the Kjeldhal method, using 6,25 as conversion factor of nitrogen into protein.

Fats

The assessment of fat content in the sample was carried out using the solvent extraction method with aacid hydrolysis.

Determination of total fibre

Dietary fibre was assessed with the AOAC, 1995 method. Soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) were estimated. Total dietary fibre (TDF) content corresponds to the sum of SDF and IDF

Carbohydrates

Carbohydrates were calculated as the difference between all other nutrients and 100.

7.2.2 Determination of carotenoids and tocols

Extraction of carotenoids and tocols

The extraction of carotenoids and tocols was carried out following the (Panfili et al., 2003; 2004) method suitably modified. This method requires a first stage of hot saponification of the sample followed by solvent extraction and chromatographic determination in HPLC.

Extraction includes the following steps:

- 0.3g lyophilized sample is double weighed in dedicated 25 ml Pyrex glass tubes with screw caps;
- 10 glass beads are added into each pyrex tube.

Successively the following are added in turn:

- 5 ml of a 6% pyrogallol solution in 95% ethanol as oxidant;
- 3 ml 95% ethanol;
- 1 ml 1% w/v sodium chloride;
- 2 ml 60% w/v potassium hydroxide for saponification;

After bubbling nitrogen in the tubes to remove oxygen, the tubes are tightly sealed. Successively, they are placed in a water bath at 70-80°C for 45 minutes making sure to shake the mixture every 5-10 minutes; after 45 minutes, the saponification reaction is stopped by cooling rapidly the tubes in ice. Once the saponification stage is completed, the solvent extraction is started. Therefore, 15ml of the solution of 1% w/v sodium chloride are added into the tubes and the mixture is stirred by hand. Then 15 ml of a solution of (9:1 v: v) n-hexane/ethylacetate is added, the mixture is stirred by hand and left until the polar phase containing the saponified part and the upper organic phase containing unsaponifiable elements are separated. Thereafter the upper phase is retrieved. Saponification is repeated adding 15 ml (9:1) n-hexane/ethylacetate and replicating the steps as described above.

Subsequently, the flasks containing the extract are evaporated until dry with a rotating evaporator in a water bath at the set temperature of 30°C. Once the residue is suitably retrieved, it is stored at -20 °C and analyzed in HPLC.

Determination of carotenoids through High Performance Liquid Chromatography (HPLC)

The analytical determinations of carotenoid content have been carried out with a HPLC Dionex, equipped with an Ultimate 3000 pump and fitted with a UVD detector (λ = 450nm), using aC30 YMC (Hampsted, NC, USA) column, 5 mm inside diameter, 250 x 4,6 mm, thermostated at 20 °C.

The determination of carotenoids was carried out in gradient mode, with a flow of 1ml/min and injection volume of 50 µl, using as a mobile phase a methyl tertiary butil ether (MTBE) mixture for 58 minutes. The gradient used refers to the work of Mouly et al. 1999. Chromatographic data was processed with Cromeleon ver. 6.60 software. The elution order of the different compounds is as follows: violaxanthin, neoxanthin, lutein, zeaxanthin, β-cryptoxanthin, α-carotene, 13-cis βcarotene, β-carotene, 9-cis βcarotene. The quantitative analysis of carotenoids was carried out with the external standard method, building up a calibration curve for each compound by using known concentration standard solutions.

Determination of tocols through High Performance Liquid Chromatography (HPLC)

The determination of tocols was carried out with an HPLC Dionex system equipped with an ULTIMATE 300 Pump and a RF2000 Fluorescence Detector and a Phenomenex Kromasil silica column, particle size 5 μm (250 x 4.6 mm diametre). The sample run was carried out in isocratic mode with a flow of 1.6 ml/min, with a mobile phase consisting of n-hexane ethylacetate/ acetic acid (97.3/1.8/0.9 v.v.v.) (Panfili et al., 2003). The different isomers were revealed fluorometrically by setting the excitation wavelength at 280 nm and the emission wavelength at325 nm. The chromatographic run lasted 28 minutes during which the different vitamin E vitamers eluted and were separated in the following order: α-tocopherol, α-tocotrienol, β-tocopherol, γ-tocopherol, β-tocotrienol, γ-tocotrienol, δ-tocopherol, δ-tocotrienol. The quantitative analysis of tocopherols was carried out with the external standard method building up a calibration curve for each compound using standard solutions with known concentrations of tocopherols The quantitative analysis of tocotrienols was carried out referring, for each of them, to the area of the respective tocopherol standard, since the fluorescence intensity , that is the peak area for each tocotrienol, is the same as that of the corresponding tocopherol in the same concentration.

7.2.3 *Determination of water soluble vitamins*

The determination of B1 and B2 vitamins was carried out applying the INRAN method from Hasselmann et al.,1989 modified. For vitamin B1 the sample undergoes acid hydrolysis in the presence of hydrochloric acid and the fluorescence of the thiochrome derivative is measured in HPLC chromatography and compared to a standard solution of thiamine derivatised to trichrome as regards vitamin B2 following acid hydrolysis the fluorescence of riboflavin is measured in HPLC chromatography and compared to a standard riboflavin solution.

All the operations were carried out away from light; containers were lined with aluminium foil or amber glassware was used to avoid vitamin decay.

Extraction of thiamine and riboflavin

0.4 g lyophilised sample was weighed in 50ml test tubes and 20 to 25 ml HCl 0.1 N were added. The mixture was hydrolysed in boiling bath for 30 minutes. After cooling, the sample is made to reach a 4.5 pH with a sodium acetate buffer 2.5 M. the claradiastasis enzyme (0.2 ml solution) and kept in bath at 37°C for 3 h. After three hours the volume is made to reach 25/30 ml with distilled water and the mixture is centrifuged at 10000 rpm. The sample is then filtered with 0.45 μm filters.

Derivatisation of thiamine to thiochrome

In the case of vitamin B_1 determination, thiamine is derivatised to thiochrome by adding to 5 ml filtrate 5 ml of an alkaline solution of potassium ferrocyanide. After 60 sec it is neutralized with 0.7 ml H_3PO_3 85%.

Removal of interfering components

Before chromatography determination, compounds which may interfere with chromatographic separation are removed. Solid phase extraction cartridges C_{18-X} (Strata-X, Phenomenex) are used after activation with methanol (5 ml) first and then with water (10 ml). For thiamine, 5 ml derivatised sample are added, or 5ml filtrate for riboflavin; the sample is rinsed with acetate buffer 0.05 M (2 X 5 ml) and eluted with H_2O-metanolo 40:60 v/v reacing a volume of 10 ml in a weighed flask.

Determination of thiamine and riboflavin through High Performance Liquid Chromatography (HPLC)

Chromatographic separation was carried out on a C18 (25 x 460 mm, 100A) Luna column of Phenomenex (Torrance, CA, USA) with 5 µm diametre particles. HPLC Dionex, equipped with an Ultimate 3000 Dionex pump and a RF2000 Fluorescence Detector and 50 µl loop were used. The fluorometric detector is set for thiamine determination at an excitation wavelength of 366 nm, and emission wavelength of 435 nm, while for riboflavin excitation wavelength was 453 nm and emission wavelength was 580 nm.

The mobile phase consists of a methanol- acetate buffer (40:60 v: v), pH 4.5, with isocratic elution and flow speed at 0.8 ml/min.

The identification of the analysed vitamins B was carried out through comparison with a known standard sample, while quantitative determination was carried out by comparing the areas of the sample to those of the standard.

7.4 Effect of home cooking on carotenoids and tocols

Investigated species

At this stage, preliminary analyses were conducted on two studied species, *Sonchus oleraceus e Sonchus asper*. For both WEPs the examined material refers to two harvests made in two different years (2018-2019), sampled in the pastures of San Massimo, in the Matese Massif (altitude 709 m a.s.l, coordinates Lat. 41 ° 29′19,09 ″ N; Long. 14 ° 23′29,28 E) as basal rosettes.

Cooking conditions

Cooking techniques have been analysed for two methods:

- ✓ Conventional boiling
- ✓ Steam cooking

Before defining the cooking protocol to be adopted, preliminary investigations were conducted for each examined species, establishing the minimum cooking time to reach mellowness, palatability and flavour based on information about traditional culinary know how, such as consumption patterns and recipes. For both treatments each batch of plants was divided into three parts to guarantee the experiment at least three replications. Consequently, for each test, 100 g leaves were used; these were minced and boiled in a beaker in 1 litre of water (food 1:10: water). For conventional boiling 1000 mL of boiling water were added to a fresh portion for 10 minutes. Whereas for steam cooking, the portion of greens was placed on a steaming grill above boiling water in closed bain-marie for 10 minutes On completion of the cooking procedure, boiling water was left to flow out for 5 minutes. After cooking, the greens were drained. At the end of this stage, the cooked portions, the water samples and the fresh controls were lyophilised (Genesis 25SES lyophilizer, VirTis Co., Gardiner, NY), ground with a refrigerated IKA A10 laboratory grinder (Staufen, Germania), accurately mixed and stored at -20 ° C.

Eventually, a number of samples were used to prepare a single sample stored in the dark at -20° C up to the time of analysis. All samples were analysed in triplicate and all results are reported as the average of three assessments. Also the dessicated water residue was weighed to assess the soluble loss after cooking. For the analyses on the vegetable material investigated we have carried out centesimal analysis, extraction and quantification of carotenoids and tocols through procedures above indicated in this chapter.

7.5 Statistical analysis

Data was subjected to variance analysis (ANOVA). The least significant differences were obtained through a LST TEST file ($p < 0,05$). An SPSS 13.0 version for Windows (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis.

CHAPTER VIII

STUDIO II

Bioactive Compounds in the analysed Wild Asteraceae Edible Plants

8.1. Bioactive compounds in *Sonchus asper, Sonchus oleraceus e Crepis vesicaria*

The results, discussions and conclusions related to the nutritional composition of these species referred to in this study are reported in the attached work to this thesis:

Bioactive Compounds in Wild Asteraceae Edible Plants Consumed intheMediterraneanDiet

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PlantFoodsforHumanNutrition
https://doi.org/10.1007/s11130-020-00842-y

PlantFoodsforHumanNutrition
https://doi.org/10.1007/s11130-020-00842-y

ORIGINALPAPER

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BioactiveCompoundsinWildAsteraceaeEdiblePlantsConsumed intheMediterraneanDiet

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Abstract
Three wild edible plant species belonging to the Asteraceae family, Crepis vesicaria L. (s.l.), Sonchus asper (L.) Hill s.l., and Sonchus oleraceus L., usually consumed in the Mediterranean diet, were tested for their nutritional composition and content of carotenoids, tocols, thiamine and riboflavin. Low amounts of thiamine and riboflavin were found. All species were sources of xanthophylls (violaxanthin, neoxanthin, lutein, zeaxanthin and β-cryptoxanthin) and carotenes (α-carotene, β-carotene, 9-cis-βcarotene and 13-cis-β-carotene). Lutein accounted for the highest content (about 4 mg/100 g). They had good tocol amounts, in particular α-tocopherol (about 2–3 mg/100 g). Taking into account the Recommended Daily Allowance (RDA) established by the EU Regulation, the analyzed plants can be declared as a source of fiber, vitamin A and E. These data could be useful for database on the nutritional and bioactive compound profile of studied plants and can contribute in promoting their use in functional foods.

Keywords Wildedible plants. Antioxidants. Vitamins. Bioactive compounds. Tocols. Carotenoids

Introduction

According to the Food and Agriculture Organization (FAO), over 100 million people in the EU consume wild foods, being a part of people diet around the world and playing an important role in the Mediterranean diet [1]. In the last years, the interest in wild edible plants (WEPs) has quickly grown and a large number of studies on their therapeutic and nutritional properties has been carried out. WEPs have been associated with several health effects against different chronic disorders such as obesity, cancer, cardiovascular diseases, immune deficiency, and brain disorders [1]. Wild plants have high contents of fiber, proteins and different minerals [1–4]; they provide high amounts of bioactive compounds, such as flavonoids, proanthocyanidins, flavonols, vitamin C, tocols (vitamin E), carotenoids (vitamin A) andxanthophylls that can contribute to a healthy condition [1, 2, 5] Carotenoids and tocols are an important group of bioactive compounds with antioxidant activity and health-promoting properties [6]. Different carotenoids are precursors of vitamin A; moreover, the color of a wide variety of foods depends on their carotenoid content [7]. Tocols, also known as vitamin E, comprise two groups of vitamers, tocopherols and tocotrienols, occurring in eight forms: α-tocopherol (α-T), β-tocopherol (β-T), γ-tocopherol (γ-T), δ-tocopherol (δ-T) and α-tocotrienol (α-T3), β-tocotrienol (β-T3), -tocotrienol (γ-T3), δ-tocotrienol (δ-T3). Tocols have been demonstrated to prevent certain types of cancer, heart and other chronic diseases [8]. Their main sources are vegetable oils but they are also found in a large amount in different vegetable products [1, 9–13]. Thiamine (vitamin B1) is a water-soluble vitamin involved as a co-factor of several enzymes present in wholegrain, enriched cereals, pork, liver, legumes, nuts and seeds. Riboflavin (vitamin B2) takes part in several flavoprotein enzymes. Milk products, leafy green vegetables, whole cereals provide good amounts of riboflavin [14]. In Italy, the use of alimurgical wild edible species has always been a relevant feature of local cultures; however, WEPs

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Published online: 15 August 2020

are becoming neglected due to urbanization and the globalization of agriculture. In particular, the Asteraceae family includes numerous native wild edible species usually consumed in the Mediterranean basin, most of which are used as salad vegetables or as vegetable mixtures. By consulting the Italian WEP database (named AlimurgITA) [15], it has been possibleto focus on three annual or biennial species belonging to the Asteraceae family: Crepis vesicaria L s.l., Sonchus asper L. Hill s.l., and Sonchus oleraceus L. They are among the most used plants in Italian and Mediterranean traditional cuisine [1]. In Southern Italy, the WEP mesclun, in fact, represents a base element in the eating habits defined by the term “Mediterranean diet”. So far, despite the wide diffusion of the mentioned species, the knowledge of nutritional and bioactive compound profile of alimurgical WEPs is scarce and mostly limited to Sonchus spp. [1, 3, 4, 16, 17]. In this study Crepis vesicaria L. (s.l.), Sonchus asper (L.) Hill s.l. and Sonchus oleraceus L. have been investigated for their nutritional composition with particular regard to carotenoids, tocols, thiamine and riboflavin, in order to highlight their importance in human diet. Materials and Methods

Plant Material

Plants of Crepis vesicaria L. (s.l.), Sonchus asper (L.) Hill s.l., and Sonchus oleraceus L. (Asteraceae), were collected in two sites of the Molise Region, Italy. Crepis samples were harvested in the fields near Ripalimosani (elevation 600 m.a.s.l., coordinates: Lat. 41°36′41.25″N, Long. 14°39′59.58″E) while Sonchus samples in the pastures of San Massimo, Matese Massif (elevation 709 m.a.s.l., coordinates Lat. 41°29′19.09″N; Long. 14°23′29.28″E). Plants were gathered during two consecutive years: 2018 (1y) and 2019 (2y), in particular, Crepis in spring 2018 and 2019 while Sonchus spp. in autumn 2018 and spring 2019. The collected plants have been identified on the basis of their morphological characters, following the nomenclature of Conti et al. [18]. At least 20 specimens of each species were collected, randomly chosen in relation to the basal rosettes status. The basal leaves were harvested and the non edible portion was discarded. From each sample, a minimum of 500 g of edible portion was gathered, cleaned by removing damaged parts and soil particles. Then, the leaves were freeze-dried (Genesis 25SES freeze dryer, VirTis Co., Gardiner, NY) and grounded with a refrigerated IKA A10 laboratory mill (Staufen, Germany), carefully mixed and stored at −20° C. Two bulk samples were prepared by combining the samples of each year and stored in dark at −20° C until analysis. Samples were analyzed in triplicate.

Chemicals and Reagents

Solvents were commercially obtained (Sigma Aldrich) at the highest quality. All other used reagents were of analytical grade. Violaxanthin, neoxanthin α-carotene, 9-cis-β-carotene and 13-cis-β-carotene standards were obtained from CaroteNature (Lupsingen, Switzerland); lutein, zeaxanthin, and β-cryptoxanthin were from Extrasynthese (Z.I. Lyon- Nord, Genay, France). All-trans-β-carotene, thiamine and riboflavin standards were from Sigma Chemicals (St. Luis, MO, USA). α-, β, γ- and δ-tocopherol standards were from Merck (Darmstadt, Germany); α-, β-, γ- and δ-tocotrienol standards were purified as reported in Panfili et al. [12].

