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An ethnobotanical perspective on traditional fermented plant foods and beverages in Eastern Europe

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Abstract

Ethnopharmacological relevance: Fermented food and beverages represent an important part of the worldwide *foodescape*, medicinal food domain and domestic strategies of health care, yet relevant traditional knowledge in Europe is poorly documented.

Methods. Review of primary ethnographic literature, archival sources and a few ad-hoc ethnobotanical field studies in seven selected Eastern European countries (Albania, Belarus, Bulgaria, Estonia, Hungary, Kosovo, and Poland) were conducted.

Results. Current or recently abandoned uses of 116 botanical taxa, belonging to 37 families in fermented food or medicinal food products were recorded. These findings demonstrate a rich bio-cultural diversity of use, and also a clear prevalence of the use of fruits of the tannin- and phenolic-rich Rosaceae species in alcoholic, lactic- and acetic acid fermented preparations. In the considered countries, fermentation still plays (or has played until recent years) a crucial role in folk cuisines and this heritage requires urgent and in-depth evaluation.

Discussion. Future studies should be aimed at further documenting and also bio-evaluating the ingredients and processes involved in the preparation of homemade fermented products, as this can be used to support local, community-based development efforts to foster food security, food sovereignty, and small-scale local food-based economies.

Keywords: Ethnobotany; Fermented Foods; Food Security; Eastern Europe
1. Introduction

Foods and beverages arising from fermentation processes continue to represent an important part of the global *foodscape*. Indeed, the Food and Agriculture Organization (FAO) of the United Nations noted the significance of fermented products more than 15 years ago, highlighting their cultural and economic importance for local communities in developing countries (Battcock and Azam-Ali, 1998). We use the term ‘fermentation’ here to refer to the transformative effect of microorganisms and their products (especially enzymes, alcohols, \( \text{CO}_2 \) and organic acids) on food as employed by humans in food preparation.

While a number of research studies and reviews have focused on indigenous fermented food in continents other than Europe (see, for example, Agbobatinkpo et al., 2011; Beuchat, 1983; Das and Deka, 2012; Garabal, 2007; LeBlanc et al., 2013; Maroyi, 2013; Masarirambi et al., 2009; McGovern et al., 2004; Singh et al., 2012; Steinkraus, 1996; Tamang and Kailasapathy, 2010; Valadez-Blanco et al., 2012; Valdez, 2012), there is still a remarkable lack of scientific documentation concerning the plant-based fermentations that have played a fundamental role in traditional European folk cuisines. The last attempt at discussing this phenomenon in Europe was completed by Maurizio (1927), almost one century ago.

Recently, some of the co-authors of this article analysed the revival of juniper beer in Poland (Madej et al., 2014) and the resilience of wild plant-based and dairy lacto-fermented products among the Slavic Gorani of NE Albania (Quave and Pieroni, 2014). These studies have shown that fermented foods and beverages not only represent (especially up until a few decades ago) a significant part of the daily cuisine, but, most interestingly, local communities still perceive them to be a crucial part of their culture, with practices that are deeply embedded into the local environment and history. Furthermore, the availability of fermented foods contributes to food security and sovereignty, especially during the long winter periods when fresh produces are unavailable, in isolated mountainous communities of the Balkans (Quave and Pieroni, 2015).

It can be argued that the ethnobiological knowledge underpinned in the often neglected fermented food products serves as a crucial pillar for implementing food security and especially food sovereignty (Nolan and Pieroni, 2014), since they belong to local bio-cultural heritage, which has evolved through centuries of interactions between local societies and their environment (Nabhan, 2010). In other words, the adaptive nature of the fermentation process within a given territory, which arose from centuries of human relationships with microbial
niches in the environment, suggests that the processes and products of fermentation are part of a complex socio-ecological system made of living and non-living components and of their interactions (Scott and Sullivan, 2008). In this sense, they ultimately contribute to local population identities and their gastronomic “sense of place” as well (Evans et al., 2015; Redzepi, 2010).

On the other hand, fermented foods and beverages, and especially the lacto-fermented ones, have been the focus of many bio-scientific studies over the past decades. Importantly, these studies have pointed out the probiotic potential of fermented products and, in general, their remarkable role in human health and preventative medicine (Aggarwal et al., 2013; Arora et al., 2013; Borresen et al., 2012; Chorawala et al., 2011; Feyisetan et al., 2012; Franz et al., 2014; Khan, 2014; Khani et al., 2012; Lan et al., 2013; Marsh et al., 2014; Satish Kumar et al., 2013; Selhub et al., 2014; Singh and Bunger, 2014; Singh and Pracheta, 2012).

The purpose of this survey was to document traditional plant-based foods and beverages still in use or used until the recent past in seven Eastern European countries (Albania, Belarus, Bulgaria, Estonia, Hungary, Kosovo, and Poland), upon which further microbiological, nutritional, and pharmacological studies could be developed to assess their rational use. This could be useful for rural development experts, who foster projects aimed at sustaining local, endogenous, practices of domestic care. Moreover, new trajectories in both the avant-garde and the “folk” gastronomy have embraced aspects of food fermentation, particularly in terms of interesting tastes and increased perceived healthiness. The food and beverage and nutraceutical industry and the world of the sustainable gastronomy could benefit from the revival of the kinds of foods and techniques found in this paper, also beyond the communities/areas where these traditional preparations do still exist.

2. Methods

2.1. Literature review

Andrásfalvy, 1957; Balassa and Ortutay, 1980; Balázs, 1998; Balázs, 2008; Balázs Kovács and Kovács, 2009; Bálint, 1977; Bödi, 1981; Bőrcsök, 1979; Csoma, 2012; Dénes et al., 2012; Ecsedi, 1934; Égető, 2001; Farnadi et al., 2001; Gunda, 2001; Kardos, 1943; Kisbán, 1997; Kiss, 1929; Kóczián, 2014; Lantos, 2014; Nagyváthy, 1820; Oláh, 1536; Ortutay, 1977; Paládi-Kovács, 1966; Paládi-Kovács, 1982; Papp et al., 2014; Schilberszky, 1899; Sinkó, 1996; Szathmáry, 1930; Szathmáry, 1932; Ujváry, 1957; Varga, 1993; Varga, 1970; Váróczy, 2013; Vincze, 1960; Zentai, 1968; Zsupos, 1987), Kosovo (Mustafa et al., 2012a, 2012b; Sejdiu, 1984), Poland (Łuczaj, 2011; Łuczaj and Köhler, 2014; Madej et al., 2014) and in the Aegean Region of Turkey (Dogan et al., 2004; Dogan, 2012).

Some of these works are well documented with voucher specimens. For example, voucher specimens of wild food plants of Poland (Łuczaj, 2011) are stored in the herbarium of the Polish Ethnographic Atlas in Cieszyn (Poland); and specimens from Western Belarus (Łuczaj et al., 2013) in the herbarium of Institute of Botany of Warsaw University, Warsaw (WA code, Poland). Nomenclature followed The Plant List database (2013) for plants and Index Fungorum (2015) for fungi. The Angiosperm Phylogeny Group III system was used for family assignments (Stevens, 2012).

