

ARMORACIA RUSTICANA GAERTN., MEY. & SCHERB. A NEGLECTED MULTIUSEFUL SPECIES

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Abstract

Horseradish (*Armoracia rusticana* Gaertn., Mey. & Scherb.) has been used by man in many parts of the world as a food natural preservative, cooking spice and folk medicinal. The roots are most frequently used in ethnomedicine and they have a very pungent smell, intensive lachrymatory odour and bitter taste. Because of its valuable effects in health, it is traditionally used for treatment of sinus infections, bacterial infections of the respiratory tract, urinary bladder and gastrointestinal systems, festering wounds and ease pain such as pain associated with sciatica and rheumatism. The horseradish has not been an object of scientific reports in Albania and its uses have had even less attention. In Devolli area of Korça region, semi-cultivated or naturalized horseradish is extremely rare and generally restricted to the mountain areas. In this area leaves and roots of *A. rusticana* Gaertn., Mey. & Scherb. are used in the process of pickling. Actually, this practice is neglected and local people must insist for this plant to be part of the local cuisine. The aim of this paper is to present a bibliography review on ethnobotanical aspects, therapeutic properties and potential medicinal uses of horseradish and to bring some ethnobotanical data based on original field investigation by authors, in order to contribute in future cultivation and use of horseradish in Albania and Korca region.

Key words: Devolli region, *Armoracia rusticana* Gaertn., Mey. & Scherb., ethnobotany, etnomedicine, functional food.

Përmbledhje

Reheni (*Armoracia rusticana* Gaertn., Mey. & Scherb.) është përdorur si konservues natyror i ushqimeve, në kuzhinë dhe në mjekësinë popullore në shumë vende të botës. Rrënjët e bimës, me një erë të athët dhe me shije të hidhur dhe lotsjellës, janë më të përdorura në etnomjekësi. Kjo specie ka veti antiinflamatore, antibakteriale, antiseptike, diuretike, laksative etj. Për shkak të efekteve në shëndetin e njerëzve bima është përdorur për të trajtuar infeksionet bakteriale dhe të sistemit respirator, gastrointestinal dhe urinar, si për të lehtësuar dhimbjet si në rastin e reumatizmave. *A. rusticana* Gaertn., Mey. & Scherb. nuk ka qenë objekt i ndonjë studimi në Shqipëri dhe përdorimit të saj nuk i është kushtuar shumë rëndësi. Në zonën e Devollit, Korçë, kjo bimë gjendet në natyrë ose "seminatural" vetëm në zonat malore. Gjethet dhe rrënjët e saj përdoren në procesin e përgatitjes së turshive. Sot kjo praktikë po përdoret gjithnjë e më pak. Qëllimi i këtij studimi është paraqitja e një përmbledhje të literaturës lidhur me vetitë terapeutike dhe përdorimet etnobotanike të kësaj bime, duke sjellë edhe disa të dhëna nga përdorimi mjekësor dhe etnobotanik në zonën e Devollit, me qëllim për të kontribuar në njohjen dhe mundësinë e kultivimit dhe përdorimit të kësaj bime në rajonin e Korçës.

Fjalëkyçet: Zona e Devollit, *Armoracia rusticana* Gaertn., Mey. & Scherb., etnobotanikë, etnomjekësi, ushqim funksional.

Introduction

Albania is characterized by a rich diversity of plants, a massive abundance of wild edible species, due to which their use is still widely practiced, but still insufficiently documented. Wild plant use is a relevant component of local traditional ecological knowledge. It entails a thorough experience of, and interaction between, human beings and their natural resources (Lozada *et al.*, 2006). Local knowledge about wild plant gathering transmitted from generation to generation was neglected in the last decades in Albania. However, wild plant gathering becomes again a popular and fashionable activity in many parts of Albania. Today, the renewed interest in wild edible plants, and knowledge of the healthy role of phytochemical compounds, makes it possible to define them as “new functional foods” (Ceccanti *et al.*, 2018). Wild plants generally contain a large spectrum of phytochemicals such as polyphenols, terpenoids, polysaccharides, etc., which make them good candidates as functional foods, which contain potentially health-promoting ingredients (Benítez *et al.*, 2017).