Proximate Analysis

Moisture, proteins, fats, ash and fiber were determined according to the AOAC methods [19]. Proteins and fats were determined by the Kjeldhal (N × 6.25) and the Soxhlet method, respectively. Soluble dietary fiber (SDF) and insoluble dietary fiber (IDF) were estimated as in Niro et al. [10]. Total dietaryfiber (TDF) content corresponds to the sum of SDF and IDF. Carotenoid and Tocol Analysis The extraction of carotenoids and tocols was carried out according to Panfili et al. [12, 20], with some modifications. About 0.3 g of freeze-dried samples was weighed in a screw-capped tube. Then 5 mL of ethanolic pyrogallol (60 g/L), 3 mL of absolute ethanol, 1 mL of sodium chloride (10 g/L) and 2 mL of potassium hydroxide (600 g/L) for alkaline digestion were added. The tubes were put for 45 min in a 70° C water bath and stirred every 5–10 min. After cooling, 15 mL of sodiumchloride (10 g/L) were added. Compounds were extracted with 15 mL of n-hexane/ethyl acetate (9:1, v/v), until the organic layer was colorless. Organic layers were collected and evaporated to dryness. For carotenoid analysis, the dry residues were suspended in 50:50 (v/v) methanol: tert-methyl-butyl-ether (MTBE). Carotenoid extracts were separated, through a HPLC (Dionex, Sunnyvale, CA), as in Mouly et al. [21], by means of a YMC (Hampsted, NC, USA) stainless steel column (250 × 4.6 mmi.d.), packed with 5 μmsilica spheres that were chemically bonded with a C30 material. Methanol: MTBE: water was the mobile phase, at a flow rate of 1 mL/min. Details of the gradient profile are given in the original work. The eluted compounds were detected by a Dionex photodiode array detector set at 430 nm. A Dionex Chromeleon Version 6.6 chromatography system was used to process data. Vitamin A activity was expressed as Retinol Equivalent (R.E.), in μg/100 g of wet basis (WB), as reported by EFSA [22]. For tocol analysis, the dry residues were suspended in 2 mL of isopropyl alcohol (1%) in n-hexane and were analyzed by a Dionex HPLC, using a 250 × 4.6 mm i.d., 5 μm particle size Kromasil Phenomenex Si column (Torrance, CA, USA), as reported in Panfili et al. [12]. Fluorometric detection of all tocols was performed by means of a Dionex RF 2000 spectrofluorimeter, at an excitation wavelength (exc) of 290 nm and an emission wavelength (em) of 330 nm. Compounds were identified by comparing their retention times with standard solutions and through their spectral characteristics, and quantified through the calibration curves of each standard solution. Vitamin E activity was expressed as Tocopherol Equivalent (T.E.) (mg/100 g WB), as in Sheppard et al. [23].

Thiamine and Riboflavin Analysis

The extraction procedure of Hasselmann et al. [24] was applied.0.4 g of sample was weighted in 100 mL volumetricflasks; 20 mL of 0.1 N HCl were added, followed by heatingin a water bath at 100° C for 30 min. Further details are reportedin Niro et al. [10]. A HPLC Dionex (Sunnyvale, CA), with a U3000 pump and an injector loop (Rheodyne, Cotati), was used to separate the extracts, through a 5 μm C18 LunaPhenomenex stainless steel column (250 × 4.6 mm i.d.) (Torrance, CA, USA). The mobi l e phase wasmethanol: sodium acetate (40:60 v/v), at a flow rate of0.8 mL/min. Fluorometric detection was performed at an excof 453 nm and an em of 580 nm, for riboflavin, and at an excof 366 nm and an em of 453 nm, for thiamine, after its derivatizationto thiocrome, by means of a Dionex RF 2000 spectro fluorimeter. A Dionex Chromeleon Version 6.6 chromatographysystem was used to process data. Thiamine and riboflavinwere identified through available standards.

Statistical Analysis

Data were subjected to the analysis of variance (ANOVA). The least significant differences were obtained through anLSD test ($p < 0.05$). A SPSS version 13.0 for Windows (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis.

Results and Discussion

Nutritional Composition

Table 1 reports the nutritional composition of the analyzed WEPs, expressed on wet basis (WB). Fat content was very low (0.3–0.4 g/100 g). No significant differences in fat and ash content were found among samples ($p > 0.05$). Sonchus oleraceus contained significant ($p < 0.05$) higher amounts of proteins than the other tested plants (3.0 g/100g as to 1.7 and 1.8

g/100 g of Crepis vesicaria and Sonchus asper, respectively). Total fiber went from 6.4 g/100 g for Crepis vesicaria, to 5.4 g/100 g for Sonchus asper, being the insoluble dietary fiber the predominant fraction (from 4.7 g/100 g for Crepis vesicaria, to 3.6 g/100 g for Sonchus asper). Guil-Guerrero et al. [3] and de Cortes Sánchez-Mata and Tardío [1] report similar results on Sonchus asper and Sonchus oleraceus. According to the European law [25], Sonchus asper and Sonchus oleraceus can be declared on the label with the claim "source of fiber", since they contain at least 3 g of fiber per 100 g, while Crepis vesicaria can be declared with the claim "high fiber content", since it contains at least 6 g of fiber per 100 g. The reported results are in agreement with different papers, which found green leafy vegetables as rich sources of proteins and fiber [1, 3, 4]. Generally, the chemical composition of plant species could differ, depending on the harvest period and growth conditions (e.g., climate, treatments, rainfall, irrigation, soil quality, etc.). The content of carotenoids (mg/100 g WB) in the investigated plants, in the two harvest years, is reported in Table 2. In the present study, 9 carotenoid compounds were detected and identified in all plants: xanthophylls (violaxanthin, neoxanthin, lutein, zeaxanthin and β-cryptoxanthin) and carotenes (α-carotene and β-carotene with its isomers 9-cis-βcarotene and 13-cis-β carotene) (Fig. 1). The mean total carotenoid content varied from 10.0 mg/100g in Crepis vesicaria to about 15.0 mg/100g in S. asper. Lutein was the main carotenoid (range about 3–4 mg/100 g), while β-carotene accounted for about 2–3 mg/100 g. In Crepis vesicaria lutein accounted for 35% of total carotenoids, followed by β-carotene (20%), while, in S. asper and S. oleraceus, lutein and violaxanthin accounted for about 25 and 27% of total carotenoids, respectively, followed by β-carotene (20%). Between the two years of harvesting no difference was found in the qualitative distribution of the different carotenoids while a quantitative variability emerged in both Sonchus spp. In these plants appreciable significant ($p < 0.05$) lower amounts of lutein, β-cryptoxanthin, β-carotene, 9-cis-β-carotene and totalcarotenoids were found in the 2019 harvest year.

Table 1. Proximate composition of WEPs (g/100 g WB)

Species	Moisture	Protein	Fat	Ash	Fiber		
					Soluble	Insoluble	Total
S. asper	89.1 ± 2.68ᵃ	1.8 ± 0.05ᵃ	0.3 ± 0.03ᵃ	1.9 ± 0.02ᵃ	1.8 ± 0.06ᵃ	3.6 ± 0.15ᵃ	5.4 ± 0.51ᵃ
S. oleraceus	89.3 ± 3.04ᵃ	3.0 ± 0.13ᵇ	0.4 ± 0.01ᵃ	1.5 ± 0.01ᵃ	1.6 ± 0.03ᵇ	3.9 ± 0.18ᵃ	5.5 ± 0.35ᵃ
C. vesicaria	87.1 ± 3.52ᵃ	1.7 ± 0.00ᵃ	0.3 ± 0.02ᵃ	1.7 ± 0.18ᵃ	1.7 ± 0.05ᵃ	4.7 ± 0.20ᵇ	6.4 ± 0.74ᵇ

Values are expressed as mean ± standard deviation (n = 3). WB–wet basis. Total fiber–sum of soluble and insoluble fiber. Different letters within the same column indicate a significant difference ($p < 0.05$)

Table 2. Content of carotenoids in WEPs (mg/100 g WB) in the two harvest years

Compound		C. vesicaria	% tot	S. asper	% tot	S. oleraceus	% tot
Violaxanthin	1y	1.1ᵃ		3.4ᵃ		3.9ᵃ	
	2y	1.4ᵃ		4.4ᵃ		3.1ᵃ	
	Mean	1.3	13	3.9	26	3.9	28
Neoxanthin	1y	0.9ᵃ		1.7ᵃ		1.7ᵃ	
	2y	1.1ᵃ		1.3ᵃ		1.2ᵃ	
	Mean	1.0	10	1.5	10	1.5	11
Lutein	1y	3.9ᵃ		4.9ᵃ		4.8ᵃ	
	2y	3.1ᵃ		3.1ᵇ		3.1ᵇ	
	Mean	3.5	35	4.0	27	3.1	22
Zeaxanthin	1y	0.9ᵃ		0.4ᵃ		0.2ᵃ	
	2y	1.7ᵃ		0.5ᵃ		0.2ᵃ	
	Mean	1.3	13	0.5	3	0.2	1
β-Cryptoxanthin	1y	0.1ᵃ		0.2ᵃ		0.2ᵃ	
	2y	0.1ᵃ		0.1 ᵇ		0.1ᵇ	
	Mean	0.1	1	0.1	< 1	0.1	< 1
α-Carotene	1y	0.2ᵃ		0.7ᵃ		0.6ᵃ	
	2y	0.3ᵃ		0.5ᵃ		0.4ᵃ	
	Mean	0.2	2	0.6	4	0.5	3
13-Cis-β-carotene	1y	0.1ᵃ		0.1ᵃ		0.1ᵃ	
	2y	0.1ᵃ		0.1ᵃ		0.1ᵃ	
	Mean	0.1	1	0.1	< 1	0.1	< 1
β-Carotene	1y	2.0ᵃ		3.8 ᵃ		3.5ᵃ	
	2y	2.0ᵃ		2.3 ᵇ		2.0ᵇ	
	Mean	2.0	20	3.0	20	2.8	20
9-Cis-β-Carotene	1y	0.5ᵃ		1.1 ᵃ		1.0ᵃ	
	2y	0.6ᵃ		1.0ᵇ		0.7ᵇ	
	Mean	0.5	5	1.0	7	0.8	6
Total carotenoids	1y	9.5ᵃ		16.2ᵃ		16.0ᵃ	
	2y	10.5ᵃ		13.3ᵇ		11.1ᵇ	
	Mean	10.0		14.7		14.0	
R.E. (µg/100 g WB)		408.0		606.8		644.8	

Values are expressed as mean (n = 3). WB–wet basis. R.E. – Retinol Equivalent [22]1y 2018, 2y 2019. Different letters within the same column indicate a significant difference ($p < 0.05$)

This variability could be due to the harvest period and environmental conditions (temperature, humidity, etc.). For Crepis vesicaria, where samples were collected in the same season of the two years, no significant differences ($p > 0.05$) were found, so the results of Sonchus WEPs may suggest a major role of seasonality in influencing the carotenoid content of these species thatwere, instead, collected during different seasons of the two years. Table 2 also reports values of vitamin A, expressed as Retinol Equivalent (R.E.) (µg/100 g WB) [22].

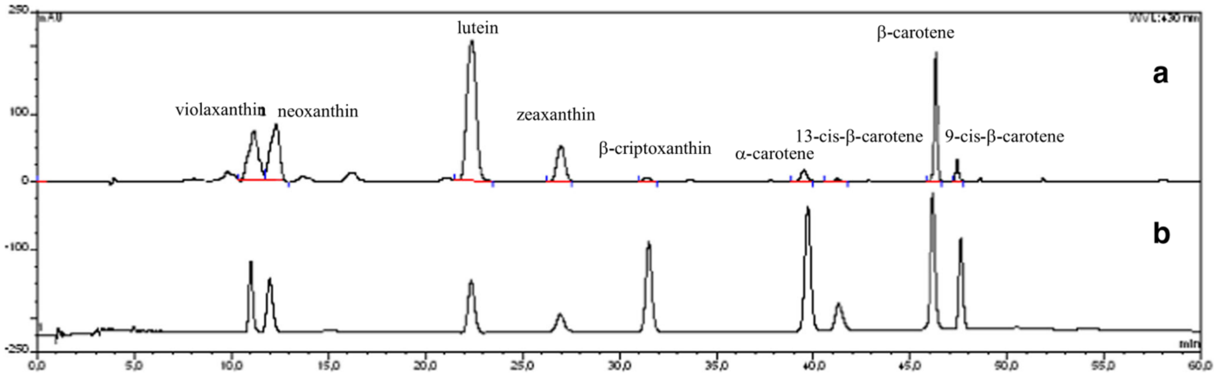

Figure 1. Typical chromatogram of carotenoids of Crepis vesicaria (a) and a standard mix (b)

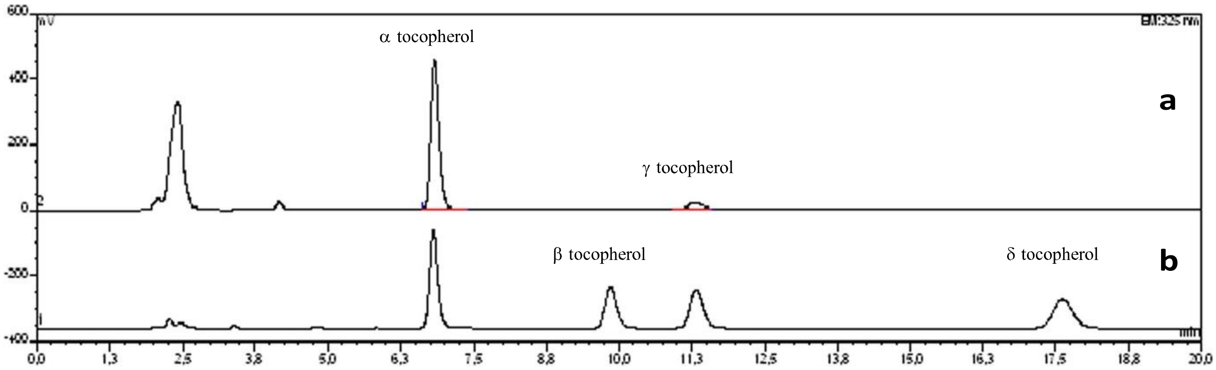

Figure 2. Typical chromatogram of tocols of Crepis vesicaria (a) and a standard mix (b)

Taking into account the Recommended Daily Allowance (RDA) for vitamin A, which is 800 µg/day [26], 100 g of leaves contribute from 50% of the RDA in Crepis vesicaria to about 80% in S. oleraceus, so that all plants can be declared as a “source of vitamin A”. Moreover, a mean portion of 200 g provides about 7–8 mg of lutein. According to Alves-Rodrigues and Shao [27], the intake of 6 to 14 mg of lutein per day is associated with more than 50% reduction in risk for age-related macular degeneration (AMD) and cataract. Our data of Sonchus species are confirmed by other literature studies [1, 3, 28]. No data are available for

Crepis vesicaria. Several authors studied the total carotenoid in species traditionally consumed in the Mediterranean area, with contents going from 2.5 mg/100 g for Bellis perennis to 13.3 mg/100 g for Allaria Petiolata [1]. Different green leafy vegetables (spinach, chicory, broccoli, lettuce, watercress) were confirmed to be rich sources of lutein [1, 29–31] and good sources of β- carotene, with contents in a range similar to those found inmost WEPs [1, 29, 32]. It is difficult to compare the different literature data related to the HPLC analysis of carotenoids, since the available results have been obtained by differentanalytical methods and these pigments may vary dependingon genotype, weather conditions, maturity stage, location, partof the analyzed plant, seasonality [31]. Tocol composition and content (mg/100 g WB) are shownin Fig. 2 and Table 3. Table 3 also reports values of vitamin Eactivity provided by 100 g of product, expressed asTocopherol Equivalent (T.E.) (mg/100 g WB) [23]. The maindetected tocopherol was α-tocopherol, which was found in allthe studied species and provided about 86% of total tocols; β-tocopherol was detected only in S. asper, at less than 0.1%. *Crepis vesicaria* showed the highest value of γ-tocopherol (0.6 mg/100 g), followed by S. asper and S. oleraceus (0.4and 0.3 mg/100 g, respectively). No tocotrienols were detected. The variability of the tocol content of the investigatedsamples between the two harvest years showed, in Sonchusspecies, significantly higher values for α-tocopherol and totaltocols in plants collected during spring 2019 ($p < 0.05$). Acomparison with literature data is very difficult, due to thevery few available data and to the same reasons already seen for carotenoids.