2.2. Field studies

A survey on current and recently abandoned uses of fermented plants was conducted during broader ethnobotanical field studies and also via a few ad-hoc investigations conducted by the authors in the years 2011-2014 in the following countries, populations, and areas (Figure 1):

Albania (AL): Albanians and Gorani of the Gora Mountains (NE Albania) – AP and CLQ; Albanians and Macedonians of Gollobordo (NE Albania) – AP; Albanians of the Rrajcë and Mokra areas and Aromanians of the Mokra area (Eastern Albania) – AP; Bulgaria (BG): Bulgarians of Rhodopes Mountains (S Bulgaria) and Bulgarian Turks originating from the same region and living in Izmir area (Turkey) – AN and YD; Estonia (EE): Estonians of Saaremaa – RS and RK; Hungary (HU): Hungarians of Ormánság, Baranya (SW Hungary) – DA; Kosovo (KS): Albanians of the Gollak area and the Albanian Alps – AH and BM; Albanians, Turks, and diverse Slavic groups (Bosniaks, Serbs, and Gorani) of the Sharr Mountains (Kosovo) – AH, AP and CLQ; Circassians of Fushë Kosovë plain (Kosovo) – AP.

Local informants were asked to free-list the food preparations or beverages based on plants, still in use or used until the recent past (in their childhood, meaning max. 50-60 years ago),
which could have undergone a fermentation process (the concept of which was given in various semantic ways, depending on the interlocutors and cultural contexts). For each of the named items, researchers documented details regarding the plants involved as main or additional ingredients, their local names, ecology, part(s) used, processes/manipulations, and the final food/beverage obtained products.

In some cases data come from a participant observation approach taken by some of the co-authors who have spent their lifetime in their native countries observing local food customs (PL: the Carpathian Foothills, SE Poland – ŁŁ; EE: Eastern and Central Estonia – RS and RK).

While the major part of these data have been recently or very recently published (Kalle and Sõukand, 2013a, 2013b; Mustafa et al., 2012a, 2012b; Nedelcheva, 2013; Pieroni et al., 2014a, 2014b, 2015; Quave and Pieroni, 2014, 2015), a small section of the collected data is still unpublished.

Taxonomic identification of the wild taxa was conducted by the authors, following standard works of the respective national or former national floras (and quoted in Pieroni et al., 2014a; Mustafa et al., 2012a; Kalle and Sõukand, 2013a; Nedelcheva, 2013). Wild plant materials were collected, when available, dried, identified by authors and deposited at following herbaria: Herbarium of the University of Gastronomic Sciences, Pollenzo (Italy); Herbarium of the University of Life Sciences, Tartu (Estonia); Herbarium of the University of Sofia (Bulgaria); Herbarium of Janus Pannonius Museum, Pécs (Hungary); Herbarium of Emory University Center for the Study of Human Healthy (USA). Nomenclature followed also in this case The Plant List database (2013) for plants and Index Fungorum (2015) for fungi and the Angiosperm Phylogeny Group III system was used for family assignments (Stevens, 2012).

3. Results and discussion

3.1. The plant biodiversity of fermentations

Table 1 reports the rich botanical diversity used to make fermented foods in the studied area. In total, 116 botanical taxa, belonging to 37 families have been documented to serve as part of the natural reservoir upon which local communities forged their food security, especially during the winter months.
The most commonly reported species in the study area were *Prunus spinosa*, *Prunus cerasus*, and *Pyrus pyraster*, with citations in six different countries; *Solanum lycopersicum*, *Cucumis sativus*, *Brassica oleracea*, *Beta vulgaris*, *Humulus lupulus*, *Prunus cerasus*, *Malus domestica*, and *Secale cereale*, with citations in five different countries; and *Rosa canina*, *Vaccinium myrtillus*, *Sambucus nigra*, *Pyrus communis*, *Anethum graveolens*, *Juniperus communis*, *Armoracia rusticana*, *Rubus idaeus*, *Betula pendula* and *Hordeum vulgare*, with citations in four different countries.

3.2. The geography of traditional plant-based fermentations

Figure 1 shows the number of plant and fungi taxa used for fermentation in the studied countries. Most of the entries came from Bulgaria, Estonia, and Poland, demonstrating a significant predominance of plant fermentation diversity among Nordic and Slavic populations towards non-Slavic populations, such as Hungarians and Albanians.

The geographic distribution of the recorded fermented taxa is reported in Figure 1. In all parts of the Eastern-European macro-region considered, there appears to be a broad distribution of an incredible reservoir of bio-cultural fermented food refugia (Barthel et al., 2013). We have found that fermentation still plays (or has played until recent years) a crucial role in the local foodscape and that this heritage requires urgent in-depth evaluation. However, many of the practices and artisanal skills related to these food preparations are often in the hands of the elderly generations, and less well known to younger population subsets, as is described below.

Out of all of the foods documented here, a few have particularly strong cultural value in Eastern European countries. Here we should especially mention fermented rye bread, different kinds of beers, gherkins and sauerkraut. As cereal-based staple foods such as rye and wheat sourdough breads and barley beers are the most well-known and well-documented fermented products in Eastern Europe since the times of Maurizio, we will skip their description and rather concentrate on other products lesser known outside of the region of study (Kowalski, 2000; Maurizio, 1903, 1927; Moszyński, 1929; and many other 20th c. works).

Making lacto-fermented cucumbers (gherkins) is a very widespread tradition among all of the northern Slavs, all of the Baltic states (Lithuania, Latvia and Estonia) and Hungarians (Table 1). The main additives that both stabilize the fermentation process and add aroma to the end-product are garlic, horseradish, dill and leaves (e.g. *Ribes nigrum*, *Prunus cerasus* and *Quercus robur*). Sauerkraut is also still widely homemade in Eastern Europe, lacto-fermented
merely with salt or with one or several additives like whole apples, slices of carrot, caraway seeds or cranberry (Table 1).

3.3. Wild vs. cultivated species and the prevalence of Rosaceae

Moreover, Figure 2 illustrates the proportion of wild and cultivated taxa used in local fermented food products in each country; while in Poland, Albania, and Kosovo wild taxa represented the large majority of the fermented spices, in Bulgaria cultivated species are the core of the fermented plant cuisine.

This may be partially due to the different degree of cultural attachment to horticultural traditions, which were historically and are still predominant in the Slavic SE Europe, and minimal in non-Slavic, pastoralist, and mountain-dwelling Albanian communities.

It is notable, however, that wild plants still represent an important portion of the overall records, thus indicating the urgent need to maintain the traditional ethnobotanical and gastronomic knowledge related to the correct identification, gathering, use and processing of these ingredients.

Figure 3 illustrates the families with the higher number of used taxa, and the proportion of plant taxa within these families recorded to be used as main components (when the main plant ingredient is/was fermented), additives (when secondary plant ingredients are/were added into the main fermented products), or both.

These findings demonstrate a clear prevalence of the tannin- and phenolic-rich Rosaceae species, whose fruits are used in fermented foods and beverages, in alcoholic, lactic and acetic-fermented preparations.