Horseradish (*Armoracia rusticana* Gaertn., Mey. & Scherb.) is a source of many biologically active compounds and the richness in phytochemicals has encouraged its use as functional food. The increasing interest in plant-derived secondary metabolites such as glucosinolates (GLSs) and antioxidant compounds, in which horseradish is a rich source, associated to the long tradition of using horseradish in food preservation and as condiment in many countries, is generating new applications of this plant in several agro-industrial and pharmaceutical sectors and is encouraging the use of its roots and leaves in functional food and medicine for human health (Agneta *et al.*, 2013). Although, horseradish has been cultivated for its white and tapered root that has a mix of intense pungency and cooling taste (Rivelli *et al.*, 2017) for over 2000 years (Sampliner & Miller, 2009) around the world. This plant is little known in Albania and Kosovo, and also, there have been no previous studies for this vegetable, spice and medicinal plant.

In Devoll area of Korça region, Albania, *A. rusticana* Gaertn., Mey. & Scherb. is used in the process of pickling. Today, in this area, the use of horseradish in traditional methods to prepare pickled vegetables and fruits is decreased or neglected. This study emerged from an ethnobotanical survey conducted in the upper Devoll. During our survey we have encountered in use of horseradish in the process of pickling. In this review we would like to give an overall picture of the phytochemical compounds of *A. rusticana* Gaertn., Mey. & Scherb., therapeutic properties and traditional uses of horseradish, as well as to provide some new data on the ethnobotanical use of horseradish in Devoll area, in order to contribute on introduction and use of horseradish in Albania and Korça region. The folk knowledge and practices concerning botanicals are not only important for understanding

local perceptions and uses of plants, but also for providing baseline data that could be employed for a sustainable valorization of the local flora (Pieroni & Sökand, 2017).

Methods

This paper is based on an ample review of published literature linked with specific data and aspects of horseradish. The published ethnobotanical and ethnomedicinal literature, references on the pharmacological properties and gastronomic literature based on original field investigations were considered. The different titled papers included in this review after a deep analysis. Although this study involved an extensive literature review, it is not an exhaustive review all of materials on this subject.

A survey on current and recently abandoned uses of horseradish via a few ad-hoc investigations was carried out by the authors between April and September 2018 in the nine selected villages (Sinicë, Arrzë, Qytezë, Dardhë, Koshnicë, Sul, Hoçisht, Miras and Ponçarë) of Devoll area (Korça region, Albania). Local informants were asked in the free talks for the local use of horseradish, still in use or used until the recent past (30–50 years ago) and the way of its use.

In all the nine villages were interviewed at least five informants over 50 years old from both genders. The interview was in semi-structured form where they were asked for part(s) they used and the way of use (processes/manipulations) of horseradish.

Description

Origin and distribution

Horseradish, *A Armoracia rusticana* Gaertn., Mey. & Scherb. has a long history as food and medicinal plant and it was already mentioned in “De material medica”, libri quinque, written year 100 AD (Wedelsbäck Bladh, 2014). Even 1,500 years before Christ, Egyptians knew about it, and Greeks used it against pains in the back and as an aphrodisiac (Filipović *et al.*, 2015).

Although horseradish can now be found nearly worldwide, it is believed that most likely originated in the temperate regions of Eastern Europe (Sarli *et al.* 2012; Nguyen, 2016; Rivelli *et al.*, 2017). Other authors highlight that that horseradish originates from South-Eastern Europe and Western Asia (Khurshid *et al.*, 2012; Filipović *et al.*, 2015), where, even nowadays, one can meet its wild ancestors (Filipović *et al.*, 2015).

Horseradish is indigenous to Eastern and Northern Europe and the Mediterranean and is also cultivated in Central Europe (Tomsone *et al.*, 2013). Outside of cultivation *A. rusticana* Gaertn., Mey. & Scherb. grows best in moist habitats, disturbed areas such as fields and along roadsides, in home gardens, weedy areas, farmland areas throughout Europe (Mongue, 2013; Sarli *et al.*, 2012).

The main areas of commercial cultivation are Central Europe, North America, Russia, Caucasus, Asia and some other regions (Sarli *et al.*, 2012). In Europe, the main production takes place in Hungary (1200 ha), but Austria, Germany and Poland are also producers (Rivelli *et al.*, 2016). USA is now the largest producer of horseradish in the world, about 1600 ha (Alnsour, 2013, Rivelli *et al.*, 2016). In Italy this plant grows in the Northern part and in the Lazio and Basilicata regions (Sarli *et al.* 2012). According to Hammer *et al.* (2011), cited by Agneta *et al.* (2013), it was possibly that this plant has been introduced as a traditional spice plant from Albania with Albanian immigrants to South Italy, where today is particularly diffused in the Arbëreshë areas of Basilicata, far away from North Italy.