Table 3 Content of tocols in WEPs (mg/100 g WB) in the two harvest years

Compound		C. vesicaria	% tot	S. asper	% tot	S. oleraceus	% tot
α-Tocopherol	1y	3.7^a		2.0^a		1.7^a	
	2y	3.3^a		3.5^b		2.2^b	
	Mean	3.4	85	2.8	87	1.9	86
γ-Tocopherol	1y	0.6^a		0.3^a		0.3^a	
	2y	0.7^a		0.5^a		0.4^a	
	Mean	0.6	15	0.4	13	0.3	14
Total tocopherols	1y	4.3^a		2.3^a		2.0^a	
	2y	4.0^a		4.0^b		2.6^b	
	Mean	4.1		3.2		2.3	
T.E. (mg/100 g WB)		3.6		2.9		2.1	

Table 4 Content of thiamine and riboflavin in WEPs (mg/100 g WB) in the two harvest years

Values are expressed as mean (n = 3). WB–wet basis. T.E. Tocopherol Equivalent [23] 1y 2018, 2y 2019. Different letters within the same column indicate a significant difference ($p < 0.05$)

Species		Thiamine	% RDA	Riboflavin	% RDA
S. asper	1y	0.12[a]		0.01[a]	
	2y	0.07[b]		0.01[a]	
	Mean	0.09	8	0.01	0.7
S. oleraceus	1y	0.10[a]		0.02[a]	
	2y	0.09[a]		0.01[a]	
	Mean	0.10	9	0.01	1.2
C. vesicaria	1 y	0.15[a]		0.01[a]	
	2y	0.12[b]		0.03[a]	
	Mean	0.13	12	0.02	1.4

Values are expressed as mean (n = 3). WB– wet basis. RDARecommended Daily Allowance [26] 1y–2018, 2y–2019.Different letters within the same column indicate a significant difference ($p < 0.05$)

References for tocols are not available for Crepis vesicaria, while, for Sonchus species, similar results are reported byMorales et al. [16], Petropoulos et al. [17] and Sánchez-Mata and Tardío [1], with amounts of α-T going from 0.29–1.75 mg/100g in *Sonchus oleraceus*. Similar tocol
amounts and T. E are found in other green vegetables [33]. For WEPs and some Asteraceae species, tocol contents are of the same or lower order of magnitude [1, 16]. Conforti et al. [34],
in S. oleraceus and S. asper, found no tocols; this finding could be probably due to the different extraction method used, which does not include a saponification procedure and therefore it is not able to hydrolyze esters and eventually present bound forms of tocols. The Recommended Daily Allowance (RDA) for vitamin E is 12 mg/day [26]; therefore, 100 g of Crepis vesicaria, *S. asper* and *S. oleraceus* contribute approximately to about 30, 24 and 18% of the RDA, respectively, to be declared as a "source of vitamin E". Table 4 reports the amounts (mg/100 g WB) of thiamine and riboflavin of analyzed plants in the two harvest years. Good amounts of thiamine and low contents of riboflavin were found in all species. Some slightly significant ($p < 0.05$) differences for thiamine were found between years for Crepis vesicaria and S. asper, but for the few found amounts, these data need further investigation. Since the RDA for thiamine is of 1.1 mg/day [26], 200 g of all species contribute approximately to 15% of the RDA, so that to be declared "as a source of thiamine". Data about B-complex vitamins in WEPs is very scarce, but contents in literature are quite in accordance with those of some green leafy vegetables [1, 35]. Similar data on thiamine (4–32 μg/100 g), but higher amounts of riboflavin (71–101 μg/100 g) were reported by Sánchez-Mata and Tardío [1] for S. asper.

Conclusion

The analyzedWEPs resulted as rich sources of fiber, carotenoids and tocols, such as to encourage an in depth investigation on the health potentiality of these plants and to justify their

future commercial production, given the consumer and industry increasing demands for healthy foods. First results demonstrated the differences between different harvest years. Future researches are needed in order to better investigate the different compositional variations due the stage of maturity, climate or season, eventually farming practices, as well as the effect of

the commonly used food processing on the content of nutritional compounds.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflict of interest.

Human and Animal Participants This article does not contain any studies

with human or animal subjects.

References

1. Sánchez-Mata MC, Tardío J (eds) (2016) Mediterranean wild edible plants. Ethnobotany and food composition tables. Springer Nature Switzerland AG, New York

2. Trichopoulou A, Vasilopoulou E, Hollman P, Chamalides C, Foufa E, Kaloudis T, Kromhout D, Miskaki P, Petrochilou I, Poulima E, Stafilakis K, Theophilou D (2000) Nutritional composition and flavonoid content of edible wild greens and green pies: a potential rich source of antioxidant nutrients in the Mediterranean diet. Food

Chem 70:319–323. https://doi.org/10.1016/S0308-8146(00)00091-1

3. Guil-Guerrero JL, Giménez-Giménez A, Rodríguez-García I, Torija-IsasaME (1998) Nutritional composition of Sonchus species (S. asper L, S. oleraceus L and S. tenerrimus L). J Sci Food Agric 76:628–632. https://doi.org/10.1002/(SICI)1097-0010(199804)76: 4<628::AIDJSFA997>3.0.CO;2-U

4. Jimoh FO, Adedapo AA, Afolayan AJ (2011) Comparison of the nutritive value, antioxidant and antibacterial activities of Sonchus asper and Sonchus oleraceus. Rec Nat Prod 5:29–42

5. Sánchez-Mata MC, Cabrera Loera RD, Morales P, Fernández-Ruiz V, Cámara M, Díez Marqués C, Pardo-de-Santayana M, Tardío J (2012) Wild vegetables of the Mediterranean area as valuable sources of bioactive compounds. Genet Resour Crop Evol 59: 431–443. https://doi.org/10.1007/s10722-011-9693-6

6. Eggersdorfer M, Wyss A (2018) Carotenoids in human nutrition and health. Arch Biochem Biophys 15:18–26. https://doi.org/10. 1016/j.abb.2018.06.001

7. Fratianni A, Irano M, Panfili G, Acquistucci R (2005) Estimation of color of durumwheat. Comparison ofWSB, HPLC, and reflectance colorimeter measurements. J Agric Food Chem 53:2373–2378. https://doi.org/10.1021/jf040351n

8. Shahidi F, de Camargo AC (2016) Tocopherols and tocotrienols in common and emerging dietary sources: occurrence, applications, and health benefits. Int J Mol Sci 17:1745. https://doi.org/10. 3390/ijms17101745

9. Mignogna R, Fratianni A, Niro S, Panfili G (2015) Tocopherol and tocotrienol analysis as a tool to discriminate different fat ingredients in bakery products. Food Control 54:31–38. https://doi.org/10. 1016/j.foodcont.2015.01.032

10. Niro S, D'Agostino A, Fratianni A, Cinquanta L, Panfili G (2019) Gluten-free alternative grains: nutritional evaluation and bioactive compounds. Foods 8:1–9. https://doi.org/10.3390/foods8060208

11. Niro S, Fratianni A, Panfili G, Falasca L, Cinquanta L, Alam MR (2017) Nutritional evaluation of fresh and dried goji berries cultivated in Italy. Ital J Food Sci 29:398–408

12. Panfili G, Fratianni A, Irano M (2003) Normal phase highperformance liquid chromatography method for the determination of tocopherols and tocotrienols in cereals. J Agric Food Chem 51: 3940–3944. https://doi.org/10.1021/jf030009v

13. Panfili G, Fratianni A, Di Criscio T,Marconi E (2008) Tocol and β- glucan levels in barley varieties and in pearling by-products. Food Chem 107:84–91. https://doi.org/10.1016/j.foodchem.2007.07.043

14. Zhang Y, Zhou WE, Yan JQ, Liu M, Zhou Y, Shen X, Ma YL, Feng XS, Yang J, Li GH (2018) A review of the extraction and determination methods of thirteen essential vitamins to the human body: an update from 2010. Molecules 23:1484. https://doi.org/10. 3390/molecules23061484

15. Paura B, Bufano A, Salerno G, Di Iorio A, Brugiapaglia E (2019) The database of the Italian Alimurgical Flora (AlimurgITA): first results. XVI OPTIMA meeting 2-5 October 2019. Agricultural University of Athens, Greece

16. Morales P, Ferreira ICFR, Carvalho AM, Sánchez-Mata MC, Cámara M, Fernández-Ruiz V, de Santayana MP, Tardío J (2014) Mediterranean non-cultivated vegetables as dietary sources of compounds with antioxidant and biological activity. LWT-Food Sci Technol 55:389–396. https://doi.org/10.1016/j.lwt.2013.08.017

17. Petropoulos SA, Fernandes Â, Tzortzakis N, Sokovic M, Ciric A, Barros L, Ferreira ICFR (2019) Bioactive compounds content and antimicrobial activities of wild edible Asteraceae species of the

Mediterranean flora under commercial cultivation conditions. Food Res Int 119:859–868. https://doi.org/10.1016/j.foodres. 2018.10.069

18. Conti F, Abbate G, Alessandrini A, Blasi C (2005) An annotated checklist of the Italian vascular flora. Palombi Editori, Roma

19. AOAC (2000) Official methods of analysis, 17th edn. Association of Official Analytical Chemists, Washington, DC

20. Panfili G, Fratianni A, Irano M (2004) Improved normal-phase high-performance liquid chromatography procedure for the determination of carotenoids in cereals. J Agric Food Chem 52:6373– 6377. https://doi.org/10.1021/jf0402025

21. Mouly PP, Gaydou EM, Corsetti J (1999) Determination of the geographical origin of Valencia orange juice using carotenoid liquid chromatographic profiles. J Chromatogr A 844:149–159. https://doi.org/10.1016/S0021-9673(99)00337-4

22. EFSA (2015) Scientific opinion on dietary reference values for vitamin a. EFSA J 13:4028

23. Sheppard AJ, Pennington JAT, Weihrauch JL (1993) Analysis and mdistribution of vitamin E in vegetable oil and foods. In: Packer L,Fuchs J (eds) Vitamin E in health and disease. Marcel Dekker, New York

24. Hasselmann C, Franck D, Grimm P, Diop PA, Soules C (1989) High-performance liquid chromatographic analysis of thiamin and riboflavin in dietetic foods. J Micronutr Anal 5:269–279

25. Regulation EC No 1924/2006 of the European Parliament and of the council of 20 December 2006 on nutrition and health claims made on foods. Official Journal of the European Union

26. Regulation EU No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers. Official Journal of the European Union

27. Alves-Rodrigues A, Shao A (2004) The science behind lutein. Toxicol Lett 150:57–83. https://doi.org/10.1016/j.toxlet.2003.10. 031

28. LiXM,Yang PL (2018) Research progress of Sonchus species. Int J Food Prop 21:162–172. https://doi.org/10.1080/10942912.2017.1415931

29. Adadi P, Barakova NV, Krivoshapkina EF (2018) Selected methods of extracting carotenoids, characterization, and health concerns: a review. J Agric Food Chem 66:5925–5947. https://doi.org/ 10.1021/acs.jafc.8b01407

30. Fratianni A, Mignogna R, Niro S, Panfili G (2015) Determination of lutein from fruit and vegetables through an alkaline hydrolysis extraction method and HPLC analysis. J Food Sci 80:2686–2691. https://doi.org/10.1111/1750-3841.13122

31. Walsh RP, Bartlett H, Eperjesi F (2015) Variation in carotenoid content of kale and other vegetables: a review of pre- and postharvest effects. J Agric Food Chem 63:9677–9682. https://doi. org/10.1021/acs.jafc.5b03691

32. Žnidarčič D, Ban D, Šircelj H (2011) Carotenoid and chlorophyll composition of commonly consumed leafy vegetables in Mediterranean countries. Food Chem 129:1164–1168.https://doi. org/10.1016/j.foodchem.2011.05.097

33. Knecht K, Sandfuchs K, Kulling SE, Bunzel D (2015) Tocopherol and tocotrienol analysis in raw and cooked vegetables: a validated method with emphasis on sample preparation. Food Chem 169:20–27. https://doi.org/10.1016/j.foodchem.2014.07.099

34. Conforti F, Marrelli M, Colica C,Menichini F, Perri V, Uzunov D, Statti GA, Duez P, Menichini F (2011) Bioactive phytonutrients(omega fatty acids, tocopherols, polyphenols), in vitro inhibitionof nitric oxide production and free radical scavenging activity ofnon-cultivated Mediterranean vegetables. Food Chem 129:1413–1419. https://doi.org/10.1016/j.foodchem.2011.05.085

35. del Carmen M-PA, Vázquez-Odériz L, Romero-Rodríguez MÁ (2011) Development and validation of an HPLC method for the determination of thiamine and riboflavin in green leafy vegetables using clara-diastase. J Food Sci 76:C639–C642. https://doi.org/10. 1111/j.1750-3841.2011.02151.x

RESULTS AND DISCUSSION

8.2. Bioactive compounds in *Blitum bonus- henricus, Tragopogon porrifolius*

The species *Blitum bonus henricus* and *Tragopogon porrifolius* were analysed for their content in carotenoids and tocols; the carotenoids, with an important presence of the xanthophyll fraction (violaxanthin, neoxanthin, lutein, zeaxanthin, β-cryptotoxanthin) and two carotenes (α-carotene and β-carotene and its isomers 9cis-βcarotene, 13cis-β-carotene).Table 7 shows the amounts of carotenoids of the samples analyzed, as far as *Blitum bonus-henricus* data refer to the average of the two annuities as they do not show significant differences.The total carotenoid content (mg / 100 g dry weight d.w.) varies significantly from 97.2 mg / 100g in *Blitum bonus henricus* to 132.4 mg /100g in *Tragopogon porrifolius. T*en carotenoid compounds were detected in the two species studied, in *Blitum bonus henricus* the main compounds are lutein and violaxanthin which represent respectively 31% of the total carotenoid compounds, this data is also confirmed by (Hanganu et al., 2012), while in Tragopogon porrifolius lutein and violaxanthin represent respectively 28% and 26% of total carotenoids. (For *Tragopogon porrifolius*, no carotenoid content studies are available in the literature.) The variability of carotenoid content (expressed by variability coefficient, CV%) shows a high level in most carotenoids. This variability may be due to the harvest period and growing conditions. *Tragopogon porrifolius* roots do not show carotenoids. Table 7 also shows the values of vitamin A, expressed as Retinol Equivalent (R.E.) (g / 100 g fresh weight of the product, f.w.) (EFSA, 2015). Taking into account the recommended daily intake (RDA) for vitamin A, which is 800 (g / day (EU Regulation no. 1169/2011), 100 g of leaves contribute from 44% of the RDA to *Blitum bonus-henricus* to 104% in *Tragopogon porrifolius*, therefore, in both species, the leaves can be declared "source of vitamin A".The tocopherol content is presented in Table 8.The main tocopherol was α-tocopherol which was detected in all species studied and provides about 82% of the total tocopherols in *Blitum bonus henricus* to about 97% in *Tragopogon porrifolius*.β-tocopherol was only detected for Tragopogon porrifolius for about 1%. *g* -tocopherols represented about 17.9% of total tocopherols in *Blitum*, while in *Tragopogon porrifolius* it represented about 3.45%. Table 8 also gives the values of vitamin E activity, expressed as Tocopherol Equivalent (T.E.) (mg / 100 g fresh weight of the product, f.w.) (Sheppard et al., 1993). Taking into account the recommended daily intake (RDA) for vitamin E, which is 12 mg / day (EU Regulation. No. 1169/2011), 100 g *Blitum bonus-henricus* contribute to about 20% of the RDA, whileTragopogon porrifolius (leaves) contributes to 75% of the RDA*Tragopogon* *porrifolius* roots contribute 10% of the RDA. All leafy plants can be declared "source of vitamin E".

Table7. Carotenoid composition in 2 alimurgical species (mg/100g d.w.).

	Blitum bonus henricus	**% tot**	***Tragopogon porrifolius (leaves)***	**% tot**
violaxanthin	30.7 (3.0)	31	34.9 (5.4)	26
neoxanthin	11.1 (6,0)	11	13.7 (14.2)	10
lutein	30.6 (4.0)	31	37.5 (8.9)	28
zeaxanthin	4.3 (13.0)	4	10.4 (16.6)	8
β-criptoxanthin	0.4 (20.0)	0.4	0.7 (1.1)	0.5
α-carotene	2.2 (39.0)	2	4.0 (3.5)	3
13-cis-β-carotene	0.41 (12.0)	0.4	0.5 (10.5)	0.4
β-carotene	14.0 (5.0)	14	24.7 (9.5)	18
9-cis-β-carotene	3.5 (31.0)	4	6.1 (13.5)	5
Total carotenoids	97.2 (2.0)		132.4 (5.5)	
R.E.* (µg/100 g f.w.)	353.0		832.4	

a: coefficient of variability * R.E. Retinol equivalent

Table 8. Tocol composition in 2 alimurgical species (mg/100g d.w.)

	Blitum bonus henricus	**% tot**	***Tragopogon porrifolius* (leaves)**	**% tot**	***Tragopogon porrifolius* (roots)**	**% tot**
α-tocopherol	19 (3.0)	82.1	53.6 (1.97)	97.4	5.4 (8.8)	92.8
g-tocopherol	4.1 (19.8)	17.9	1.0 (22.0)	1.8	0.3 (5.3)	5.1
Total tocopherol	23.1 (10.0)		54.6 (15.0)		5.7 (20.0)	
T.E. (mg/100 g f.w.)	2.8 (0.2)		9.0 (0.6)		1.2 (5.0)	

a: coefficient of variability; b: Not detectable; T.E.: Tocopherol equivalent

8.3 CONCLUSIONS

The data produced by the analysis of *Tragopogon porrifolius* and *Blitum bonus-henricus*, have shown that the two species have been found rich sources of carotenoids and tocols, such as to promote future investigations that go to deepen the health aspects of these taxa.The first results showed no significant differences between the different years of collection for *Blitum bonus-henricus,* while for *Tragopogon porrifolius* it was not possible to evaluate the differences obtained from different years of collection.Therefore, it is essential to carry out new research in the future to better investigate the different variations in composition due to the vegetative stage, climatic variations, and harvest season, as well as the presence of other bioactive compounds.