In this context, our findings suggest that the centrality of phenolic-rich plants in the fermented domain of local cuisines echoes the crucial role played by phenolic anti-oxidants in human evolution (Benzie, 2003). Moreover, the remarkable consumption of meat and its cultural importance, which is considered at least since the last Century the distinctive characteristic of all Eastern European diets could be nutritionally balanced by the traditional phenolic-rich fermented foods, prepared for consumption especially during the winter months, in an analogous way as it has been well described in the past for the diets of pastoralists in Western Africa (Chapman et al., 1997; Johns et al., 1999).

Figure 4 shows the proportions of the different categories of fermented preparations that
emerged from this review. These categories, according to which the recorded fermented culinary preparations were classified, correspond to the emic perceptions of their functions within the considered folk cuisines. Pickles and alcoholic beverages (both non-distilled beverages – beers, wines, and similar beverages – and distilled beverages, i.e. spirits) dominate the fermented plant-based folk cuisine of Eastern Europe; less relevant preparations include instead bread leaving ingredients, sour drinks, vinegars, soups, gruels, and sarma, i.e. fermented leaves rolled around a filling made by rice and/or minced meat and various seasoning ingredients, and very prototypical for Balkan and Near Eastern cuisines (Dogan et al., 2015).

3.4. Most uncommon (and endangered) recorded preparations

3.4.1. Gruels and sour beverages made of cereals

Fermented oat (Avena sativa) dishes were a popular component of the Eastern European diet but now are strongly declining. Bexhin (or baxhin), a cold, thick soup made by fermented oat, is a cultural marker for the few remaining Circassian families living in the Fushë Kosovë plain of Kosovo, which represents in turn the last trace of a unique diaspora that arrived from the Caucasus in the former territory of the Ottoman Empire after their defeat (1864) in the Circassian-Russian War. The dish is prepared by roasting oat Caryopsis – still locally cultivated in the area – and leaving it to ferment in a small amount of water for three days. The resulting porridge is briefly heated in order to increase the viscosity and is consumed especially by the elderly in the morning, accompanied by a glass of syrup (sherbet) made from sugar and water in order to compensate for the sour taste. It is considered a panacea and to be especially beneficial in the prevention of heart disease. This preparation is endangered since the know-how of bexhin is only retained by Circassian families, and not shared with the surrounding Roma, Albanian, and Slavic communities. Given the fact that during the last Yugoslav Wars, the Circassian community quite entirely moved back to the Caucasus and to Turkey, this food tradition is very likely to disappear in SE Europe in the next few years, as it has already disappeared for example in Estonia and Belarus.

Different fermented dishes and drinks made of oat were widely eaten as regular meals in Estonia until the end of 19th century and sporadically until the middle of 20th century, but nowadays their popular use is limited to special groups trying to restore national food heritage (Figure 5). For example, oat seeds were macerated in warm water, left to ferment for a few
days, and then the milky water was squeezed out and the resulting sour liquor, called *kaera kiesa* or *kaerapiim*, was drunk on the side of the meal. Such a drink was also known among Votic people and called *piku pimā* (the milk for the foal), as it was also given to foals during weaning. A bit of a different beverage, called *kile*, was made of oat flour mixed with water; it was left to stay in warmth for a night. This filtered sour beverage was consumed instead of sour milk on the side of the meal. If the filtrate was boiled, it became a kind of gruel, which was also called *kile*, but also *kiisel* or *kisla*, and eaten hot with butter or fat or later, as a cold jelly. The boiling procedure took a long time at slow heat and required constant mixing; it had to meet an exact standard of sourness, otherwise it would not produce the required result. Similar gruels (also similarly named) were prepared from rye or from rye and potatoes (Moora, 2007). In Belarus, lacto-fermented gruel was called *kisiel*, but also a semi-liquid fermented dish from the oat flour was called by the same name. It was eaten with poppy or cannabis milk and is now, as in Estonia, recognized as a historical use only.

Sour foods, especially some types of cereals-based soups were widespread in Hungary but have seemingly disappeared today. Rye or wheat bran was poured into a large pot with water and fermented with an additional leavening agent. Some days later, it was filtered and the remaining material mixed with water again and kept in a warm place. It was also used as a soup or light summer beverage (Kisbán, 1997; Ortutay, 1977; Nagyváthy, 1820). The traditions of preparing and using of this beverage still exists among Hungarians living in other surrounding countries (especially in Romania).

### 3.4.2. Juniper beer

A fermented drink made with juniper berries as the main ingredient, usually accompanied by honey and hops, has been made in many parts of northern Poland. Similar drinks were also made in other countries around the Baltic Sea, e.g. Estonia and Finland. The use of this beverage became nearly completely obsolete in the mid-20th century but was resurrected in the Kurpie area in NE Poland and now receives a lot of media attention (Madej et al., 2014). The tradition of making this drink in northern Europe may have prehistoric origins as remnants of a similar beverage were found in some archaeological sites in Denmark dating back to 1500 B.C. (McGovern et al., 2013).
3.4.3. Fermented tree saps

Birch (Betula pendula, B. pubescens) and Norway maple (Acer platanoides) sap has often been fermented with a small addition of grain, rye bread or dried fruits into a low-alcoholic beverage in Russia, Belarus, Ukraine, Estonia, and more rarely in Poland. Fermented birch sap was also typical in Hungary, but only from B. pendula (Ecsedi, 1934; Kisbán, 1997; Kiss, 1929; Papp et al., 2014; Szathmáry, 1932; Varga, 1993). Such beverages were kept in a cool dark place until the period of cutting hay or harvesting cereal in the summer. This practice has largely decreased in use, but is still living in some rural areas of Eastern and Northern Europe, as it is in Scandinavia, especially Sweden (Svanberg et al., 2012).

3.4.4. Beer-like low-alcoholic fermented drinks: taar, kvas, and kali

Historically, several low alcoholic drinks were made in Estonia. One of them, called taar, was made of rye and barley, rarely also oats. Grains were milled into flour and put into a tub and mixed with boiled water. Later it was poured into a specific vessel called tõrike which had a filter made of branches and straw at the bottom, used to prevent the thick part of the drink from coming out with the liquid part. The beverage had to turn sour for 2–3 days, and the resulting drink taar was taken from beneath the vessel. After the liquid part was consumed, more hot water was added until the resulting beverage had a taste that differed from water (Moora, 2007). To prolong the preservation of taar and to add specific taste, aromatic species (like Origanum vulgare and Ledum palustre) were added during the fermentation process (Kalle and Sõukand, 2013b).

In juniper-rich regions, taar was flavoured with juniper cones. Cones were smashed with a mortar and pestle, put into a pot, covered with water and left to stay in a warm oven for 2–4 days; often the oven was repeatedly heated to retain the necessary temperature. When taken from the oven, the fruits were again mixed with water and left to stay for a few hours covered with a cloth; when the result "tasted good", it was ready for consumption. However, in order to produce the beer, a source of yeast and hops were added and left to further ferment. After pouring the ready-made beer into a closed container, the leftover fruit “draff” was covered with water and fermented into taar (Moora, 1984). Although presently some people interviewed in Saaremaa still remember that their (grand)parents made such a drink, the authors did not succeed in documenting any modern practices. The only current day use of juniper documented was that the fruit-bearing branches were used as a strainer for filtering
and to add a specific taste to the resulting beer.