In the Korça, Albania, regions horseradish is found naturalized on the edge of the Prespa Lake (Qosja, 1973) and in administrative unit of Miras and Hoçisht, where can be grown in wild and cultivated habitats, notably in mountainous home gardens. In particular, in the some Devoll's villages, in the area of Miras, there is a culinary tradition related to the use of this plant. *A. rusticana* Gaertn., Mey. & Scherb. growing in home gardens in Devoll area can be considered semi-cultivated specie, because it is encouraged, among other plants that grow spontaneously in gardens since farmers use the roots and very limited number of plants that can be grown in few gardens. It now occurs as an established ruderal weed and is rather collected from the wild than grown.

Etymology

The name *Armoracia* comes from Celtic: ar 'near', mor 'the sea', rich 'against' and roughly means a plant growing "near the sea" (Krasniqi *et al.*, 2003, Mongue, 2013; Agneta *et al.*, 2013). The common name horseradish probably derived from the old German word "*meerettich*" meaning "*sea radish*" (Wright, 2010; Mongue, 2013) and this term was resulted most likely as a mistranslation confusing 'meer' (sea) for 'mare' or 'mähre' (old horse) (Alnsour, 2013, Wright, 2010; Mongue, 2013). The new name "horseradish" was developed instead of the original one (sea-radish) (Alnsour, 2013). However, the common name came to be, it is rather ironic because horseradish is toxic to horses, pigs, and cattle (Mongue, 2013).

Chren, a common word of Slavic language (Alnsour, 2013, Agneta *et al.*, 2013), which is the most primitive name for horseradish (Agneta *et al.*, 2013), is the origin of the names of horseradish in German and French dialects (Alnsour, 2013, Agneta *et al.*, 2013). Other names for horseradish are known in other European civilizations, but *chren* stays the most ancient one (Alnsour, 2013).

In Albania, the plant is known as *kren*, *rilk* (Krasniqi *et al.*, 2003; Lako, 1965; Papparisto *et al.* 1988), in Kosovo as *kren* (Berisha *et al.*, 2012), in Macedonia in Albanian language *kren*, *ren* (Shabani, 2004). We have found other local names as 'bari për gjë' in Kosovo (Mustafa *et al.* 2012) and as 'rehen' in Devoll. These local names are different from the official ones.

Botanical Description

Horseradish (*Armoracia rusticana* Gaertn., Mey. & Scherb.) is an herbaceous perennial, and an important crop of the *Brassicaceae* family, which includes broccoli, turnips, white and black mustard that have considerable economic importance for their pungent flavor. It has well defined botanical characteristics which clearly separate the species from other *Brassicaceae* (Agneta *et al.*, 2013).

The plant can reach the height of 120 cm (Agneta *et al.*, 2013). It has a hardy glabrous stem, from which wavy margin leaves arise directly following a circular arrangement pattern (basal rosette) (Nguyen, 2016). The basal leaves grow to a length of 30 cm up to 100 cm (Sampliner & Miller 2009), and are long-petioled, oblong-ovate, cordate at the base, unevenly crenate (Wedelsbäck Bladh, 2014). The shape of leaves on stalk are smaller in size, have narrow bases and mostly sessile, are alternate, lanceolate, and unevenly serrate to entire-margined (Agneta *et al.*, 2013). Whereas a shorter petiole and a lobe shape with entire or serrate margin are characteristics of lower leaves, upper leaves have a narrow base, obtuse apex, oblong or lanceolate shape with crenate or serrate margin. The margin is linear or almost entire in the case of uppermost leaves (Nguyen, 2016). It is interesting to note that leaf morphology varies throughout the growing season from entire laminate in the summer to more pinnate or fern leaves in the autumn (Wedelsbäck Bladh, 2014). The intermediate types of leaves are visible throughout the season (Agneta *et al.*, 2013). The plants start to produce the pinnate leaves when they prepare for winter dormancy, probably induced by the colder temperature in the autumn (Wedelsbäck Bladh, 2014).

Horseradish flowers in late spring to early summer with small white flowers arranged in branched clusters. The flowers have four corollas arranged in a cruciform, a characteristic of the *Brassicaceae* family (Wright, 2010). It has a smooth, brown angustiseptate fruit—a fruit (pod) flattened at a right angle to the septum, which usually contains very few (≤ 6) or no seeds (Nguyen, 2016). The seeds are smooth and brown when mature and plants are incapable of producing viable seeds (Agneta *et al.*, 2013) or seldom set viable seeds (Wedelsbäck Bladh, 2014). The lack of evidence that horseradish grows from seeds suggests sterility (Sampliner & Miller, 2009).