CHAPTER IX

9.1 COOKING EFFECTS

Carotenoid evaluation

Table 9 shows the quantities of carotenoids in the samples analysed. In both Sonchus species, the main representatives of carotenoids are violaxanthin, neoxanthin, lutein, and β-carotene. In particular, in fresh samples of *Sonchus oleraceus* and *Sonchus asper*, violaxanthin varied respectively from about 77-43 mg / 100 g dm, while lutein from about 46 mg / 100 g dm in S. oleraceus to about 28, mg / 100 g dm in S. asper. While β -carotene from about 30 mg / 100 g d.m. in S. oleraceus, at 20.8 mg / 100 g d.m. in *S. asper*. These data have been confirmed by other literature studies on the species Sonchus Panfili et al., 2020, Sanchez-Mata 2012.Different trends can be observed during cooking. Epoxicarotenoids (violaxanthin and neoxanthin) are the most sensitive to thermal treatments, as observed by (Melèndez-Martínez, Britton, Vicar, & Heredia, 2008, Fratianni et al., 2010; Fratianni et al., 2013b), then subjected to steam process decrease. While lutein and β-carotene show different trends, these appear to increase in some cases or remain unchanged in others. The effect of home cooking on fat-soluble compounds studied is controversial. (Friedman, 2015; Nayak, Liu, and Tang, 2015) In order to investigate the results of the effects of home cooking treatments on carotenoids, further tests will be carried out. While Table 10 shows that among the tocols there are only α-tocopherol (α-T) from 15.9 mg / 100 g dm in the species Sonchus oleraceus to 25.5 mg / 100 g dm in Sonchus asper; while γ–tocopherol (γ–T) are present from 3.1 mg / 100 g dm in *S. oleraceus* to 5.0 mg / 100 g dm in S. asper. The references for tocols in the species studied are in agreement with those reported by several authors, for *Sonchus* (Panfili et al., 2020, Sánchez-Mata et al., 2012). Therefore, we can conclude that for both Table 9 carotenoids and Table 10 tocols a significant overall increase (mg/100g dm) of all compounds can be observed for the two fresh species after boiling.

Table 9. Composition of carotenoids in 2 alimurgic species analyzed fresh and after cooking (mg/100g d.m).

Carotenoids	Treatment	*S. oleraceus*	*S. asper*
Violaxantina	fresh	77,0 [a]	43,0 [a]
	boiling	71,4 [a]	28,9 [b]
	steaming	54,8 [b]	8,9 [c]
Neoxantina	fresh	31,0 [a]	11,9 [a]
	boiling	32,9[a]	14,6 [a]
	steaming	6,3[b]	1,9 [b]
Lutein	fresh	46,0[a]	28,2 [a]
	boiling	75,1[b]	42,2 [b]
	steaming	59,9[b]	23,3 [a]
Zeaxantina	fresh	4,5 [a]	4,3 [a]
	boiling	5,8 [b]	4,2 [a]
	steaming	6,2[b]	2,2[b]
α- carotene	fresh	4,7[a]	4,6[a]
	boiling	4,3[a]	5,9[a]
	steaming	4,2[a]	3,0[b]
13cis-β–carotene	fresh	1,3[a]	0,9[a]
	boiling	2,0[a]	0,7[a]
	steaming	1,7[a]	0,4[a]
β-Carotene	fresh	30,0 [a]	20,8 [a]
	boiling	54,0[b]	30,8 [b]
	steaming	45,2 [b]	16,9 [a]
9cis-β–carotene	fresh	6,1[a]	8,2[a]
	boiling	9,4[b]	10,9[b]
	steaming	9,3[b]	5,4[a]
Total carotenoids	fresh	112,5[a]	125,0 [a]
	boiling	105,3 [b]	142,5 [a]
	steaming	96,8[a]	63,3[b]

Different letters among the same column, for each carotenoids indicate a statistically significant difference at $p < 0.05$.

Table10. Content of the main tocols in 2 alimurgic species studied before and after cooking (mg / 100 g d.m.).

Tocols	Treatment	S. oleraceus	S. asper
α-tocoferolo	fresh	15,9 ^{a}	25,5^{a}
	boiling	30,6^{b}	31,8^{b}
	steaming	20,3^{b}	27,0^{a}
γ-tocoferolo	fresh	3,1 ^{a}	5,0^{a}
	boiling	7,6^{b}	4,7^{a}
	steaming	2,8^{a}	3,9^{b}
Tocoli totali	fresh	18,0^{a}	30,5^{a}
	boiling	38,2^{b}	36,5^{b}
	steaming	23,1^{a}	30,9^{a}

Different letters among the same column, for each carotenoids indicate a statistically significant difference at $p < 0.05$.

9.2 CONCLUSIONS

The preliminary data emerging from this research show that, in order to have reliable data on the effect on internal processing on fat-soluble pigments, further tests will be necessary in order to improve the knowledge of a subject not yet well studied.

CHAPTER X

10.1 CONCLUSIONS

The study of wild edible plants, the subject of this paper, developed from the creation of the WEP Database for Italyand was later connected to functional functions of five species commonly used within the Italian alimurgic tradition.

Interesting topics for discussion have emerged from the overall results.

As we have seen, Italy has a huge gastronomic heritage dependent on the structure of its territories, the climate and the social cultural heritage which distinguishes it. In this context, we find the considerable floristic variety of wild edible plants (1103 entities) included in the AlimurgITA database which represent 13.09% of the Italian flora, used in the gastronomic tradition. The high frequency of edible Asteraceae, accounting for 20.22% of total WEPs, is apparently associated with the high number of taxa in Italian flora, to their palatability which is combined with their large availability in several seasons. The regional distribution of WEPs is far from homogeneous, ranging from a minimum of 86 taxa recorded in Trentino-Alto Adige to the maximum of Apulia, with 569 taxa Over time the consumption of wild vegetables has undergone great changes with the advent of industrialization and the abandonment of cultivated lands and pastures, which have however survived in some limited areas of the Peninsula, as evidence of a still vital agricultural and shepherding heritage. From the analysis of the percentage results on a national scale, the use of alimurgic flora amounted to 7.6% compared to the potential value, this data, representative of the average value for Italy, has been calculated from the ratio of the recorded edible plants by region to the species potentially present; as regards the regional flora, WEPs represent 2.73% in Trentino Alto-Adige and 22.69% in Puglia. As for the southern regions and the major islands, the values are higher, testifying to ethnobotanical research anchored to traditional cultural heritage still present, and therefore detectable. This is the case of some conservative cultural sites, where there is a historical-ethnic link, still known, with the countries of the eastern Adriatic (Greece, Albania, Croatia) (Pieroni, A.; Quave, C.L., 2006). As an example in the Greek communities in Calabria, more than half of the harvested plant species (58%) are also used as food plants in Greece, (Nebel and Heinrich, 2010). The strong and rooted link with the traditions of its territory is underlined by the evidence that in Puglia, Sicily and Sardinia, as well as in other Mediterranean countries, the usual consumption of Weps is still very much preserved thanks to the maintenance of the traditional market system, in which people can find, on the counter, fresh wild vegetables (Geraci et al. 2018). However, edible plant species yield more than just food and income; in the communities which traditionally use wild food, the bond with the land is strong and vivid. (Pilgrim et al., 2008).

Sadly, it should be noted that the habit of harvesting and cooking uneducated edible plants, is still alive among the older generations, is almost entirely neglected in recent generations reflecting a link with their land increasingly feeble. (Nebel e Heinrich 2010). The decline of traditional lifestyles and the decrease in the use of wild food are therefore intricately connected. (Pilgrim et al., op cit). On the other hand, the tendency to give up using WEPs is counterbalanced by a widespread phenomenon linked to a “desire for Nature” and to neo-rurality, which have become more than a fleeting trend of our times. As a matter of fact, in the last few years, there has been a transfer of ethnobotanic knowledge, not among individuals within the same culture but rather from one society to another, prevalently made up of experts and enthusiasts. (Foragers).

Therefore, in recent years a new scenario has been opened on the use of alimurgic species also on aspects not evaluated on functional qualities, focusing on the growing interest of alimurgic species as nutraceuticals.

The studies carried out in this paper have further confirmed the remarkable functional properties observed in five alimurgic species. (*Sonchus oleraceus* L. *Soncus asper* L., *Crepis vesicaria* L., *Blitum bonus- henricus*. L., *Tragopogon porrifolius* L.).

WEPs are, in fact, unanimously acknowledged as being rich in nutrients, often contained in lesser quantity in cultivated species, selected mainly for their high production yield. (Geraci et al., op. cit.). All the plants analyzed have a good content in carotenoids and tocols, as for carotenoids all the species studied show an important presence of the fraction related to xanthophylls (violaxanthin, neoxanthin, lutein, zeaxanthin, β-cryptotoxanthin) and two carotenes (α-carotene and β-carotene and its isomers 9cis-βcarotene, 13cis-β-carotene). In the tocol composition α-tocopherol is the predominant compound in all species, while other tocol isomers are present in different contents in the various species analysed. In particular as regards the carotenoid content, according to Regulation (EU) no 1924/2006 all plants can be considered "high in vitamin A" since 100 g provide more than 30% of the RDA, and "source of vitamin E" Since 100 g of plants cover 15% of the RDA according to Regulation (EU) No 1169/2011. As for the content in thiamine and riboflavin, all the species analyzed have a good content in thiamine, in particular the species Crepis vesicaria can be considered "source of thiamine", while they are secondary for the content in riboflavin. Furthermore, the WEPs investigated have shown that the latter are considered rich sources of fiber since, by eating a 200 g. serving, adults take dietary fiber from adults for about 46% of their recommended daily dose, far exceeding 25 g. / day recommended (LARN, 2014). Moreover, the wild edible plants studied can be claimed as " vitamin A source "and “vitamin E source". The data which emerged from the analysis of the two cooked *Sonchus*species show that, when assessing solid loss, boiling had not significantly influenced the main carotenoids and tocols in the studied vegetables, whereas steam cooking had had a small effect on their quantity. Further experiments are necessary to investigate the nature of the solids dissolved in the cooking water, also compared to other vegetables with a different tissue structure.

These data raise the hope that further studies will favor a deeper knowledge about their health potential. Also, the data produced by this study can give a useful contribution to databases on nutritional composition and the content in bioactive compounds of these species and can also help promote the use of these overlooked underused resources.

Recent scientific progress, such as the development of metabolomics, provide the scientists with new tools to carry out accurate assessments of the potential value of genetic resources.

With these tools, WEP nutritional and antinutritional elements can be typified in order to evaluate their safety for human and animal consumption. These assessment studies would lead to a greater use of WEPsfor human nutrition and healthcare, meeting consumers' demand and, at the same time supplying new job opportunities.

Until now, scientific interest has almost totally ignored the environmental effects on the nutritional and nutraceutical content of plants; they should also be assessed with respect to the different growth conditions in order to determine whether the passage from in situ cultivation to farm cultivation alters the qualities of WEPs.

In addition, collaboration with culinary schools could lead to the production of new vegetable-based foods using WEPs.

The value of alimurgic species is not limited to the ethnobotany- functional properties duo so far analyzed, but it should be explored and connected to several interdisciplinary relationships (e.g. ecological, agroecological, health-genetic etc.) which should involve a number of professionals (e.g. agriculturists, botanists, agronomists ecologists, ethnobiologists, biochemists, nutritionists, immunologists, microbiologist, chemists, anthropologists, stakeholder associations, culinary schools (for taste education and food creation), farmer associations and rural communities) in order to develop an approach, which should be participatory and systemic to WEP promotion and use. To make this happen, it is necessary to make a collaborative effort to establish a significant commitment between different disciplines and between scientists and society, thus encouraging pondering knowledge, practices and values and generating a positive fallout on society at large.

The picture that is emerging, which we may define as the new paradigm for WEPs, is therefore a complex one, full of opportunities and challenges; a synthetic analysis will be provided hereafter.

First of all, considering the study carried out and in progress, priority should be given to the most interesting WEPs with respect to traditional knowledge and to their uses in local cuisine. Practically, it appears necessary to intensify in situ survey and mapping of WEP species to fill the gaps in data regarding distribution, wealth, state of preservation and harvest. The results of the Italian WEPs database, has, in fact, pointed out that in several Italian regions (e.g. Trentino Alto-Adige, Umbria) the level of knowledge is poor, in relation to the findings available for other areas of ethnobotanic knowledge.

These knowledge gaining activities should also be accompanied by appropriate surveys aiming at regarding WEPs as *ex situ*genetic reserves, ideally kept by universities or other bodies focused on 1) implementing/expanding germplasm bank collections and 2) devising an online database platform to supplement the data already collected with further data pertaining to other WEPs information fields.

As seen in the introduction of this paper, alimurgic plants are a reservoir of genetic variability with a significant potential to improve crop production and biological diversity at farm and landscape level. WEPs should be acknowledged as having an important role in ecosystem-based services and therefore deserve greater attention at a political level.

Nowadays, when the great issue of climate change requires ready efficient answers, alimurgic plants may represent a favorable condition to implement a more sustainable agriculture, considering their typical rusticity.The adaptability and value of wild plants enable them to grow, bloom and fructify without energetic support (watering, use of fertilizers or phytosanitary products); this entails a significant decrease of costs and management resources and leads the production process to have a lesser impact on the environment.(Bretzel 2006).

Governments could (and should) be encouraged to promote WEP culture in sustainable cropping systems, and to helprevive and protect neglected, though ecologically rich, spaces at the edge of farmlands, thus reviving a market for these local WEPs.

In the field of Common Agricultural Policy (CAP) 2014-2020 ("Green payment") the initiatives sponsored by the national government can help farmers gain skills to carry out their new missions through the promotion of participative conservation and of the empirical selection of WEPs by farmers. For example, starting from 2015 any UE farmer applying for direct payment and owning over 15 hectares of arable land must have at least 5% of his arable land occupied by "areas of ecological interest ".

These areas are therefore destined to bring about environmental benefits, improve biodiversity and keep landscapes ecologically functional, as well as to preserve their specific attractiveness; as such, they are ideal sites for WEP conservation and selection.

Consider, for example, underprivileged mountain areas, particularly suitable for productive recovery and the rehabilitation of marginal lands, as well as for the enhancement of local resources (MIPAAF 2014-2016).

Among the future prospects, the cultivation of WEPs as horticultural plants will renew the vigor of sustainable agriculture and, at the same time, it will make it possible to avoid too strong a pressure on the natural biodiversity of the territory, minimizing the collection of plant essences in the wild.

The environmental effects on the nutritional and nutraceutical content of the plants should be assessed with respect to the different growth conditions, so as to establish whether the passage from in situ cultivation to farm cultivation alters WEP quality.

From the human nutrition point of view, it is important to assess the nutrigenomic effects (vegetable extracts) of the wide range of WEP bioactive compounds with respect to elements considered focal for health, (the so-called "big killers") associated to three great factors: cardiovascular (heart diseases, ischemia, stroke), cancerand respiratory (pulmonary disease, chronic obstructive pulmonary disease, lower respiratory tract infections).

In Italy, for instance, in 2019 cardiovascular diseases have been the main death cause, accounting for 34.8% of total deaths. With 29% of deaths (Istat 2016 data) cancer is the second death cause in our country while respiratory system diseases come third, at 8.5%.

It is encouraging to witness the gradual interest of biomedical scientific research for the curative power of these foods. This is a modern translation with scientific evidence, of the intuition attributed to the Greek physician Hippocrates of Kos and expressed in the famous quote: “Let medicine be your food and let your food be your medicine”. For example, only, here follow some instances of recent scientific surveys; although carried out on extraordinarily common alimurgic plants, they have produced some surprising results.

Molecules has recently published a study ( ) which claims the remarkable epigenetic capacity of silibinin and of the Phyto complex of *Silybum marianum* (milk thistle) to inhibit prostate tumoral cells. A team of Spanish scholars has brought to light how two principles contained in rosemary (carnosic acid and carnosol) manage to perform, synergically, through an epigenetic mechanism, an efficient check of colon and pancreatic cancers. (González-Vallinas, et al 2014). In 2017 a team of Japanese researchers has published in “Lipids in Health and Disease”, the surprising results of a study carried out on 306 patients; it highlighted the positive effects of the regular consumption of the oil obtained from the seeds of borage (*Borago officinalis*) (Ouchi, et al 2017) on the prevention of cardiovascular diseases. That oregano (*Origanum vulgare*) possessed antiseptic properties was already known by Hippocrates himself, but a study carried out in 2018revealed the power of its essential oil againstmethicillin-resistant *Staphylococcus aureus,* which has become resistant to beta-lactam antibiotics, including penicillin. (Lu, et al. 2018).