*Kvas* is a popular beverage in the countries of the former Soviet Union. It is fizzy, and in homemade versions, the fermentation may be kick-started using a sourdough (mainly *Secale cereale*-based) mother culture. Nowadays, it is industrially produced, often sold pasteurized and with preservatives added, the fizz of the industrial version coming from carbonation of the pasteurized drink, rather than bottle fermentation. Unfortunately, the tradition of home-making such beverages has declined and is mainly restricted to food-conscious individuals or hobbyists. Making *kvas* was also common in parts of eastern Poland and has now all but vanished. In Estonia, historically the spent grain from beer production was used to produce *kali* (similar to *kvass*). While the technology was similar to that used to make *taar*, it was made of malted cereals and produced after the beer was already made.

3.4.5. *Millet beer* “boza”

"Beer" brewing from millet (*Panicum miliaceum*) is a very old tradition in Hungary and South-Eastern Europe (especially in Albania, Kosovo, and Macedonia). *Boza* is a slightly alcoholic (1.5%), sour drink made without any additional malt. The millet is ground, mixed with water, cooked and fermented (Balázs, 1998; Bižint, 1977; Ecsedi, 1934; Kibin, 1997; Ortutay, 1977; Paliđi-Kovčs, 1966; Szathmíry, 1932). Beer brewing from millet has been recorded since the 16th century in Hungary (Oljih, 1536); the original means of preparation has disappeared, but there is another kind of preparation currently used also from millet but with some additional malted barley. In South-Eastern Europe wheat and maize flours have nowadays instead replaced millet and this tradition is mainly kept in the former Yugoslavia by (often Gorani or Slavic Muslims) artisan confectioners.

3.4.6. *Lacto-fermented hogweed soup*

Soup made of the lacto-fermented shoots and leaves of hogweed (*Heracleum sphondylium*) was a popular food in Poland, Lithuania and Belarus up until the 19th century and is still made in the 20th century by some individuals (Maurizio, 1927; Łuczaj, 2010, 2011; Łuczaj et al., 2013). In Belarus, some other green vegetables were fermented into a similar soup called *kisla vara* (Łuczaj et al., 2013). Unfortunately, the tradition of preparing this soup now seems to be extinct and the only sour soup made of wild green vegetables in Eastern Europe is sorrel.
(Rumex acetosella and other R. spp.) soup. It is important to note that in this case, the sorrel is not fermented, rather it has a natural sour taste.

3.4.7. Turshiena chorba

For Bulgarians, the liquid portion of pickles called turshiena chorba (туршиена черба) is often used as the winter substitute for cold summer soups. It tastes salty, pungent, spicy and acidic. The acidity produced is the result of lactic acid fermentation in a brine solution, and the spiciness comes from the addition of hot peppers or horseradish roots. The more hot the liquid, the more intriguing: a fact which finds expression materialized in making pickles only from spicy peppers (Markova 2011; Nedelcheva 2013)

A comparative study on Bulgarian immigrants in Turkey (İzmir area) clearly showed that one of the best-preserved food traditions following migration is the preparation of pickles. All informants in this study described the differences between Bulgarian and Turkish pickles, defining the latter as more acidic (because of the use of citric acid), spicier and richer in components. However, they stick to well-known recipes, mainly pickled cabbage, with less vegetable additives and using vinegar for production of a moderately sour taste. Pickle liquid is perceived to be very healthy for conditions like gastritis and ulcers and is commonly used as a healthy beverage especially during the winter.

3.4.8. Salted/fermented mushrooms

Several species of fungi have been salted and lacto-fermented by Eastern Slavs, Estonians and Poles (Table 2; Figure 7, see also Łuczaj and Köhler, 2014). This is the primary way of preserving the mushrooms for winter. The most common types of mushrooms used for this purpose were various species of milk caps (Lactarius). Some of them are actually toxic in a raw state (L. rufus, L. torminosus) and fermenting is one of the traditional methods for detoxifying them.

3.4.9. Green pepper fermented with grape marc törkölyös paprika

Green pepper (Capsicum annuum var. longum) inoculated with grape marc is a rare tradition of South-Hungary. Green peppers and the grape marc are layered, salted and flavoured with
black pepper (*Piper nigrum*), horseradish or bay in a large clay pot, usually soon after making wine. A stone is used to weigh the top of the pot and it is fermented in the cellar until December (Balázs Kovács, 2009; Kisbán, 1997).

3.4.10. Wild apple and Cornelian cherry vinegars

The tradition of preparing home-made vinegars leaving ripe fruits of wild apple (*Malus sylvestris*) and Cornelian cherry trees (*Cornus mas*) to ferment in water for at least 30-40 days, which have been well documented more than one decade ago among the Istro-Romanians living in Croatia (Pieroni et al., 2003), is still remarkably alive in South Kosovo and NE Albania, also because the locals attribute strong health properties to these products. A small glass of homemade vinegar, with the addition of sugar, is often drunk in fact as a preventive “healthy” beverage. However, the pervasive trend of using industrial vinegars, largely available on commercial markets, may seriously endanger the transmission of the culinary knowledge concerning the home-made production of these traditional vinegars. Vinegar making from wild apple was widespread also in Hungary in the past (Gunda, 2001; Kardos, 1943; Kóczián, 2014; Ortutay, 1977; Sinkó, 1996; Varga, 1993; Zentai, 1968); Ormánság was a very important region for this, where the fruits were smashed with special machine similar to a mill wheel (Zentay, 1968) (Figure 6). There is a renascence of preparing home-made apple vinegar in Hungary, but mainly from the cultivated varieties only.

3.4.11. Fruits and roots-based fermented beverages

A number of fruits or roots from wild (Cornelian cherries, gentian roots [*Gentiana lutea*], sloe [*Prunus spinosa*], wild apples, juniper berries [*Juniperus communis*]) and cultivated (apples, plums, damsons, cherry-plums [*Prunus cerasifera*]) plants are fermented in water by the Slavic Gorani minority living in isolated mountainous areas of NE Albania and South Kosovo to produce non-alcoholic (or low-alcohol content) fizzy, sour-sweet beverages, all of which are drunk for their refreshing quality and perceived “health” benefits (Quave and Pieroni, 2014). The traditional knowledge regarding this set of products, even partially shared with surrounding Slavic populations, is especially retained by the tiny Gorani communities and elderly women are often the only holders of this know-how.

In Devin area (South Bulgaria, Rhodopes Mts.), locals made a special type of fruit pickle
called vódenu from wild apples, pears, plums, blackberries (*Rubus caesius*), raspberries (*Rubus idaeus*), lingonberries (*Vaccinium vitis-idaea*), and medlars (*Mespilus germanica*), individually or mixed. Local peoples call this mixture *hamur* or “prepared pickles in *hamur*”. These pickles are prepared in a container with a tap. Fruits are added into the container, filled with water and left to ferment. After fermentation is complete, the liquid found in the bottom of the container will have a pleasantly acidic taste. This liquid is then drained and drunk, while additional water is added to the top of the container for continued fermentation. This process continues until the character of the liquid has a fruity taste. Local people call it *liuto* (люто), which means spicy, because of its unique and specific taste. This liquid was a valuable source of vitamins during the winter months, especially in the past, when fresh cultivated vegetables were not available (Markova, 2011, Nedelcheva, 2013).