The root system consists of a long, white, cylindrical or tapering main root with several thin lateral roots (Rivelli *et al.*, 2016; Agneta *et al.*, 2013) branched to form an extensive system, that can grow to about 60 cm in loose soils; undisturbed, the root system can reach a depth of 3–4 m with a lateral spread of about 1 m (Agneta *et al.*, 2013).

Phytochemical Composition

Among the cruciferous vegetables, the horseradish is proving to be a rich source of glucosinolates, phenolics, flavonoids and other constituents, including vitamins (Rivelli *et al.*, 2017). *A. rusticana* Gaertn., Mey. &

Scherb. contains high levels of sulfur-containing glycosides, so called glucosinolates (GLSs) (Wedelsbäck Bladh 2014; Tomsone *et al.*, 2013). GLSs play an important role in the plants defensive system (Nguyen, 2016) and provide the characteristic flavour and aroma as a result of their breakdown into isothiocyanates (ITCs) and others sulfur compounds (Calabrone *et al.*, 2015). From 17 different GLSs that have been identified recently (Rivelli *et al.*, 2016), sinigrin is the main GLS found in horseradish (Cirimbei & Vizireanu, 2014; Rivelli *et al.*, 2016). The final product from hydrolysis of sinigrin is the allyl-isothiocyanate (AITC) that is most likely responsible for the pungent, lachrymatory odor and taste of horseradish root, as well as irritates the mucus membrane of the sinuses and eyes (Nguyen, 2016).

Horseradish is a source of many biologically active compounds. Its roots are rich in vitamin C (Cirimbei *et al.*, 2013; Rivelli *et al.*, 2017) and B1, minerals (iron, potassium, calcium and magnesium), phytoncide, essential oils (Cirimbei *et al.*, 2013), phenolic compounds (flavonoids and phenolic acids) (Cirimbei & Vizireanu, 2014; Herz *et al.*, 2017) and enzymes as well as kaempferol and quercetin (Herz *et al.*, 2017). The complex mixture of phenolic compounds possesses antioxidant activity and they show the inhibitor effect against pancreatic lipase (Calabrone *et al.*, 2015). The average content of vitamin C in horseradish can be almost three times higher than in citrus fruits (Rivelli *et al.*, 2017). The horseradish also is a rich source of peroxidase enzyme that catalyses a variety of oxidative transformations of organic and inorganic compounds (Nguyen, 2016) and has been proposed as part of the treatment for bladder, breast, and nasoesophageal cancer (Mongue, 2013).

Health benefits

Over the years, the pharmacological effects of horseradish have been receiving a great interest (Wedelsbäck Bladh, 2014) and phytotherapeutic properties have been documented (Cirimbei, *et al.*, 2013). The richness in phytochemicals has recently encouraged its use in the medical field and as functional food (Rivelli *et al.*, 2017), as well as in many innovative applications in various sectors (Wedelsbäck Bladh, 2014).

Many scientific researchers have revealed that horseradish possesses numerous therapeutic properties. Horseradish has antibacterial, antiseptic and diaphoretic properties (Filipović *et al.*, 2015). It is an effective diuretic (Wright, 2010; Mongue, 2013), digestant, expectorant, antibiotic, carminative, laxative, stimulant (Filipović *et al.*, 2015) and rubifaciens (Wright, 2010; Filipović *et al.*, 2015). Horseradish is one of the plants with increased interest for anti-cancer substances (Weil *et al.*, 2005), for toothache (Nguyen, 2016), as aphrodisiac (Mongue, 2013; Nguyen, 2016) and as an antipyretic drug and against symptoms of flu (Papp *et al.*, 2018). Studies have shown that horseradish displays inhibitory effects on different kinds of cancer such as stomach cancer, colon cancer (Filipović *et al.*, 2015)

and prostate cancer as well as induction of lung cancer and development of tumors in liver (Wedelsbäck Bladh, 2014).

Because of its medicinal effects, it is increasingly being used to treat respiratory tract, gastritis, rheumatism, festering wounds, sciatica and pleurisy and it has been used as an agent against worms, scurvy, ulcers and venereal diseases (Filipović *et al.*, 2015). Horseradish is helpful in the determination of glucose in blood (Khurshid *et al.*, 2012). Also, horseradish roots are known for their strong anti-inflammatory and antibacterial characteristics and are used for the treatment of acute sinusitis, bronchitis, and urinary bladder infection (Herz *et al.*, 2017), also paradontosis, anemia, flu and stomatitis can be treated by using horseradish (Khurshid *et al.*, 2012).