Not to forget the wide range of bioactive compounds typical of WEPsthat could be further tested as feed components to improve animals ‘health, thus helping limit the use of antibiotics, hereby improving product quality. Here too, popular tradition can supply useful suggestions: *Urtica dioica*, for example, has been, and still is, used to make poultry tastier and give their meat and eggs a more appealing color.

As well as supplying the means to express belonging to a territory, WEPs adaptability can also be an opportunity of local concerns to make profits. (Pieroni et al., 2005).

To date, in a society in which food is no longer mere “foodstuff” but also “nourishment” (as shown by the thriving market for supplements). alimurgic plants could secure an interesting market niche within the range of products endowed with functional characteristics.

However larger scale WEP marketing cannot ignore:

- Statistics; to date they are quite deficient both in market demand and offer (quantity actually harvested);

- Profiling methods and sensorial mapping, crucial to study how the selected plants are perceived and described by consumers.

Thus, wild edible plants can represent, for our country, a strategic resource, a point of strength to which a number of positive values can be associated: ecological nutritional, socio-cultural and agri-food (MIPAAF 2014-2016). According to FAO by 2050, the world will have to produce twice the food produced at the beginning of the century. However, the shrinking of available arable land, beside climate changes, will present a new challenge for farmers in years to come (FAO, 2010) and wild plants will turn out to be a precious extra food source for the present and future generations (Pasta et al. 2011).

BIBLIOGRAPHY

Aberoumand, A. (2009) Nutritional evaluation of edible Portulaca oleracia as plant food. Food Analyt. Meth. 2, 204–207. (doi:10.1007/s12161-008-9049-9)

Aberoumand, A.; Deokule, S.S. (2009). Determination of elements profile of some wild edibleplants. Food Anal.Methods 2, 116–119.

Albuquerque, B. R.; Prieto, M. A.; Vázquez, J. A.; Barreiro, M. F.; Barros, L.; & Ferreira, I. C. (2018) Recovery of bioactive compounds from Arbutus unedo L. fruits: Comparative optimization study of maceration/microwave/ultrasound extraction techniques. Food Research International, 109, 455-471.

Aggarwal, B B.; Sundaram, C.; Prasad, S.; Kannappan R. (2010). Tocotrienols, the vitamin E of the 21st century: Its potential against cancer and other chronic diseases. Biochemical Pharmacology 80,1613–1631

Allebone-Webb, S. M. (2009) Evaluating dependence on wildlife products in rural Equatorial Guinea. PhD thesis, London, UK: Imperial College.

Al Akeel, R.; Al-Sheikh, Y.; Mateen, A.; Syed, R.; Janardhan, K.; e Gupta, VC. (2014). Valutazione dell'attività antibatterica di estratti di proteine grezze da semi di sei diverse piante medicinali contro ceppi batterici standard. Giornale saudita di scienze biologiche, 21 (2), 147-151.

Amirul Alam, M.; Juraimi, A.S.; Rafii, M.Y.; Hamid, A.A.; Kamal Uddin, M.; Alam, M.Z.; Latif, M.A. (2014). Genetic improvement of purslane (Portulaca oleracea L.) and its future prospects. Mol. Biol. Rep. 41, 7395–7411.

Akram, B.; Javed, M. (2014). Disturbi alimentari tra gli studenti universitari: prevalenza e differenza di genere. Asian Journal of Research in Social Sciences and Humanities, 4 (6), 66-75.

Akram, M.; Hamid, A.; Khalil, A.; Ghaffar, A.; Tayyaba, N.; Saeed, A.; & Naveed, A. (2014). Rassegna sugli usi medicinali, farmacologici, fitochimici e sull'attività immunomodulante delle piante. *Rivista internazionale di immunopatologia e farmacologia*, *27* (3), 313-319.

Anestopoulos, I., Sfakianos, A. P., Franco, R., Chlichlia, K., Panayiotidis, M. I., Kroll, D. J., & Pappa, A. (2017). A novel role of silibinin as a putative epigenetic modulator in human prostate carcinoma. Molecules, 22(1), 62.

AOAC, (1995). Total, Insoluble and Soluble Dietary Fiber in Food-Enzymatic-Gravimetric Method (Method 991.43) MESTRIS Buffer. Official Methods of Analysis. 16th Ed. AOAC International, Gaithersburg, MD.

AOAC, (2000). "Official Methods of Analysis" 17th Ed. Association of Official Analytical Chemists, Washington, DCa.

Appi, E.; Appi, R.; Pagnucco, A.; Pagnucco, D. (1979) Le piante nell'uso popolare in Friuli. Terapia e Cucina Ed. Concordia Sette, Pordenone pp 120.

Arcidiacono S. (2016). Etnobotanica Etnea - Le piante selvatiche e l'uomo. Editrice Danauspp.150

Arietti, N. (1941) La nostra flora nell'economia domestica. Brescia: La scuola.

Arm, J. P.; Boyce, J. A.; Wang, L.; Chhay, H.; Zahid, M.; Patil, V.; ... & Chilton, F. H. (2013) Impact of botanical oils on polyunsaturated fatty acid metabolism and leukotriene generation in mild asthmatics. Lipids in health and disease, 12(1), 1-11.

Atzei, A.D. (2003) Le piante nella tradizione popolare della Sardegna C. Delfino Ed., Sassari pp.596

Azzetti, A. (2013) Edible wild plants-Fitoalimurgia, Berbenno (SO), 2013, p.3, materiale tratto dal sito www.othilia.it consultato il 29 maggio 2017.

Asprilla-Perea, J.; Díaz-Puente, J.M. (2019) mportance of wild foods to household food security in tropical forest areas. Food Secur. 2019, 11, 15–22.

Bâ, A. (2008) *Metabolic and structural role of thiamine in nervous tissues*. Cell. Mol. Neurobiol., 28, 923–931.

Ball, GFM. (2005) Vitamins in foods: analysis, bioavailability, and stability. CRC Press, USA

Bacchetta, L.; Visioli, F.; Cappelli, G. et al., (2016) A manifesto for the valorization of wild edible plant. Journal of Ethnopharmacology, 191, 180–187.

Barbosa, A. P. D. O.; Silveira, G. D. O.; de Menezes, I. A. C.; Rezende Neto, J. M.; Bitencurt, J. L. C.; Estavam, C. D. S.; ... & dos Santos, M. R. V. (2013) Antidiabetic effect of the Chrysobalanus icaco L. aqueous extract in rats. *Journal of medicinal food*, *16*(6), 538-543.

Bartolucci, F.; Peruzzi, L.; Galasso, G.; Albano, A.; Alessandrini, A.; Ardenghi, N.M.G.; Astuti, G.; Bacchetta, G.; Ballelli, S.; Banfi, E.; et al. An updated checklist of the vascular flora native to Italy. Plant Biosyst. (2018), 152, 179–303. [CrossRef]

Belcher, B.; Ruíz-Pérez, M.; Achdiawan, R. (2005) Global patterns and trends in the use and management of commercial NTFPs: Implications for livelihoods and conservation. World Dev. 2005, 33, 1435–1452.

Backes, E.; Pereira, C.; Barros, L.; Prieto, M. A.; Genena, A. K.; Barreiro, M. F.; & Ferreira, I. C. (2018) Recovery of bioactive anthocyanin pigments from Ficus carica L. peel by heat, microwave, and ultrasound based extraction techniques. *Food Research International*, *113*, 197-209.

Bellagamba, A. (1997) alimentazione in Remotti F., Fabietti U. (1997) (a cura di) Dizionario di Antropologia, Bologna, Zanichelli 1997, pp. 30-31

Béné, C. (2020) Resilience of local food systems and links to food security—A review of some important concepts in the context of COVID-19 and other shocks. Food Secur. 2020.

Bentreud, A. (1977) Vitamin losses during thermal processing. In: Hoyem T, Kvale O (eds.). Physical, chemical and biological changes in food caused by thermal processing. Applied Science Publishers Limited, London, UK. 185 pp

Bharucha, Z.; Pretty, J. (2010) The roles and values of wild foods in agricultural systems. Philos. Trans. R. Soc. B Biol. Sci. 2010, 365, 2913–2926.

Bianco, V.; Mariani, R.; Santamaria, P. (2009) *Piante Spontanee Nella Cucina Tradizionale Molese. Storie, Curiosità e Ricette*; Edizioni Levante: Bari, Italy, 2009

Biscotti, N.; Bonsanto, D.; & Del Viscio, G. (2018) The traditional food use of wild vegetables in Apulia (Italy) in the light of Italian ethnobotanical literature. Italian Botanist, 5, 1.

Bonet, MÀ.; Vallès, J. (2002) Use of non-crop food vascular plants in Montseny biosphere reserve (Catalonia, Iberian Peninsula). Int J Food Sci Nutr. 2002;53(3):225–248. http://dx.doi.org/10.1080/09637480220132841

Bondonno, C.P.; Croft, K.D.; Ward, N.; Considine, M.J.; Hodgson, J.M. (2015) Dietary Flavonoids and nitrate: effects on nitric oxide and vascular function. Nutr.Rev. 73,216–235.

Bretzel, F.; & Calderisi, M. (2006) Metal contamination in urban soils of coastal Tuscany (Italy). *Environmental Monitoring and Assessment*, *118*(1), 319-335.

Broegaard, R.B.; Rasmussen, L.V.; Dawson, N.; Mertz, O.; Vongvisouk, T.; Grogan, K. (2017) Wild food collection and nutrition under commercial agriculture expansion in agriculture-forest landscapes. For. Policy Econ. 2017.

Camangi, F.; Stefani, A.; Lippi, A; Tomei, P.E. (2007) Piante selvatiche d'uso alimentare nella tradizione popolare della Garfagnana “erbe buone ed erbe cattive”. Studio d'Arte fotografica Comunita Montana della Garfagnana pag.94

Camara, G.; Soterroni, A.; Ramos, F.; Carvalho, A.; Andrade, P.; Souza, R. S.; & Bocqueho, G. (2016) Modelling Land Use Change in Brazil: 2000-2050 (Dataset).

Camarda, I.; Carta, L.; Vacca, G; e Brunu, A. (2017) Les plantes alimentaires de la Sardaigne: un patrimoine ethnobotanique et culturel d'ancienne origine. Flora Mediterranea, 27, 77-90.

Caneva, G.; & Cutini, M. (2009) Flora, vegetazione e tradizioni etnobotaniche di Maratea. Flora, vegetazione e tradizioni etnobotaniche di Maratea, 1-175.

Caneva, G.; Pieroni, A.; Guarrera, P.M. (2013) "Etnobotanica. Conservazione di un patrimonio culturale come risorsa per uno sviluppo sostenibile", CUEBC - Studio, Tutela e Fruizione dei Beni Culturali 4, Edipuglia 2013

Cappelli, A.; Cini, E. (2020) Will the COVID-19 pandemic make us reconsider the relevance of short food supply chains and local productions? Trends Food Sci. Technol. 2020, 99, 566–567.

Cao, G.; Alessio, HM.; e Cutler, RG. (1993) Oxygen radical absorbance capacity assay for antioxidants. Free Radic Biol Med 14: 303–311, Federal Register, 1997. Part V, Department of Health and Human Services, Food and Drug Administration

Carvalho, AM.; Morales R. (2010) Persistence of wild food and wild medicinal plant knowledge in a northeastern region of Portugal. In: Pardo-de-Santayana M, Pieroni A, Puri RK, editors. Ethnobotany in the new Europe: people, health, and wild plant resources. New York NY: Berghahn Books; 2010. p. 147–171.

Carvalho, A.M.; Barata, A.M. (2016) The Consumption of Wild Edible Plants. In Wild Plants, Mushrooms and Nuts; John Wiley & Sons, Ltd.: Chichester, UK, 2016; pp. 159–198

Cassandra, L. Q.; Pieroni A., (2015) “*A reservoir of ethnobotanical knowledge informs resilient food security and health strategies in the Balkans.*” - Nature Plants: 14021.

Castelletti, L.; Castiglioni, E.; e Rottoli, M. (2001) L'agricoltura dell'Italia Settentrionale dal Neolitico al Medioevo. In Le piante coltivate e la loro storia. Milano: Franco Angeli Ed.

Christanell, A.; Vogl-Lukasser, B.; Vogl, CR.; Gütler, M. (2010) The cultural significance of wild gathered plant species in Kartitsch (eastern Tyrol, Austria) and the influence of socio-economic changes on local gathering practices. In: Pardo-De-Santayana M, Pieroni A, Puri RK, editors. Ethnobotany in the new Europe: people, health, and wild plant resources. New York NY: Berghahn Books; 2010. p. 51–75.

Chang, S.K.; Prasad, N.K.; Amin, I. (2013) Carotenoids retention in leafy vegetables based on cooking methods. Int. Food Res. J. 20, 457–465.

Chiva-Blanch, G.; e Visioli, F. (2012) Polifenoli e salute: andare oltre gli antiossidanti. Journal of Berry Research, 2 (2), 63-71.

Clydesdale, FM.; Ho, CT.; Lee, CY. et al., (1991) The effects of postharvest treatment and chemical interactions on the bioavailability of ascorbic acid, thiamin, vitamin A, carotenoids, and minerals. Critical Reviews in Food Science and Nutrition, 30, 599–638.

Coassini Lokar, L.; Poldini, L.; Angeloni Rossi G. (1983) Appunti di etnobotanica del Friuli-Venezia Giulia. Gortania n. 4, 101-151.

Corsi, G.; & Pagni, A.M. (1978) Studi sulla flora e vegetazione del Monte Pisano (Toscana nord-occidentale). 1. Le piante della medicina popolare nel versante pisano. Webbia, 33(1), 159-204.

Couplan, F. (1995) Les plantes sauvages comestibles, 2nd edn. Paris: Editions Sang de la Terre.

Couplan, F. (2009) "Les plantes sauvages comestibles." Sang de la Tere, Paris.

Damodaran, S.; Parkin, KL.; e Fennema, OR. (2007) Fennema's Food Chemistry. CRC Press, USA.

de Cortes Sánchez-Mata, M.; & Tardío, J. (Eds.). (2016) Mediterranean wild edible plants: ethnobotany and food composition tables. Springer

dos Reis, L.C.R.; de Oliveira, V.R.; Hagen, M.E.K.; Jablonski, A.; Flˆores, S.H.; de Oliveira Rios, A. (2015b) Effect of cooking on the concentration of bioactive compounds in broccoli (Brassica oleracea var. Avenger) and cauliflower (Brassica oleracea var. Alphina F1) grown in an organic system. Food Chem. 172, 770–777.

de Merode, E.; Homewood, K.; & Cowlishaw, G. (2003) The value of bushmeat and other wild foods to rural households living in extreme poverty in DR Congo. Biol. Conserv. 118, 573–581.

Della, A.; Paraskeva-Hadjichambi, D.; Hadjichambis, AC. (2006) An ethnobotanical survey of wild edible plants of Paphos and Larnaca countryside of Cyprus. J Ethnobiol Ethnomed. 2006; 2:34. http://dx.doi. org/10.1186/1746-4269-2-34

Dempewolf, H.; Eastwood, R.J.; Guarino, L.; Khoury, C.K.; Müller, J.V.; Toll, J. (2014) Adapting agriculture to climate change: a global initiative to collect, conserve, and use crop wild relatives. Agroecol. Sustain. Food Syst. 38,369–377.

D'Evoli, L.; Tufi, S.; Gabrielli, P.; Lucarini, M.; Lombardi-Boccia, G. (2013) *Analisi simultanea delle isoforme della vitamina E in campioni alimentari tramite cromatografia liquida-spettrometria di massa.* La Rivista di Scienza dell'Alimentazione, numero 3, Anno 42.

Di Renzo, E. (2011) Alimentazione, salute, età in un contesto specifico di studio. Le pratiche foitoalimurgiche nel comprensorio di Oratino (CB) in Longo E, Cedri C, Giustini M. (Ed.). Convegno. Invecchiare oggi: una sfida per il domani. Risultati del Progetto Europeo CHANGE (Care of Health Advertising New Goals for Elderly people). Istituto Superiore di Sanità. Roma, 3 dicembre 2010. Atti. Roma: Istituto Superiore di Sanità 25-38

Dogan, Y.; Baslar, S.; Ay, G.; & Mert, H. H. 2004 The use of wild edible food plants in western and centralAnatolia. Econ. Bot. 58, 684–690. (doi:10.1663/0013 0001(2004)058[0684: TUOWEP] 2.0.CO;2)

Eato, S. B.; & Konner, M. (1985) Paleolitico nutrizione. UNconsiderazione di suo natura e attuale implications.N. Engl. J. Med. 312,283 ± 289.