4. Perspectives of plant-based fermentations in modern gastronomies, public health/nutrition, and healthy food/beverage market

Fermented foods are complex and peculiar expressions of local gastronomies; moreover, they often represent items, on which local communities often build their identity. Human perpetuation and general use of ‘wild-type’ starter mixtures for inoculation demonstrates an intimate traditional knowledge of fermentation kinetics and the interactions between transformative microorganisms and the core and additive ingredients. In most cases, traditional folk fermentation recipes have not been recorded with precision, and little of their microbiology is known. The particular microbial ecology of each food product has a significant impact on shaping their gastronomic properties, since microbiota are place-specific and their use in specific culinary preparations is the result of a long co-evolution, which “expresses” the bio-cultural dimension of a given place.

Many familiar fermented foods, such as gruels, gherkins or sauerkraut can be simple to prepare (water and salt); the inclusion of seasoning or preservative plant-ingredient such as garlic, horseradish, dill, oak or blackcurrant leaves provides scope for more complex tastes and innovations. Moreover, in gastronomy the acidic products of lactic or acetic fermentation are useful for balancing food tastes, while hetero-fermentative lactic acid bacteria produce carbon dioxide,
which provides some fizz, and this can be a desirable aspect in few final products.

Drinks, such as fruit beers, fermented birch saps, fruit sodas, kvass, taar and kali provide
great gastronomic latitude as infinite variations are possible. In modern gastronomy, drinks
are often used not only to hydrate and refresh, or for their alcoholic content, but rather also for
the enjoyment gained from consumption of certain flavours or other characteristics, which can
augment the consumer’s experience of the food.

Although the functional purpose of food fermentation is often preservation based, a few of the
fermented final products recorded in this work were and still are perceived by the local
population as "folk nutraceuticals" (plant products ingested in order to maintain a status of
health, Pieroni and Quave 2006) and the final fermented products are often more celebrated
than the original ingredients. Plant-based fermentations may offer a myriad of options to the
traditional cook and the experimental chef. Enhanced appreciation for and understanding of
traditional fermentation practices could be of great benefit to those wishing to the push
boundaries of commercial cuisines as it provides a window into a complex nexus of
interaction between plants, microbes and human culture.

Microbes are one of the most powerful tools local communities have at disposal for creating
foods that are diverse, delicious, nourishing, and speak genuinely of their place in the world.
Moreover, traditional fermented foods can help to improve the food security and sovereignty
of local populations and should be seriously reconsidered in public/heath nutritional policies.
The role of fermented foods is seen in fact nowadays as crucial in shaping modern strategies
of public health/nutrition; the role of lactic fermentation products as probiotics, which are able
to keep healthy gut bacteria and to prevent metabolic and cardio-vascular diseases, is in fact
increasingly recognised (Lovegrove and Jackson, 2011; Quigley, 2012; Tsai et al., 2014;
Sanchez et al., 2014). These findings match actually how fermented products were perceived
by locals sometimes, and put a new light into the importance of evaluating the healthy
benefits of these neglected food items of peasant domestic arenas.

Further studies are however urgently needed for a better understanding of the microbiology,
phytochemistry, and nutraceutical potentialities of several Eastern European traditional
fermented foods; these studies could also lead to the re-introduction of a few forgotten
fermented products into small-scale markets.
5. Conclusions

We have presented the results of several recent ethnobotanical surveys on fermented products of Eastern Europe, with a focus on the lesser known products that are still, or were until recently, generally produced in the home. A common theme noted for production of these foods and beverages was the reliance on natural starter cultures available in the local environment, or more frequently, arising from microbes growing on the primary ingredients themselves (autochthonous ‘wild type’ starter cultures). However, these unique sets of local knowledge are at risk as trends in the displacement of these food traditions by products of the large-scale industrialised agriculture and food industry on the market prevail, even in rural areas. This trend, combined with declines in the transmission of traditional knowledge concerning local microbial refugia, fermented food ingredients and fermentative processes, has resulted in the marginalization and even disappearance of many such practices today. Future studies should aim to further document rare and disappearing ethnobotanical knowledge concerning both the ingredients and processes involved in the creation of homemade fermented products as such information can have great utility in supporting local, community-based development efforts aimed at enhancing food security, food sovereignty, and small-scale local economies.
Acknowledgments

Special thanks are due to all of the study participants from diverse areas of Eastern Europe that shared their traditional knowledge and *know-how* regarding fermented plant foods and beverages. Thanks are due to ethnographers Anikó Báti and Gábor Kőszegi, for their assistance with references on the Hungarian fermented foods. Authors also want to acknowledge the financial support of the University of Gastronomic Sciences, Pollenzo, Italy for funding the field studies of AP; of the Emory University Center for the Study of Human Health for funding the field studies of CLQ; and of the Estonian Science Foundation Grants IUT 22-5 and EKKM14-300 for funding the fieldwork in Saaremaa of RS and RK.
Legends

Table 1. The botanical taxa used for fermentation in the reviewed countries.

Table 2. Wild fungi used for making lacto-fermented pickles

Figure 1. Location of the countries involved into the review and the number of plant and fungi taxa used for fermentation in every country.

Figure 2. Proportion of wild and cultivated taxa used in each country. AL: Albania; BG: Bulgaria; BY: Belarus; EE: Estonia; HU: Hungary; KS: Kosovo; PL: Poland.

Figure 3. Botanical families with higher number of used taxa and proportion of plant taxa used as main components, additives or both.

Figure 4. Proportions of the kind of different fermented preparations recorded.

Figure 5. Oat *kile* served at the Estonian Agriculture Museum during a conference dedicated to food culture (December 2014; photo: Renata Sõukand).

Figure 6. Apple fermentation in Hungary: apple fruits were smashed with a special machinery similar to a mill wheel called *almatörő járgány* (apple-cracker capstan). (Picture is from the archive photo gallery of Janus Pannonius Museum, Pécs, Hungary).

Figure 7. Fermented mushrooms (Central Estonia, September 2014; photo: Renata Sõukand).
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## Table 1. Plant and fungal taxa recorded in the researched areas as used in local fermented foods.