EFSA, (2015) Scientific Opinion on Dietary Reference Values for vitamin A. EFSA Journal; 13(3):4028.

Etkin, N. L.; & Ross, P. J. (1982) Food as medicine and medicine as food: an adaptive framework for the interpretation of plant utilization among the Hausa of northern Nigeria. *Social Science & Medicine*, *16*(17), 1559-1573.

Etkin, N. L. (1994) The cull of the wild. *Eating on the wild side: the pharmacologic, ecologic, and social implications of using noncultigens*, 1-21.

Ertug, F. (2000) An ethnobotanical study in central Anatolia (Turkey). Economic Botany, 54(2):155-182

Ertuğ, F. (2004) Wild Edible Plants of the Bodrum Area (Muğla, Turkey). Turkish Journal of Botany 28 (1-2), 161-174. Retrieved from https://dergipark.org.tr/tr/pub/tbtkbotany/issue/11829/141330

FAO, (2001) Chapter 3 Thiamin, riboflavin, niacin, vitamin B6, pantothenic acid and biotin in: Human Vitamin and Mineral Requirements.

FAO, (2009) The state of food insecurity in the world. Rome, Italy: FAO.

FAO, (2010) Rome.Sustainable diet and biodiversity.

Falk, J.; Bosch, S.M. (2010) *Tocochromanol functions in plants: antioxidation and beyond.* Journal of Experimental Botany, Vol. 61, No. 6, pp. 1549–1566.

Fernandes, N. (2020) Economic effects of coronavirus outbreak (COVID-19) on the world economy. SSRN Electron. J. 2020

Fernández-Ruiz, V.; Morales, P.; Ruiz-Rodríguez, B.M.; Isasa, E.T. (2016) Nutrients and Bioactive Compounds in Wild Fruits Through different Continents. In Wild Plants, Mushrooms and Nuts; John Wiley & Sons, Ltd.: Chichester, UK, 2016; pp. 263–314.

Fidanza, A.; e Fidanza, F. 1988. Vitaminologia.pag 4-11.

Fitzpatrick, TB.; Basset, GJC.; Borel, P.; et al., (2012) Vitamin Deficiencies in Humans: Can Plant Science Help? American Society of Plant Biologists; The Plant Cell, Vol. 24: 395–414

Flyman, M. V.; & Afolayan, A. J.; (2006) The suitability of wild vegetables for alleviating human dietary deficiencies. S. Afr. J. Bot. 72, 492–497. (doi:10.1016/j. sajb.2006.02.003)

Fratianni, A.; Adiletta, G.; Di Matteo, M.; Panfili, G.; Niro, S.; Gentile, C.; Farina, V.; Cinquanta, L.; Corona, O. (2020) Evolution of carotenoid content, antioxidant activity and volatiles compounds in dried mango fruits (*Mangifera Indica L.*). *Foods* **2020**, *9*, 1424. DOI: 10.3390/foods9101424.

Friedman, M. (2015) Acrylamide: Inhibition of formation in processed food and mitigation of toxicity in cells, animals, and humans. Food and Function, 6, 1752–1772

Frison, E. A.; Smith, I. F.; Johns, T.; Cherfas, J.; & Eyzaguirre, P. B. (2006) Agricultural biodiversity, nutrition and health. Food Nutr. Bull. 27, 167–179.

Galluzzi, G.; Negri, V. (2010) Contribution of backyard gardens to conservation of biological and cultural diversity and to human well-being. ActaHortic.,179–183.

Garcia-Herrera, P.; Sánchez-Mata, MC.; Cámara, M.; Tardío, J.; Olmedilla, A.B. (2013) Carotenoid content of wild edible young shoots traditionally consumed in Spain (*Asparagus acutifolius* L., *Humulus lupulus* L., *Bryonia dioica* Jacq. and *Tamus communis* L.). Journal of the Science of Food and Agriculture 93(7): 1692-1698.

Gartner, C.; Stahl, W.; Sies, H. (1997) Lycopene is more bioavailable from tomato paste than from fresh tomatoes. Am. J. Clin. Nutr. 66, 116–122.

Geraci, A.; Amato, F.; Di Noto, G.; Bazan, G.; Schicchi, R. (2018) The wild taxa utilized as vegetables in Sicily (Italy): A traditional component of the Mediterranean diet. *J. Ethnobiol. Ethnomed.* **2018**, *14*, 14

Giacometti, J.; Kovačević, DB; Putnik, P.; Gabrić, D.; Bilušić, T.; Krešić, G.; & Jambrak, AR. (2018) Estrazione di composti bioattivi e oli essenziali dalle erbe mediterranee con tecniche innovative convenzionali e verdi: una revisione. Food research international, 113, 245-262.

Gibelli, L. (2004) “Memorie di cose. Attrezzi, oggetti e cose del passato raccolti per non dimenticare.” - Priuli & Verlucca Editori, Torino, 879 pp.

Gilani, A.H.; Bashir, S.; & Khan, A. U. (2007) Pharmacological basis for the use of Borago officinalis in gastrointestinal, respiratory and cardiovascular disorders. Journal of Ethnopharmacology, 114(3), 393-399.

Giusti, M.E.; Pieroni, A. (2009) Cercare, raccogliere ed utilizzare piante spontanee (e non). Alcune indagini etnoscientifiche in Provincia di Lucca Bollettino della Accademia degli Euteleti della Città di San Miniato (Accademia degli Euteleti della Città di San. Miniato, Italy) 76: 429-460

Ghirardini, M.; Carli, M.; del Vecchio, N.; Rovati, A.; Cova, O.; Valigi, F.; et al. (2007) The importance of a taste. A comparative study on wild food plant consumption in twenty-one local communities in Italy. J Ethnobiol Ethnomed. 2007;3(1):22. http://dx.doi.org/10.1186/1746-4269-3-22

Gonzalez, JA.; Garcıa-Barriuso, M.; e Amich, F.; (2011) The consumption of wild and semi-domesticated edible plants in the Arribes del Duero (Salamanca-Zamora, Spain):an analysis of traditional knowledge. Genetic Resource and Crop Evolution. 58:991–1006.

González-Castejón, M.; Visioli, F.; & Rodriguez-Casado, A. (2012) Diverse biological activities of dandelion. Nutrition reviews, 70(9), 534-547.

González-Vallinas, M.; Molina, S.; Vicente, G.; Zarza, V.; Martín-Hernández, R.; Garcia-Risco, M.R..; & De Molina, A. R. (2014) Expression of microRNA-15b and the glycosyltransferase GCNT3 correlates with antitumor efficacy of Rosemary diterpenes in colon and pancreatic cancer. PloS one, 9(6), e98556.

Goulet, O. (2015) Potential role of the intestinal microbiota in programming health and disease. Nutr. Rev. 73 (Suppl.1), 532–540

Grivetti, L. E. & Ogle, B. M. (2000) Value of traditional foods in meeting macro- and micronutrient needs: the wild plant connection. Nutr. Res. Rev. 13, 31–46. (doi:10. 1079/095442200108728990)

Gu, R.; Wang, Y.; Long, B.; Kennelly, E.; Wu, S.; Liu, B.; ... & Long, C. (2014) Prospecting for bioactive constituents from traditional medicinal plants through ethnobotanical approaches. Biological and Pharmaceutical Bulletin, 37(6), 903-915.

Guarrera, P.M. (1994) Le piante del Lazio nell’uso terapeutico, alimentare, domestico, religioso e magico: etnobotanica laziale e della media penisola italiana a confrontoRoma: Dip. Biologia vegetale, Università “La Sapienza”

Guarrera, P. M.; Forti, G.; Marignoli, S.; Gelsomini, G. (2004) Piante e tradizione popolare ad Acquapendente Quaderni del Museo del Fiore n.2. Comune di Acquapendente, regione Lazio. Acquapendente

Guarrera, PM. (2006) “*Usi e tradizioni della flora italiana. Medicina popolare e etnobotanica*.” - Aracne editrice, Roma. pp.432

Guarrera, P.; Salerno, G.; Caneva, G. (2006) Food, flavouring and feed plant traditions in the Tyrrhenian sector of Basilicata, Italy. J Ethnobiol Ethnomed. 2006;2(1):37. http://dx.doi.org/10.1186/1746-4269-2-37

Guarrera, P.M.; Savo, V. (2016) Wild food plants used in traditional vegetable mixtures in Italy. Journal of Epthnopharmacology 185: 202-234.

Guil Guerrero, J.L.; Giménez Martínez, J.J.; TorijaIsasa, M.E. (1998) Mineral nutrient composition of edible wild plants. J. Food Compos. Anal. 11, 322–328.

Guerrero-Guil-Guil, J.L.; Gimenez, A.G.; Rodrguez-Garcia, I.; e Torija-Isasa, M.E. (1998) Nutritional Composition of Sonchus Species (S asper, S oleraceus and S tenerrimus). Journal of Science Food Agricolture, 76, 628, 632.

Guerrero, J. G., Madrid, P. C., & Isasa, M. T. (1999). Mineral elements determination in wild edible plants. *Ecology of food and nutrition*, *38*(3), 209-222.

Hadjichambis, A.C.; Paraskeva-Hadjichambi, D.; Della, A.; Elena Giusti, M.; De Pasquale, C.; Lenzarini, C.; & Skoula, M. (2008) Wild and semi-domesticated food plant consumption in seven circum-Mediterranean areas. International Journal of Food Sciences and Nutrition, 59(5), 383-414.

Hailemariam, G. A.; & Wudineh, T. A. (2020) Effect of Cooking Methods on Ascorbic Acid Destruction of Green Leafy Vegetables. *Journal of Food Quality, 2020*.

Hanganu, D.; Olah, N.; Vlase, L.; Mărculescu, A.; Pintea, A. (2012) Chemical research of carotenoids from Chenopodium bonus henricus L. (Chenopodiaceae). Farmacia, 60, 6.

Hasselmann, C.; Franck, D.; Grimm, P.; Diop, P.A. Soulrs, C. (1989) High performance liquid chromatographic analysis of thiamin and riboflavin in dietetic foods. Journal of Micronutrient Analysis. 5: 269-279.

Hadjichambis, A. C.; Paraskeva-Hadjichambi, D.; Della, A.; Elena Giusti, M.; De Pasquale, C.; Lenzarini, C.; ... & Pieroni, A. (2008) Wild and semi-domesticated food plant consumption in seven circum-Mediterranean areas. *International Journal of Food Sciences and Nutrition*, *59*(5), 383-414.

Hedren, E.; Diaz, V.; Svanberg, U.; (2002) Estimation of carotenoid accessibility from carrots determined by an in vitro digestion method. Eur. J. Clin. Nutr. 56, 425–430.

Heinrich, M.; Kufer, J.; Leonti, M.; Pardo de Santayana, M. (2006a) Ethnobotany and ethnopharmacology: Interdisciplinary links with the historical sciences. J. Ethnopharmacol. 107,157–160.

Heinrich, M.; Nebel, S.; Leonti, M.; Rivera, D.; Obón, C. (2006b) "Local food-nutraceuticals": bridging the gap between local knowledge and global needs. Forum Nutr.,1–17.

Heimler, D.; Isolani, L.; Vignolini, P.; Tombelli, S.; & Romani, A. (2007) Contenuto di polifenoli e attività antiossidante in alcune specie di insalate appena consumate. Journal of Agricultural and Food Chemistry, 55 (5), 1724-1729.

Heywood, V.H. (2013) Overview of Agricultural Biodiversity and Its Contribution to Nutrition and Health. In Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health; Fanzo, J., Hunter, D., Borelli, T., Mattei, F., Eds.; Routledge: London, UK, 2013; pp. 35–67.

Heywood, V.H. (1999) Use and Potential of Wild Plants in Farm Households; FAO Farm System Management Series; FAO: Rome, Italy, 1999; Volume 15.

Herrera, E.; e Barbas, C. (2001) Vitamin E: action, metabolism and perspectives. Journal of Physiology and Biochemistry 57 (1), 43-56.

HLPE. Food Security and Nutrition: Building a Global Narrative towards 2030; HLPE: Rome, Italy, 2020.

Hussain, J.; Muhammad, Z.; Ullah, R.; et al., (2010) Evaluation of the Chemical Composition of Sonchus eruca and Sonchus asper. Journal of American Science,6(9).

IPES-Food. COVID-19 and the Crisis in Food Systems: Symptoms, Causes, and Potential Solutions; IPES-Food: Brussels, Belgium, 2020.

Ingold, K.U.; Burton, G.W.; Foster, D.O.; Hughes, L. (1990) Is methyl-branching in alpha-tocopherol's "tail" important for its in vivo activity? Rat curative myopathy bioassay measurements of the vitamin E activity of three 2-RS-n-alkyl-2,5,7,8-tetramethyl-6-hydroxychromans. Free Radical Biology and Medicine, 9: 205–210.

Institute of medicine, (2000) Chapter 8: β-carotene and other carotenoids in: Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. The National Academies Press.

Jacob, M.C.M.; e Albuquerque, UP. (2020) Piante alimentari biodiverse: quali lacune dobbiamo affrontare per promuovere diete sostenibili? Etnobiologia e conservazione, 9.

Jacob, M.C.M.; Araújo de Medeiros, M.F.; Albuquerque, U.P. (2020) Biodiverse food plants in the Semiarid Region of Brazil have unknown potential: A systematic review. PLoS ONE 2020, 15, e0230936

Jaenicke, H.; & Ho¨schle-Zeledon, I. (eds) (2006) Strategic framework for underutilized plant species research and development. Rome, Italy: ICUC, Colombo and Global Facilitation Unit for Underutilized Species.

Jman Redzic, S. (2006) Piante selvatiche commestibili e loro uso tradizionale nell'alimentazione umana in Bosnia-Erzegovina. *Ecologia del cibo e della nutrizione*, *45* (3), 189-232.

Johnson, T.A.; Sohn, J.; Inman, W.D.; Bjeldanes, L.F.; e Rayburn, K. (2013) Gli estratti lipofili di ortica possiedono una potente attività antinfiammatoria, non sono citotossici e possono essere superiori alle tinture tradizionali per il trattamento dei disturbi infiammatori. Fitomedicina, 20 (2), 143-147.

Jori, A. (2016) La cultura alimentare e l'arte gastronomica dei romani.

Kaplan, R.W. (1965) Archaeology and domestication in American Phaseolus (beans). Econ. Bot., 19, 358-368.

Kaur, C.; e Kapoor, H.C. (2001) Antiossidanti in frutta e verdura: la salute del millennio. Rivista internazionale di scienza e tecnologia alimentare, 36 (7), 703-725.

Keys, A.B.; Keys, M. (1975) How to Eat Well and Stay Well the Mediterranean Way; Doubleday: Garden City, NY, USA, 1975.

Kerns, J.C.; Arundel, C.; e Chawla, L.S. (2015) Thiamin deficiency in people with obesity. Adv. International Journal of Food Sciences and Nutrition, 6, 147–153.

Khanam, U.K.S.; Oba, S.; Yanase, E.; Murakami, Y. (2012) Phenolic acids, flavonoids and total antioxidant capacity of selected leafy vegetables. J. Funct. Foods 4, 979–987.

Kim, J.E.; Ferruzzi, M.G.; e Campbell, W.W. (2016) Egg Consumption Increases Vitamin E Absorption from Co-Consumed Raw Mixed Vegetables in Healthy Young Men. The Journal of Nutrition146:2199–205.

Kinnunen, P.; Guillaume, J.H.A.; Taka, M.; D'Odorico, P.; Siebert, S.; Puma, M.J.; Jalava, M.; Kyrø, C.; Skeie, G.; Loft, S., Landberg, R.; Christensen, J.; Lund, E.; e Olsen, A. (2013) Assunzione di cereali integrali da diverse fonti di cereali e alimenti e incidenza del cancro del colon-retto nella coorte HELGA scandinava. Cause e controllo del cancro, 24 (7), 1363-1374.

Kummu, M. (2020) Local food crop production can fulfil demand for less than one-third of the population. Nat. Food 2020, 1, 229–237.

Kujawska, M.; Łuczaj Ł. (2010) Studies of wild food plants in communist and post-communist Poland. changes in use and in research methodology. In: Pochettino ML, Ladio A, Arenas P, editors. Tradiciones y Transformaciones en Etnobotánica. San Salvador de Jujuy: CYTED – Programa Iberoamericano Ciencia y Tecnología para el Desarrollo; 2010. p. 545–551.

Kuhnlein, H.V.; Erasmus, B.; Spigelski, D. (2009) Indigenous Peoples' Food Systems: The Many Dimensions of Culture, Diversity and Environment for Nutrition and Health; Food and Agriculture Organization of the United Nations: Rome, Italy, 2009.

Kuhnlein, H.V. (2017) Holding on to Agrobiodiversity: Human Nutrition and Health of Indigenous Peoples. In Routledge Handbook of Agricultural Biodiversity; Hunter, D., Guarino, L., Spillane, C., McKeown, P.C., Eds.; Routledge: London, UK, 2017; p. 692

Laguerre, M.; Lecomte, J.; e Villeneuve, P. (2007) Evaluation of the ability of antioxidants to counteract lipid oxidation: Existing methods, new trends and challenges. Progress in Lipid Research; 46 244-282

LARN - Livelli di assunzione di riferimento per la popolazione italiana Revisione 2014.

Le Floc'h, É. (1983) Contribution à une étude ethnobotanique de le flore tunisienne Tunis: Imprimerie officielle de la République Tunisienne, 1983.

Leonti, M.; Nebel, S.; Rivera, D.; Heinrich, M. (2006) Wild gathered food plants in the European Mediterranean: a comparative analysis. Econ Bot. 2006;60(2):130–142. http://dx.doi. org/10.1663/0013-0001(2006)60 [130: WGFPIT] 2.0.CO;2

Licata, M.; Tuttolomondo, T.; Leto, C.; et al., (2016) A survey of wild plant species for food use in Sicily (Italy) – results of a 3-year study in four Regional Parks. Journal of Ethnobiology and Ethnomedicine, 12:12.

Li, W.; & Savage, G.P. (2015) Oxalate content of the herb Good-King-Henry, Blitum bonus-henricus. *Foods*, *4*(2), 140-147.

Li, X.M.; e Yang, P.L. (2018) Avanzamento della ricerca delle specie Sonchus. *Rivista internazionale di proprietà alimentari*, *21* (1), 147-157.

Lin, Z.; Monteiro-Riviere, N.A.; Riviere, J. E. (2014) Pharmacokinetics of metallic nanoparticles. WIREs Nanomed. Nanobiotechnol. 2014.

Liu, L.; Oza, S.; Hogan, D.; Perin, J.; Rudan, I.; Lawn, J.E.; ... e Black, R.E. (2015) Cause globali, regionali e nazionali della mortalità infantile nel 2000-2013, con proiezioni per informare le priorità post-2015: un'analisi sistematica aggiornata. The Lancet, 385 (9966), 430-440.

Lozano-Baena, M.D.; Tasset, I.; Muñoz-Serrano, A.; Alonso-Moraga, Á.; E Haro-Bailón, D. (2016) Prevenzione del cancro e benefici per la salute delle piante di Borago officinalis consumate tradizionalmente. Nutrienti ,8 (1), 48.

Lu, M., Dai, T., Murray, C. K., & Wu, M. X. (2018). Bactericidal property of oregano oil against multidrug-resistant clinical isolates. Frontiers in microbiology, 9, 2329.

Lucchetti L., Zitti S., Taffetani F. (2019) – Ethnobotanical uses in the Ancona district (Marche region, Central Italy). Journal of Ethnobiology and Ethnomedicine, 15:9-42

Łuczaj, Ł.; Szymański, WM. (2007) Wild vascular plants gathered for consumption in the Polish countryside: a review. J Ethnobiol Ethnomed. 2007;3(1):17. http://dx.doi.org/10.1186/1746-4269-3-17

Łuczaj, ŁJ. (2010) Plant identification credibility in ethnobotany: a closer look at Polish ethnographic studies. J Ethnobiol Ethnomed. 2010;6(1):36. http:// dx.doi.org/10.1186/1746-4269-6-36

Łuczaj, Ł.; Pieroni, A.; Tardío, J.; Pardo-de-Santayana, M.; Soukand, R.; Svanberg, I.; Kalle, R. (2012) Wild food plant use in 21st century Europe: The disappearance of old traditions and the search for new cuisines involving wild edibles. Acta Soc. Bot. Pol. 2012, 81, 359–370

Lupia, A. (2018) Etnobotanica in Calabria. Viaggio alla scoperta di antichi saperi intorno al mondo delle pianteEd. Rubbettino pp.341

Magrini S., Atzeri P., Bacchetta G., Bedini G., Carasso V., Carta A., Ceriani R., Ciancaleoni S., DI Martino L., DI santo M., Fabrini G., Forte L., Gratani L., Negri V., Porceddu M., Salmeri C., Sarigu R., Scialabba A., Taffetani F., Villani M., Zappa E. & Mariotti M. (2016). The conservation of the Italian Crop Wild Relatives in the RIBES seed-banks: first data to establish national inventories and conservation priorities. In: Mariotti M. & Magrini S. (Eds.), The RIBES seed-banks for the conservation of the Crop Wild Relatives (CWR). RIBES Series 2: 7-18.

Manzi, A. (1999) Le piante alimentari in Abruzzo: la flora spontanea nella storia dell'alimentazione umanaTinari editrice, Villamagna.

Manzi, A. (2020) I progenitori delle piante coltivate in Italia. I parenti selvatici dei vegetali in coltura per uso alimentare, il processo di domesticazione e la salvaguardia.

Marco, C.; Ubaud, J.; Molina, J.; Chauvet, M. (2003) Les salades sauvages: l'ensalada champanèla. Sant Jean de Cuculles: Les Écologistes de l'Euzière; 2003

Marone, P.A.; Birkenbach, V.L.; Hayes, A.W. (2018) Newer approaches to identify potential untoward effects in functional foods. Int. J. Toxicol. 35, 186–207.

Mattirolo, O. (1918) Phytoalimurgia Pedemontana, copia anastatica. Aggiornamenti di Gallino B. 2001.Peveragno: Edizioni Blu Mattirolo, O. (2001). Phytoalimurgia pedemontana. Blu.

Maxted, N.; Kell, S.P. (2007) Linking in situ and ex situ conservation with use of crop wild relatives. Crop Wild Relative Conservation and Use. pp.450–467.

Maxted, N.; Dulloo, M.E.; Ford-Lloyd, B.V.; Frese, L.; Iriondo, J.M.; Pinheiro de Carvalho, M.A.A. (2011) Agrobiodiversity conservation: Securing the diversity of crop wild relatives and landraces

Mazzeo, T.; N'Dri, D.; Chiavaro, E.; Visconti, A.; Fogliano, V.; Pellegrini, N. (2011) Effect of two cooking procedures on phytochemical compounds, total antioxidant capacity and colour of selected frozen vegetables. Food Chem. 128, 627–633.

Menendez-Baceta, G.; Aceituno-Mata, L.; Tardío, J.; Reyes-García, V.; Pardo-de-Santayana, M. (2012) Wild edible plants traditionally gathered in Gorbeialdea (Biscay, Basque Country). Genet Resour Crop Evol. 2012; 59(7):1329– 1347. http://dx.doi.org/10.1007/s10722-011-9760-z

McBurney, R.P.H.; Griffin, C.; Paul, A.A.; David, D.C.; & Greenberg, C. (2004) The nutritional composition of African wild food plants. J. Food Compos.Anal. 17, 277–289. (doi:10.1016/j. jfca.2004.03.008)

Mogol, B.A; & Gökmen, V. (2016) Thermal process contaminants: acrylamide, chloropropanols and furan. *Current Opinion in Food Science, 7*, 86-92.

Mohammadi, A.; Sahebkar, A.; Iranshahi, M.; Amini, M.; Khojasteh, R.; Ghayour-Mobarhan, M.; & Ferns, G. A. (2013) Effects of supplementation with curcuminoids on dyslipidemia in obese patients: a randomized crossover trial. *Phytotherapy Research*, *27*(3), 374-379.

Mohan, V.R.; Kalidass, C. (2010) Nutritional and antinutritional evaluation of some unconventional wild edible plants. Trop. Subtrop Agroecosyst. 12, 495–506.

Montanari, M. (2005) La fame e l'abbondanza. Storia dell'alimentazione in Europa. Economia Laterza, pp 270.

Moreno-Black, G.; Somnasang, P.; & Thamathawan, S. (1996) Cultivating continuity and creating change: women's home garden practices in northeastern Thailand. *Agriculture and Human Values*, *13*(3), 3-11.

Moreno, D.A.; L´opez-Berenguer, C.; Carvajal, M.; García-Viguera, C. (2007) Health benefits of broccoli. Influence of pre-and post-harvest factors on bioactive compounds. Food 1, 297–312

Morales, P.; Ferreira, I.C.; Carvalho, A.M.; Sánchez-Mata, C.; Cámara, M.; Fernández-Ruiz, V.; Pardo-de-Santayana, M.; Tardío, J. (2014) Mediterranean non-cultivated vegetables as dietary sources of compounds with antioxidant and biological activity. Food Sci. Technol. 2014, 55, 389–396

Morales, P.; Herrera, P.G.; González, M.C.M.; Hurtado, M.C.; de Cortes Sánchez Mata, M. (2016) Wild Greens as Source of Nutritive and Bioactive Compounds Over the World. In Wild Plants, Mushrooms and Nuts; John Wiley & Sons, Ltd.: Chichester, UK, 2016; pp. 199–261.

Mouly, P.P.; Gaydou, E.M.; Corsetti, J. (1999) Determination of the geographical origin of Valencia orange juice using carotenoid liquid chromatographic profiles. J. Chromatog. A 1999, 844, 149-159. DOI: 10.1016/S0021-9673(99)00337-4.

Mursu, J.; Virtanen, J.K.; Tuomainen, T.P.; Nurmi, T.; Voutilainen, S. (2014) Assunzione di frutta, bacche e verdura e rischio di diabete di tipo 2 negli uomini finlandesi: il Kuopio Ischemic Heart Disease Risk Factor Study. La rivista americana di nutrizione clinica, 99 (2), 328-333.

Nayak, B.; Liu, R.H.; & Tang, J. (2015) Effect of processing on phenolic antioxidants of fruits, vegetables, and grains-A review. Critical Reviews in Food Science and Nutrition, 55, 887–918.

National Academy of Sciences, (1989) Chapter 8: water-soluble vitamins in: Recommended Dietary Allowances 10th Edition.

Nebel, S.; & Heinrich, M. (2010) The use of wild edible plants in the Graecanic area in Calabria, Southern Italy. *Ethnobotany of the New Europe*, 172-188.

Oliver, J.; e Palou, A.;(2000) *Chromatographic determination of carotenoids in foods* Journal of Chromatography A 881(1-2):543-55.

Ouchi, S.; Miyazaki, T.; Shimada, K.; Sugita, Y.; Shimizu, M..; Murata, A.; ... & Daida, H. (2017) Decreased circulating dihomo-gamma-linolenic acid levels are associated with total mortality in patients with acute cardiovascular disease and acute decompensated heart failure. Lipids in health and disease, 16(1), 1-8.

Palermo, M.; Pellegrini, N.; Fogliano, V. (2014) The effect of cooking on the phytochemical content of vegetables. J. Sci. Food Agric. 94, 1057–1070.

Padulosi, S.; Mal, B.; King, O.; Gotor, E. (2015) Minor millets as a central element for sustainably enhanced incomes, empowerment, and nutrition in rural India. Sustainability 2015, 7, 8904–8933.

Panfili, G.; Fratianni, A.; Irano, M. (2003) Normal phase high-performance liquid chromatography method for the determination of tocopherols and tocotrienols in cereals. J. Agric. Food Chem. 2003, 51, 3940-3944. DOI: 10.1021/jf030009v.

Panfili, G.; Fratianni, A.; Irano, M. (2004) Improved normal-phase high-performance liquid chromatography procedure for the determination of carotenoids in cereals. J. Agric. Food Chem. 2004, 52, 6373-6377. DOI: 10.1021/jf0402025

Panfili, G.; Niro, S.; Bufano, A.; D'Agostino, A.; Fratianni, A.; Paura, B.; Falasca, L.; Cinquanta, L. (2020) Bioactive compounds in wild Asteraceae edible plants consumed in the Mediterranean diet. *Plant Foods Hum.* ***N*****utr. 2020**, *75*, 540-546. DOI: 10.1007/s11130-020-00842-y.

Paoletti, M.G.; Dreon, A.L.; Lorenzoni, G.G. (1995) Pistic, traditional food from Western Friuli, N.E. Italy. Econ Bot. 1995;49(1):26–30. http://dx.doi. org/10.1007/BF02862273

Pardo-de-Santayana, M.; Tardío, J.; Blanco, E.; Carvalho, A.; Lastra, J.; San Miguel, 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. 2007;3(1):27. http://dx.doi. org/10.1186/1746-4269-3

Paura, B.; Di Marzio, P.; Salerno, G.; Brugiapaglia, E.; & Bufano, A. (2021) Design a database of Italian vascular alimurgic flora (AlimurgITA): Preliminary results. *Plants*, *10*(4), 743.

Pasta, S.; La Rosa, A.; Garfì, G.; Marcenò, C.; Gristina, A.S.; Carimi, F.; Guarino, R. (2020) An Updated Checklist of the Sicilian Native Edible Plants: Preserving the Traditional Ecological Knowledge of Century-Old Agro-Pastoral Landscapes. *Front. Plant Sci.* **2020**,*11*, 388.

Pellegrini, N.; Chiavaro, E.; Gardana, C.; Mazzeo, T.; Contino, D.; Gallo, M.; Riso, P.; Fogliano, V.; Porrini, M. (2010) Effect of different cooking methods on color, phytochemical concentration, and antioxidant capacity of raw and frozen brassica vegetables. J. Agric. Food Chem. 58, 4310–4321.

Penicaud, C.; Achir, N.; Dhuique-Mayer, C.; Dornier, M.; Bohuon, P. (2011) Degradation of β-carotene during fruit and vegetable processing or storage: Reaction mechanisms and kinetic aspects: A review. *Fruits***2011**, *66*, 417-440. DOI: 10.1051/fruits/2011058.

Pieroni, A. (1999) Gathered wild food plants in the upper valley of the Serchio River (Garfagnana), Central Italy. Econ Bot. 1999;53(3):327–341. http:// dx.doi.org/10.1007/BF02866645

Pieroni A. (2000) Medicinal plants and food medicines in the folk traditions of the upper Lucca Province, Italy Journal of Ethnopharmacology 70: 235–273

Pieroni, A. (2001) Evaluation of the cultural significance of wild food botanicals traditionally consumed in Northwestern Tuscany, Italy. J Ethnobiol. 2001; 21:89–104.

Pieroni, A.; Nebel, S.; Quave, C.; Münz, H.; Heinrich, M. (2002) Ethnopharmacology of liakra: traditional weedy vegetables of the Arbëreshë of the Vulture area in southern Italy. J Ethnopharmacol. 2002;81(2):165–185. http://dx.doi. org/10.1016/S0378-8741(02)00052-1

Pieroni, A.; Nebel, S.; Santoro, R.F.; Heinrich, M. (2005) Food for two seasons: culinary uses of non-cultivated local vegetables and mushrooms in a south Italian village. Int J Food Sci Nutr. 2005;56(4):245–272. http://dx.doi.org/10.1080/09637480500146564

Pieroni, A.; Quave, C.L. (2006) Functional food or food medicine? On the consumption of wild plants among Albanians and Southern italians in Lucania. In *Eating and Healing: Traditional Food as Medicine*; Pieroni, A., Price, L.L., Eds.; Haworth Press: Binghamton, NY, USA, 2006; pp. 101–129.

Pieroni, A.; Giusti, M. E. (2009) “Alpine ethnobotany in Italy: traditional knowledge of gastronomic and medicinal plants among the Occitans of the upper Varaita valley, Piedmont.” Journal of Ethnobiology and Ethnomedicine 5: 32.

Picchi, G.; Pieroni, A. (2005) Atlante dei prodotti tipici: le conserve. Roma: AGRA; RAI-ERI; 2005.

Pilgrim, S. E.; Cullen, L. C.; Smith, D. J.; & Pretty, J. (2008) Ecological knowledge is lost in wealthier communities and countries.

Pinela, J.; Carvalho, A.; Ferreira, I. (2017) Wild edible plants: Nutritional and toxicological characteristics, retrieval strategies and importance for today's society. Food and Chemical Toxicology 110, 165–188.

Pisoschi, A.M.; e Pop, A. (2015) The role of antioxidants in the chemistry of oxidative stress: A review. European Journal of Medicinal Chemistry 97, 55-74.

Poggi, L. (2017) Conoscere le piante spontanee e cucinarle, 2013, p. 1, materiale tratto dal sito dell’Istituto di Istruzione Superiore A. Maserati, www.istitutomaserati.it consultato il 27 Maggio 2017

Powers, H.J. (2003) Riboflavin (vitamin B-2) and health. The American Journal of Clinical Nutrition. 77: 1352–1360.

Quave, C. L.; Pieroni, A. (2007) Traditional health care and food and medicinal plani use among historic Albanian migrants and Italians in Northern Lucania, southern Italy pp. 204-226 in Pieroni A., Vandebroek L Traveling cultures and plants. The ethnobiology and ethnopharmacy of human migrations, Oxford (UK), Berghahn 2007;

Ranfa, A.; Bodesmo, M.; Cappelli, C.; Quaglia, M.; Falistocco, E.; Burini, G.; et al., (2011) Aspetti fitoecologici e nutrizionali di alcune specie vegetali spontanee in Umbria per la conoscenza, recupero e valorizzazione di risorse ambientali. Perugia: Tipografia Grifo. pp 47.