<table>
<thead>
<tr>
<th>Families</th>
<th>Taxa</th>
<th>Countries</th>
<th>Status</th>
<th>Used parts</th>
<th>Processing</th>
<th>Preparations</th>
<th>Main or Additive Components</th>
<th>Past or Current Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aceraceae</td>
<td><em>Acer platanoides</em> L.</td>
<td>BY, EE, PL</td>
<td>C/W</td>
<td>sap, opening buds</td>
<td>fr, pr</td>
<td>beer, beverage, soup</td>
<td>M</td>
<td>pa, cu</td>
</tr>
<tr>
<td>Adoxaceae</td>
<td><em>Sambucus ebulus</em> L.</td>
<td>HU, AL</td>
<td>W</td>
<td>fruits</td>
<td>fr</td>
<td>wine, distillate</td>
<td>M</td>
<td>pa, cu</td>
</tr>
<tr>
<td></td>
<td><em>Sambucus nigra</em> L.</td>
<td>BY, HU, KS, PL</td>
<td>W</td>
<td>fruits</td>
<td>fr</td>
<td>wine, distillate, beverage</td>
<td>M</td>
<td>cu</td>
</tr>
<tr>
<td></td>
<td><em>Viburum opalus</em> L.</td>
<td>PL</td>
<td>W</td>
<td>fruits</td>
<td>fr</td>
<td>wine</td>
<td>M</td>
<td>cu</td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td><em>Atriplex spp.</em></td>
<td>BG</td>
<td>W</td>
<td>leaves</td>
<td>fr, pr</td>
<td>bread, pickle</td>
<td>A</td>
<td>pa</td>
</tr>
<tr>
<td></td>
<td><em>Beta vulgaris</em> L.</td>
<td>BY, BG, EE, HU, PL</td>
<td>C</td>
<td>roots</td>
<td>fr</td>
<td>bread, distillate, pickle, soup</td>
<td>M/A</td>
<td>pa, cu</td>
</tr>
<tr>
<td>Amaryllidaceae</td>
<td><em>Allium cepa</em> L.</td>
<td>BG, PL</td>
<td>C</td>
<td>bulbs</td>
<td>fr, pr</td>
<td>bread, pickle</td>
<td>A</td>
<td>cu</td>
</tr>
<tr>
<td></td>
<td><em>Allium sativum</em> L.</td>
<td>BG, EE, PL</td>
<td>C</td>
<td>bulbs</td>
<td>fr</td>
<td>pickle</td>
<td>M/A</td>
<td>pa, cu</td>
</tr>
<tr>
<td></td>
<td><em>Allium schoenoprasum</em> L.</td>
<td>BG</td>
<td>W</td>
<td>bulbs, leaves</td>
<td>fr</td>
<td>pickle</td>
<td>A</td>
<td>pa</td>
</tr>
<tr>
<td></td>
<td><em>Allium spp.</em></td>
<td>KS</td>
<td>W</td>
<td>bulbs</td>
<td>fr</td>
<td>yogurt starter</td>
<td>A</td>
<td>pa</td>
</tr>
<tr>
<td>Apiaceae</td>
<td><em>Aegopodium podagraria</em> L.</td>
<td>PL</td>
<td>W</td>
<td>stalks, leaves</td>
<td>fr</td>
<td>soup</td>
<td>M</td>
<td>pa</td>
</tr>
<tr>
<td></td>
<td><em>Anethum graveolens</em> L.</td>
<td>BY, BG; EE, PL</td>
<td>C</td>
<td>aerial parts, fruits</td>
<td>fr</td>
<td>pickle</td>
<td>A</td>
<td>pa, cu</td>
</tr>
<tr>
<td></td>
<td><em>Apium graveolens</em> L.</td>
<td>BG</td>
<td>C</td>
<td>leaves, roots</td>
<td>fr</td>
<td>pickle</td>
<td>A</td>
<td>cu</td>
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<tr>
<td></td>
<td><em>Carum carvi</em> L.</td>
<td>BY, EE, PL</td>
<td>C/W</td>
<td>seeds</td>
<td>fr</td>
<td>beverage, pickle</td>
<td>A</td>
<td>cu</td>
</tr>
<tr>
<td></td>
<td><em>Daucus carota</em> L.</td>
<td>BG, EE, PL</td>
<td>C</td>
<td>roots</td>
<td>fr</td>
<td>pickle</td>
<td>M/A</td>
<td>pa, cu</td>
</tr>
<tr>
<td></td>
<td><em>Heracleum sphondylium</em> L.</td>
<td>BG, BY, PL</td>
<td>W</td>
<td>stalks, leaves</td>
<td>fr</td>
<td>soup, pickle</td>
<td>M/A</td>
<td>pa</td>
</tr>
<tr>
<td>Asparagaceae</td>
<td><em>Maianthemum bifolium</em> (L.) F.W. Schmidt</td>
<td>PL</td>
<td>W</td>
<td>fruits</td>
<td>fr</td>
<td>wine</td>
<td>M</td>
<td>pa</td>
</tr>
<tr>
<td>Betulaceae</td>
<td><em>Berberis vulgaris</em> L.</td>
<td>BG, EE, PL</td>
<td>C/W</td>
<td>fruits, leaves</td>
<td>fr</td>
<td>wine, pickle</td>
<td>M/A</td>
<td>pa</td>
</tr>
<tr>
<td></td>
<td><em>Betula pendula</em> Roth Ehrh.</td>
<td>BY, EE, HU, PL</td>
<td>W</td>
<td>sap</td>
<td>fr</td>
<td>beverage, distillate, soup, vinegar</td>
<td>M</td>
<td>pa, cu</td>
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<td></td>
<td><em>Betula pubescens</em> Ehrh.</td>
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<td>fr</td>
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<td>pa, cu</td>
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<td>C/W</td>
<td>roots, leaves</td>
<td>fr</td>
<td>pickle</td>
<td>A</td>
<td>pa, cu</td>
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<tr>
<td></td>
<td><em>Brassica cretica</em> Lam.</td>
<td>AL, BG</td>
<td>C</td>
<td>leaves, inflorescences</td>
<td>fr</td>
<td>pickle</td>
<td>M</td>
<td>cu</td>
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<tr>
<td></td>
<td><em>Brassica nigra</em> (L.) K.Koch.</td>
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<td>fr</td>
<td>pickle</td>
<td>A</td>
<td>cu</td>
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<td></td>
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<td>C</td>
<td>leaves, roots</td>
<td>fr</td>
<td>pickle</td>
<td>M/A</td>
<td>pa, cu</td>
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<td></td>
<td><em>Brassica rapa</em> L.</td>
<td>BG, HU</td>
<td>C</td>
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<td>M</td>
<td>pa, cu</td>
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<td>pr</td>
<td>beer, leaven</td>
<td>M/A</td>
<td>pa, cu</td>
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<td><em>Arctium lappa</em> L.</td>
<td>PL</td>
<td>W</td>
<td>young stalks</td>
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<td><em>Artemisia absinthium</em> L.</td>
<td>EE, HU</td>
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<td>pa, cu</td>
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<td><em>Cyanus segetum</em> Hill.</td>
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<td>W</td>
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<td><em>Helianthus tuberosus</em> L._</td>
<td>BG</td>
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<td>roots</td>
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<td>pickle</td>
<td>M</td>
<td>pa</td>
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<td><em>Tanacetum vulgare</em> L._</td>
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<td>W</td>
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<td>pr</td>
<td>beer</td>
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<td>pa</td>
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<td><em>Taraxacum spp.</em></td>
<td>EE, PL</td>
<td>W</td>
<td>inflorescences</td>
<td>fr</td>
<td>wine</td>
<td>M</td>
<td>cu</td>
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<td>Cornaceae</td>
<td><em>Cornus mas</em> L.</td>
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<td>C/W</td>
<td>fruits</td>
<td>fr</td>
<td>beverage, pickle, wine</td>
<td>M</td>
<td>pa</td>
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<tr>
<td>Family</td>
<td>Species and Species Information</td>
<td>Country(s)</td>
<td>Part Used</td>
<td>Other Uses</td>
<td>Process</td>
<td>Street Name</td>