Ranfa, A., Bodesmo, M. (2017) Un'indagine etnobotanica delle conoscenze e degli usi tradizionali delle piante selvatiche commestibili nella Regione Umbria, Centro Italia. *J Appl Bot Food Qual , 90* , 246-58.

Rao, A.V.; e Rao, L.G. (2007) Carotenoids and human health. Pharmacological Research 55, 207–216.

Reina, E.; Al-Shibani, N.; Allam, E.; Gregson, K.S.; Kowolik, M.; e Windsor, L.J. (2013) Gli effetti di Plantago major sull'attivazione del burst respiratorio dei neutrofili. Journal of Traditional and Complementary Medicine, 3 (4), 268-272.

Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 *on nutrition and health claims made on foods*. Official Journal of the European Union.

Regulation EU N. 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers. Official Journal of the European Union

Riccardo, S. (1921) Le piante spontanee eduli, Catania, Edizioni Battiato.

Rivera, D.; Obon, C.; Inocencio, C.; Heinrich, M.; Verde, A.; Fajardo, J.; et al., (2005) The ethnobotanical study of local Mediterranean food plants as medicinal re¬sources in Southern Spain. J Physiol Pharmacol. 2005;56(1 suppl):97–114.

Rivera, D.; Obón, C.; Heinrich, M.; Inocencio, C.; Verde, A.; Fajardo, J. (2006) Gathered Mediterranean Food Plants—Ethnobotanical Investigations and Historical Development. In Local

Mediterranean Food Plants and Nutraceuticals; Heinrich, M., Müller, W.E., Galli, C., Eds.; KARGER: Basel, Switzerland, 2006; pp. 18–74

Rodina, K.; Timoshyna, A.; Smolej, A.; Krpan, D.; Zupanc, E.; Németh, E.; Ruzickova, G.; Gáspár, G.; Szántai, J.; Draganik, M.; Radácsi, P.; Novák, S.; Szegedi, S. (2014) TRADITIONAL AND WILD: Revitalizing traditions of sustainable wild plant harvesting in Central Europe A report published by TRAFFIC and WWF Hungary p.40

Rodriguez –Amaya, D.B.; e Kimura, M. (2004) Harvest Plus handbook for Carotenoid Analysis. Harvest Plus Technical Monograph Series 2. Breeding Crops for Better Nutrition, Washington.

Ruiz-Rodriguez, A.; Marín, F.; Ocaña A.; Soler-Rivas, C. (2008) Effect of domestic processing on bioactive compounds. *Phytochem.Rev.***2008**, *7*, 345-384. DOI: 10.1007/s11101-007-9073

Saini, R.K.; Shivraj, H.N.; e Park, S.W. (2015) Carotenoids from fruits and vegetables: Chemistry, analysis, occurrence, bioavailability and biological activities. Food Research International.76, 735–750.

Sánchez-Mata, M.C.; Cabrera Loera, R.D.; Morales, P.; Fernández-Ruiz, V.; Cámara, M.; Díez Marqués, C.; Pardo-de-Santayana, M.; Tardío, J. (2012) Wild vegetables of the Mediterranean area as valuable sources of bioactive compounds. Genet. Resou. Crop Evol. 2012, 59, 431-443. DOI: 10.1007/s10722-011-9693-6.

Sánchez-Mata, M.C.; Tardío, J. (eds) (2016) Mediterranean wild edible plants. Ethnobotany and food composition tables. Springer Nature Switzerland AG, New York

Sansanelli, S.; Ferri, M..; Salinitro, M..; & Tassoni, A. (2017) Ethnobotanical survey of wild food plants traditionally collected and consumed in the Middle Agri Valley (Basilicata region, southern Italy). *Journal of ethnobiology and ethnomedicine*, *13*(1), 1-11.

Savo, V.; Giulia, C.; Maria, GP.; & David, R. (2011) Fitoterapia popolare della costiera amalfitana (Campania, Italia meridionale). *Journal of Ethnopharmacology*, *135* (2), 376-392.

Sella, M. (1964) La Bürsch, Centro Studi Biellesi, Biella, 1964

Schaffer, S.; Heinrich, M.; Leonti, M.; Nebel, S.; Peschel, W.; Pieroni, A.; Smith, F.; Rivera, D.; Obón, C.; Inocencio, C.; Verde, A.; Fajardo, J.; Llorach, R.; Müller, W.E.; Eckert, G.P.; Schmitt Schillig, S.; Antonopoulou, S.; Kypriotakis, Z.; Manios, Y.; Nomikos, T.; Kaliora, A.; Sidossis, L.; Galli, C.; Visioli, F.; Grande, S.; Bogani, P.; de Saizieu, A.; Flühmann, B.; D'Orazio, D.; Fowler, A.; Koj, A.; Bereta, J.; Dulak, J.; Guzdek, A.; Kapiszewska, M. (2005) Understanding local Mediterranean diets: a multidisciplinary pharmacological and ethnobotanical approach. Pharmacol. Res. 52,353–366.

Schaffer, S.; Schmitt-Schillig, S.; Muller, W. E.; & Eckert, G. P. (2005) Antioxidant properties of Mediterranean food plant extracts: geographical differences. *Journal of Physiology and Pharmacology*. *Supplement*, *56*(1), 115-124.

Schaffer, S.; Schmitt-Schillig, S.; Muller, W.E.; Eckert, G.P. (2005) Antioxidant properties of Mediterranean food plant extracts: Geographical differences. Journal of Physiology Pharmacology 56(1): 115–124.

Scortegagna, S. (2013) Flora Popolare Veneta - Nomi e usi tradizionali delle piante nel VenetoWBA Monographs 3, Verona pp.704

Shackleton, S.; Paumgarten, F.; Kassa, H.; Husselman, M.; Zida, M. (2011) Opportunities for enhancing poor women's socioeconomic empowerment in the value chains of three African Non-Timber Forest Products (NTFPs). Int. For. Rev. 2011, 13, 136–151.

Sheppard, AJ.; Pennington, JAT.; Weihrauch, JL. 1993 Vitamin E in health and disease. Packer L, Fuchs J (Eds) Marcel - Dekker New York

Signorini, M.A.; Lombardini, C.; Bruschi, P.; Vivona, L. (2007) Conoscenze etnobotaniche e saperi tradizionali nel territorio di San Miniato (Pisa)Atti Soc. tosc. Sci. nat., Mem.Serie B, 114: 65-83

Simopoulos, A.P. (2004) Omega-3 fatty acids and antioxidants in edible wild plants. Biology Research 37: 263–277.

Stahl, W.; Sies, H. (1992) Uptake of lycopene and its geometrical isomers is greater from heat-processed than from unprocesseomato juice in humans. J. Nutr. 122, 2161–2166.

Shonte, T.T.; Duodu, K.; de Kock, H.L. (2020) Effect of drying methods on chemical composition and antioxidant activity of underutilized stinging nettle leaves. Heliyon 6, e 03938. https://doi.org/10.1016/j.heliyon.2020.e03938.

Schunko, C.; Grasser, S.; & Vogl, C.R. (2012) Variazione intraculturale delle conoscenze sugli usi delle piante selvatiche nella Riserva della Biosfera Grosses Walsertal (Austria). Journal of Ethnobiology and Ethnomedicine, 8 (1), 1-11.

Shumsky, S.; Hickey, G.M.; Johns, T.; Pelletier, B.; Galaty, J. (2014) Institutional factors affecting wild edible plant (WEP) harvest and consumption in semi-arid Kenya. Land UsePolicy38,48–69.

Sõukand, R.; & Kalle, R. (2011) Cambiamento nell'uso delle piante medicinali nell'etnomedicina estone: un confronto storico tra il 1888 e il 1994. Journal of Ethnopharmacology, 135 (2), 251-260.

Southon, S.; & Faulks, R. (2002) Health benefits of increased fruit and vegetable consumption. *Fruit and vegetable processing*, 2.

Stahl, W.; e Sies, H. (1999) Carotenoids: occurrence, biochemical activities, and bioavailability. In: Antioxidant Food Supplements in Human Health. Edited by Packer L., Hiramatsu M., Yoshikawa T. Academic Press.

Stahl, W.; e Sies H. (2003) Antioxidant activity of carotenoids. Molecular Aspects of Medicine 24, 345–355.

Stahl, W.; e Sies, H. (2005) Bioactivity and protective effects of natural carotenoids. Biochimica et Biophysica Acta, 1740; 101– 107.

Tabart, J.; Kevers, C.; Pincemail, J.; Defraigne, J. O.; & Dommes, J. (2009) Comparative antioxidant capacities of phenolic compounds measured by various tests. *Food chemistry*, *113*(4), 1226-1233.

Taffetani F., Giorgini A., Riolo P. (2003) - Role and ecology of the bands of spontaneous vegetation in the agroecosystems. IOBC wprs Bulletin, 26 (4), pp. 161-166.

Taffetani F., Rismondo M. (2009) - Bioindicator system for the evaluation of the environmental quality of agro-ecosystems. Fitosociologia: 46 (2): 3-22.

Taffetani F., Lucchetti L. (2015) – Erbe spontanee e ricette del Conero. I Quaderni della Selva, 7: 1-112.

Taffetani, F. (2019) Rugni, speragne e crispigne. Uso e tradizioni delle piante spontanee Academia Universa Press.

Takyi, E.E.K. (2001) Bioavailability of carotenoids from vegetables versus supplements. In: Vegetables, Fruits, and Herbs in Health Promotion. Edited by Watson R. R., CRC Press.

Tardío, J., Pascual, H., & Morales, R. (2005). Wild food plants traditionally used in the province of Madrid, Central Spain. *Economic Botany*, *59*(2), 122-136.

Tardio, J.; Pardo-De-Santayana, M.; Morales, R. (2006) Ethnobotanical review of wild edible plants in Spain. Bot J Linn Soc. 2006;152(1):27–71. http:// dx.doi.org/10.1111/j.1095-8339. 2006.00549. x

Tardío, J.; Pascual, H.; Morales, R. (2005) Wild food plants traditionally used in the province of Madrid, central Spain. Econ Bot. 2005;59(2):122–136. http:// dx.doi.org/10.1663/0013-0001(2005)059 [0122: WFPTUI] 2.0.CO;2

The Local Food Nutraccutical Consonium (2005) Understanding local Mediterranean diets: a multidis-ciplinary pharmacological and ethnobotanies approach. Pharmacol Res 2005:52:353 366.

Tomei, P.E.; Uncini Manganelli, R.E.; Trimarchi, S.; Camangi, F. (2005) Ethnopharmacobotany in Italy: State of knowledge and prospect in the future. In Proceedings of the Fourth International Congress of Ethnobotany (ICEB 2005), Istanbul, Turkey, 21–26 August 2005; Ege Yayinlari: Istanbul, Turkey, 2006; pp. 123–127.

Tomei, P.E.; Trimarchi, S. (2017) *Piante D'uso Etnobotanico in Toscana*; Ed. Maria Pacini Fazzi: Lucca, Italy, 2017.

Torero, M. (2020) Without food, there can be no exit from the pandemic. Nature 2020, 580, 588–589.

United Nations. State of the World's Indigenous Peoples; United Nations: New York, NY, USA, 2009.

United Nations. Policy Brief: The Impact of COVID-19 on Food Security and Nutrition; United Nations: New York, NY, USA, 2020; p. 23.

Van Boeckel, M.; Fogliano, V.; Pellegreini, N.; Stanton, C.; Scholz, G.; Lalljie, S.; ... & Eisenbrand, G. (2010) A review on the beneficial aspects of food processing. Molecular Nutrition & Food Research, 54, 1215–1247

Vandebroek, I.; Pieroni, A.; Stepp, J.R.; Hanazaki, N.; Ladio, A.; Alves, R.R.N.; Picking, D.; Delgoda, R.; Maroyi, A.; van Andel, T.; …& Dahdouh-Guebas, F. (2020) Reshaping the future of ethnobiology research after the COVID-19 pandemic. Nat. Plants 2020, 6, 723–730.

Van Raamsdonk, L.W.D.; Ozinga, W.A.; Hoogenboom, L.A.P.; Mulder, P.P.J.; Mol, J.G.J.; Groot, M.J.; Van DerFels-Klerx, H.J.; De Nijs, M.; (2015) Exposure assessment of cattle via roughages to plants producing compounds of concern. FoodChem. 189,27–37.

Van den Berg, H.; Faulks, R.; Granado, H. F.; Hirschberg, J.; Olmedilla, B.; Sandmann, G., ... & Stahl, W. (2000) The potential for the improvement of carotenoid levels in foods and the likely systemic effects. Journal of the Science of Food and Agriculture, 80(7), 880-912.

Vanzani, P.; Rossetto, M.; De Marco, V.; Sacchetti, L.E.; Paoletti, M.G.; Rigo, A. (2011) *Wild Mediterranean plants as traditional food: A valuable source of antioxidants*. Journal of Food Science 76(1): C46–C51.

Vavilov, N.I. (1926) Studies on the origin of cultivated plants. Bull. Appl. Bot.Genet. Pl. Breed., 16, 139-248.

Vavilov, N. I.; Vavylov, M. I.; Vavílov, N. Í.; & Dorofeev, V. F. (1992) Origin and geography of cultivated plants. Cambridge University Press.

Vincetti, B.; Eyzaguirre, P.; & Johns, T. (2008) The nutritional role of forest plant foods for rural communities. In Human health and forests: a global overview of issues practice and policy (eds C. J. P. Coler), pp. 63–96. London, UK: Earthscan.

Vitalini, S.; Grande; S., Visioli, F.; Agradi, E.; Fico, G.; & Tome, F. (2006) Antioxidant activity of wild plants collected in Valsesia, an alpine region of Northern Italy. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *20*(7), 576-580.

Visioli, F.; Galli, C. (2001) The role of antioxidants in the Mediterranean diet. Lipids 36 (Suppl.), S49–S52.

Visioli, F.; Grande, S.; Bogani, P.; Galli, C. (2004). The role of antioxidants in the Mediterranean diets: focus on cancer. Eur. J. Cancer Prev. 13, 337–343.

Wachtel-Galor, S.; Wong, K. W.; & Benzie, I.F. (2008) The effect of cooking on Brassica vegetables. *Food chemistry*, *110*(3), 706-710.

WHO (World Health Organization), (1999) Thiamine deficiency and its prevention and control in 1879 major emergencies. 65 pp

Yamada, T.; Alpers, D. H.; Kalloo, A. N.; Kaplowitz, N.; Owyang, C.; & Powell, D. W. (Eds.). (2011) *Textbook of gastroenterology*. John Wiley & Sons.

Zamora, R.; León, M.M.; & Hidalgo, F. J. (2015) Oxidative versus non-oxidative decarboxylation of amino acids: Conditions for the preferential formation of either Strecker aldehydes or amines in amino acid/lipid-derived reactive carbonyl model systems. Journal of Agricultural and Food Chemistry, 63, 8037–8043.

Zanotti, E.; Gorno, G.; Paletti, G. (2012) Le piante selvatiche commestibili. I quaderni del parco, Volume 9.

Zhao, C.; Liu, Y.; Lai, S.; Cao, H.; Guan, Y.; San Cheang, W.; Liu, B.; Zhao, K.; Miao, S.; Riviere, C. (2019) Effects of domestic cooking process on the chemical and biological properties of dietary phytochemicals. Trends Food Sci. Technol. 85, 55–66.

Zhukovskij, P.M. (1968) New centres of origin and new gene centres of cultivated plants including specifically endemic microcentres of species closely allied to cultivated species. Bot. Zh., 53, 430-460.

Zeghichi, S.; Kallithraka, S.; Simopoulos, A. (2003) Nutritional Composition of Molokhia (Corchorus olitorius) and Stamnagathi (Cichorium spinosum) World review of nutrition and dietetics 91:1-21

SITOGRAPHY

http://dryades.units.it

Giuliano, G. (2020) Coronavirus: From Wild Tobacco New Perspectives in the Treatment of COVID-19. Available online: https://www.enea.it/en/news-enea/news/coronavirus-from-wild-tobacco-new-perspectives in the-treatment-of-covid-19/

Mururia, D.; Mwale, A. Demand for Indigenous Vegetables Soar as Residents Grapple with COVID-19 Economic Shocks. Available online: https://www.kenyanews.go.ke/demand-for-indigenous-vegetables-soaras-residents-grapple-with-covid-19-economic-shocks/

Poppick, L. (2020) The Effects of COVID-19 Will Ripple through Food Systems. Available online: https://www.scientificamerican.com/article/the-effects-of-covid-19-will-ripple-through-food-systems/

Timoshyna, A.; Ling, X.; Zhang, K. COVID-19—The Role of Wild Plants in Health Treatment and Why Sustainaility of Their Trade Matters. Available online:https://www.trac.org/news/covid-19-the-role-of wild-plants-in-health-treatment/