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<tr>
<td>Cucurbitaceae</td>
<td>Citrullus lanatus (Thunb.) Matsum. &amp; Nakai</td>
<td>BG, C</td>
<td>fruits (or fruit peels) fr pickle</td>
<td>M</td>
<td>pa</td>
<td></td>
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<tr>
<td></td>
<td>Cucumis melo L.</td>
<td>BG, HU C</td>
<td>fruit, unripe fruits fr pickle</td>
<td>M</td>
<td>cu</td>
<td></td>
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<tr>
<td></td>
<td>Cucumis sativus L.</td>
<td>BY, BG, EE, HU, PL C</td>
<td>fruits fr pickle</td>
<td>M</td>
<td>pa, cu</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Cucurbita pepo L.</td>
<td>BG C</td>
<td>fruits fr pickle</td>
<td>M</td>
<td>cu</td>
<td></td>
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<tr>
<td>Capressaeae</td>
<td>Juniperus communis L.</td>
<td>AL, EE, HU, PL W</td>
<td>pseudofruits, twigs fr, pr beer, beverage, wine, distillate</td>
<td>M/A</td>
<td>pa, cu</td>
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<tr>
<td>Demnaeaebiaceae</td>
<td>Pteridium aquilinum (L.) Kuhn</td>
<td>BY W</td>
<td>rhizomes fr bread</td>
<td>M</td>
<td>pa</td>
<td></td>
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<tr>
<td>Ericaceae</td>
<td>Empetrum nigrum L.</td>
<td>EE W</td>
<td>fruits fr wine</td>
<td>M</td>
<td>pa</td>
<td></td>
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<tr>
<td></td>
<td>Ledum palustrum L.</td>
<td>EE W</td>
<td>aerial parts fr beer</td>
<td>A</td>
<td>pa</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Vaccinium myrtillus L.</td>
<td>AL, BY, EE, PL W</td>
<td>fruits, leaves fr beverage, bread, wine, pickle</td>
<td>M/A</td>
<td>pa, cu</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Vaccinium oxyccoccus L.</td>
<td>BY, EE, PL W</td>
<td>fruits fr wine</td>
<td>M/A</td>
<td>pa, cu</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Vaccinium uliginosum L.</td>
<td>EE, PL W</td>
<td>fruits fr wine</td>
<td>M</td>
<td>pa, cu</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Vaccinium vitis-ideaia L.</td>
<td>BG, BY W</td>
<td>fruits fr wine, pickle</td>
<td>M</td>
<td>cu</td>
<td></td>
<td></td>
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<tr>
<td>Fagaceae</td>
<td>Fagopyrum esculentum Moench</td>
<td>HU C</td>
<td>seeds fr distillate</td>
<td>M</td>
<td>pa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fagus sylvestria L.</td>
<td>AL W</td>
<td>bark pr leaven</td>
<td>M</td>
<td>cu</td>
<td></td>
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<tr>
<td></td>
<td>Quercus robur L.</td>
<td>BY, EE, PL C/W</td>
<td>fruits, leaves pr beverage, bread, pickle</td>
<td>A</td>
<td>pa, cu</td>
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<tr>
<td>Gentianaceae</td>
<td>Gentiana lutea L.</td>
<td>AL W</td>
<td>roots fr beverage</td>
<td>M</td>
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<td>Grossulariaceae</td>
<td>Ribes alpinum L.</td>
<td>EE W</td>
<td>fruits fr wine</td>
<td>M</td>
<td>pa, cu</td>
<td></td>
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<tr>
<td></td>
<td>Ribes nigrum L.</td>
<td>BY, EE, PL C/W</td>
<td>fruits, leaves twigs fr beverage, pickle, wine</td>
<td>M/A</td>
<td>pa, cu</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ribes rubrum L.</td>
<td>EE, HU, PL C</td>
<td>fruits fr wine</td>
<td>M</td>
<td>pa, cu</td>
<td></td>
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<tr>
<td></td>
<td>Ribes spicatum Robson</td>
<td>PL W</td>
<td>fruits fr wine</td>
<td>M</td>
<td>cu</td>
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<tr>
<td></td>
<td>Ribes uva-crispa L.</td>
<td>EE, PL C/W</td>
<td>fruits fr wine</td>
<td>M</td>
<td>cu</td>
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</tr>
<tr>
<td>Lamiaceae</td>
<td>Melissa melissophyllum L.</td>
<td>PL W</td>
<td>leaves fr distillate</td>
<td>A</td>
<td>cu</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Mentha spp.</td>
<td>EE W</td>
<td>aeral parts fr beverage</td>
<td>A</td>
<td>pa</td>
<td></td>
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<tr>
<td>Lauraceae</td>
<td>Laurus nobili L.</td>
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<td>cu</td>
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<tr>
<td>Leguminosae</td>
<td>Cicer aritinum L.</td>
<td>BG C</td>
<td>seeds fr leaven</td>
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<td>pa</td>
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<tr>
<td></td>
<td>Photorhus vulgaris L.</td>
<td>BG C</td>
<td>unripe fruits, leaves fr leaven, pickle</td>
<td>M</td>
<td>cu</td>
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<tr>
<td></td>
<td>Pisum sativum L.</td>
<td>EE C</td>
<td>seeds pr beverage</td>
<td>A</td>
<td>pa</td>
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<tr>
<td></td>
<td>Robinia pseudoacacia L.</td>
<td>HU W</td>
<td>flowers fr distillate</td>
<td>A</td>
<td>pa</td>
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<tr>
<td></td>
<td>Vicia faba L.</td>
<td>EE C</td>
<td>stalks pr beverage</td>
<td>A</td>
<td>pa</td>
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<tr>
<td>Linaceae</td>
<td>Linum usitatissimum L.</td>
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<td>chaff pr beverage</td>
<td>A</td>
<td>pa</td>
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<tr>
<td>Malvaceae</td>
<td>Alcea rosea L.</td>
<td>BG W</td>
<td>leaves pr sarma</td>
<td>M</td>
<td>pa</td>
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<tr>
<td></td>
<td>Tilia tomentosa Moench</td>
<td>BG C/W</td>
<td>leaves, inflorescences pr sarma, leaven</td>
<td>M</td>
<td>cu</td>
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<tr>
<td>Menyanthaceae</td>
<td>Menyanthes trifoliata L.</td>
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<td>aerial parts pr beer</td>
<td>A</td>
<td>pa</td>
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<tr>
<td>Moraceae</td>
<td>Morus alba L.</td>
<td>BG, HU C</td>
<td>fruits fr wine, distillate</td>
<td>M</td>
<td>pa, cu</td>
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<tr>
<td></td>
<td>Morus nigra L.</td>
<td>BG C</td>
<td>fruits fr wine</td>
<td>M</td>
<td>pa, cu</td>
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<tr>
<td>Myricaceae</td>
<td>Myrica gale L.</td>
<td>EE W</td>
<td>leaves, twigs pr beer</td>
<td>A</td>
<td>pa</td>
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<tr>
<td>Myrtaceae</td>
<td>Pimenta dioica (L.) Merr.</td>
<td>BG C</td>
<td>fruits fr wine</td>
<td>M</td>
<td>cu</td>
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### Piperaceae

<table>
<thead>
<tr>
<th>Species</th>
<th>Country(s)</th>
<th>Notes</th>
<th>Use(s)</th>
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<tbody>
<tr>
<td><em>Piper nigrum</em> L.</td>
<td>BG, EE</td>
<td>C/O</td>
<td>seeds, fr, pr</td>
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### Poaceae

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<thead>
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<th>Species</th>
<th>Country(s)</th>
<th>Notes</th>
<th>Use(s)</th>
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</thead>
<tbody>
<tr>
<td><em>Avena sativa</em> L.</td>
<td>BG, BY, EE, KS</td>
<td>C</td>
<td>seeds, fr, pr</td>
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<tr>
<td><em>Bromus secalinus</em> L.</td>
<td>EE</td>
<td>W</td>
<td>seeds, pr</td>
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<tr>
<td><em>Hordeum distichon</em> L.</td>
<td>HU</td>
<td>C</td>
<td>seeds, pr</td>
</tr>
<tr>
<td><em>Hordeum vulgare</em> L.</td>
<td>BG, BY, EE, PL</td>
<td>C</td>
<td>seeds, fr, pr</td>
</tr>
<tr>
<td><em>Panicum miliaceum</em> L.</td>
<td>BG, HU</td>
<td>C</td>
<td>seeds, pr</td>
</tr>
<tr>
<td><em>Secale cereale</em> L.</td>
<td>BG, BY, EE, HU, PL</td>
<td>C</td>
<td>seeds, fr, pr</td>
</tr>
<tr>
<td><em>Zea mays</em> L.</td>
<td>BG, HU</td>
<td>C</td>
<td>seeds, fr, pr</td>
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<tr>
<td><em>Triticum</em> spp.</td>
<td>BG, BY, EE, HU, PL</td>
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<td>seeds, fr, pr</td>
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### Polygonaceae

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<th>Notes</th>
<th>Use(s)</th>
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<tbody>
<tr>
<td><em>Persicaria bistorta</em> (L.) Samp.</td>
<td>BY</td>
<td>W</td>
<td>leaves, fr</td>
</tr>
<tr>
<td><em>Polypodium vulgare</em> L.</td>
<td>HU</td>
<td>W</td>
<td>roots, fr</td>
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### Primulaceae

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<th>Species</th>
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<tr>
<td><em>Primula veris</em> L.</td>
<td>EE</td>
<td>W</td>
<td>inflorescences, fr</td>
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### Rosaceae

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<th>Species</th>
<th>Country(s)</th>
<th>Notes</th>
<th>Use(s)</th>
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<tbody>
<tr>
<td><em>Crataegus</em> spp.</td>
<td>BY, PL</td>
<td>C/W</td>
<td>fruits, fr</td>
</tr>
<tr>
<td><em>Clydnia oblonga</em> Mill.</td>
<td>BG, HU</td>
<td>W</td>
<td>fruits, fr</td>
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<tr>
<td><em>Fragaria vesca</em> L.</td>
<td>BY, PL</td>
<td>W</td>
<td>fruits, fr</td>
</tr>
<tr>
<td><em>Malus</em> spp. (either <em>Malus domestica</em> Borkh. or <em>Malus sylvestris</em> (L.) Mill.)</td>
<td>AL, BY, BG, EE, HU, KS, PL</td>
<td>C/W</td>
<td>fruits, fr</td>
</tr>
<tr>
<td><em>Mespilus germanica</em> L.</td>
<td>BG</td>
<td>W</td>
<td>fruits, fr</td>
</tr>
<tr>
<td><em>Pyrus communis</em> L.</td>
<td>AL, BY, HU, KS, PL</td>
<td>C</td>
<td>fruits, unripe</td>
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### Pyracciae

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<tr>
<td><em>Prunus spinosa</em> L.</td>
<td>AL, BG, BY, HU, KS, PL</td>
<td>W</td>
<td>fruits, fr</td>
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<tr>
<td><em>Pyrus communis</em> L.</td>
<td>AL, BY, HU, PL</td>
<td>C</td>
<td>fruits, fr</td>
</tr>
<tr>
<td><em>Pyrus pyraster</em> (L.) Burgsd.</td>
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<td>W</td>
<td>fruits, fr</td>
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<tr>
<td>Family</td>
<td>Genus</td>
<td>Abbreviation(s)</td>
<td>Country(s)</td>
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<tr>
<td>Rutaceae</td>
<td>Citrus sinensis</td>
<td>EE</td>
<td>O</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Solanum lycopersicum</td>
<td>AL, BG, BY, EE, KS</td>
<td>C</td>
</tr>
<tr>
<td>Vitaceae</td>
<td>Vitis</td>
<td>BG, EE, HU, PL</td>
<td>C/O</td>
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</table>

Abbreviations: Status: W – wild taxa; C/W – taxa can be found wild and cultivated, and both have been used for fermentation; C – cultivated taxa; O – taxa acquired outside the local environment. Processing: fr= fermented fresh or dried; pr=processed before fermentation in various ways (i.e. macerating, boiling, roasting, germinating, scaling, cooking); M/A: M – main component; A – additive; Use: pa= past use (used in the past by currently living generations); cu=current use. For countries see Figure 1.
Table 2. Wild fungi used for making lactofermented pickles.

<table>
<thead>
<tr>
<th>Family</th>
<th>Taxa</th>
<th>Country</th>
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<tbody>
<tr>
<td>Boletaceae</td>
<td>Boletus edulis Bull.</td>
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<tr>
<td></td>
<td>Leccinum spp.</td>
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<tr>
<td></td>
<td>Suillus spp.</td>
<td>BY</td>
</tr>
<tr>
<td></td>
<td>Xerocomus spp.</td>
<td>BY</td>
</tr>
<tr>
<td>Physalacriaceae</td>
<td>Armillaria spp.</td>
<td>PL</td>
</tr>
<tr>
<td>Russulaceae</td>
<td>Lactarius deliciosus (L.) Gray 1821</td>
<td>BY, EE, PL</td>
</tr>
<tr>
<td></td>
<td>Lactarius deterrimus Gröger 1968</td>
<td>EE</td>
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<tr>
<td></td>
<td>Lactarius rufus (Scop.) Fr. 1838</td>
<td>EE</td>
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<tr>
<td></td>
<td>Lactarius torminosus (Schaeff.) Gray 1821</td>
<td>EE</td>
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<tr>
<td></td>
<td>Russula spp.</td>
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<tr>
<td>Tricholomataceae</td>
<td>Tricholoma equestre (L.) P. Kumm. 1871</td>
<td>BY, PL</td>
</tr>
</tbody>
</table>

1

2
Figure 1

ESTONIA (EE) 55 plant taxa + 6 fungi taxa
BELARUS (BY) 35 plant taxa + 5 fungi taxa
POLAND (PL) 49 plant taxa + 4 fungi taxa
HUNGARY (HU) 42 plant taxa
BULGARIA (BG) 55 plant taxa
KOSOVO (KS) 10 plant taxa
ALBANIA (AL) 16 plant taxa
An ethnobotanical perspective on traditional fermented plant foods and beverages in Eastern Europe

- Estonia (EE): 55 plant taxa + 6 fungi taxa
- Belarus (BY): 35 plant taxa + 5 fungi taxa
- Poland (PL): 49 plant taxa + 4 fungi taxa
- Hungary (HU): 42 plant taxa
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