Horseradish has a cardiogenic effect and is recommended to the people that suffer from high blood pressure (Cirimbei & Vizireanu, 2014) heart problems, peripheral blood flow and prevents the risk of thrombosis (Cirimbei *et al.*, 2013).

Traditional uses of horseradish

The horseradish is known since antiquity as a folk medicinal herb, natural preservative and dish condiment (Rivelli *et al.* 2017) and it is associated with interesting traditions and diverse use (Wedelsbäck Bladh, 2014). Its leaves and roots can be eaten, but due to their strong pungent taste, only the fleshy roots are commercially utilized (Alnsour, 2013).

Grated fresh roots are used as condiment with beef, when mixed with vinegar and salt, it can also be served with sea food after the addition of catsup (Alnsour, 2013). The root can be grated directly onto food or mixed with ketchup, vinegar, or oil to form a sauce and sometimes the root is boiled, squeezed, washed, and mixed with salt and sugar to remove some of the isothiocyanates which cause its pungent taste (Mongue, 2013). The roots, usually collected from the wild plants, were utilized as a condiment, with pickled cucumbers, grated with chopped boiled eggs, soups or meat dishes, often used at Easter (Łuczaj & Szymański, 2007; Agneta *et al.* 2013).

The leaves and roots of horseradish are used as a seasoning or as additive to lacto-fermented of vegetables such as cucumbers, tomatoes, sauerkraut (Mongue, 2013; Papp *et al.*, 2018), and as seasoning or preservatives (Łuczaj & Szymański, 2007; Agneta *et al.* 2013). The leaves are considered to prevent food spoilage processes (Rivelli *et al.*, 2017). In some countries of Balkan, the leaves are used for preparing sarma (Dogan *et al.*, 2015) and in Germany eaten as a vegetable (e. g., cooked like spinach) and in salads (Rivelli *et al.*, 2017). The raw leaves placed in the oven under baking bread, partly to prevent the bread from sticking and partly to flavour the bread, are still widely used (Łuczaj & Szymański, 2007).

Use of horseradish in Devoll

Sõukand *et al* (2015), in an ethnobotanical study that was carried in seven European countries (Albania, Belarus, Bulgaria, Estonia, Hungary, Kosovo, and Poland) reported uses of roots and leaves of horseradish for pickle preparations in four different countries, but not reported for Albania and Kosovo. Ethnobotanical records for horseradish are not found in the existing relevant publications for Albania. For Kosovo, we have found a single data that shows that leaves are applied on the breast during the night for treatment of breast oedema and fresh leaves are topically applied on the wounds for treatment of breast and skin inflammations (Mustafa *et al.* 2012).

In areas of Devoll, horseradish roots are still used for pickling pears or it is added to fermented plant products such as cabbages, tomatoes and pepper. The horseradish-infused pickled pears can conserve for 6-8 months. Pickled pears juice is used as a remedy for healing drunkenness. Grated roots are added to raki (brandy) for two weeks and this extract is used as a remedy to treat cough and bronchitis.

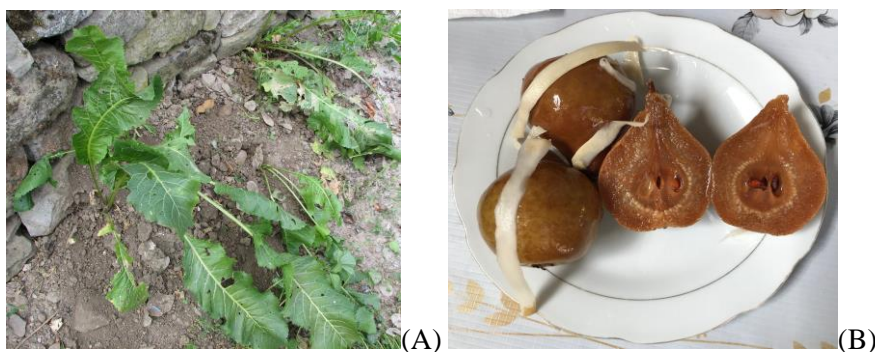


Fig. 1. Horseradish plant in Dardha village (A), pickled pears with horseradish in Koshnica village (B)

Conclusions

The horseradish possesses numerous therapeutic properties and because of its valuable effects in health, the herb is traditionally used to treat, bronchitis, sinusitis, urinary bladder infection, paradontosis, rheumatism, anemia, gastritis, rheumatism, pleurisy, etc. AITC of horseradish has a great potential for medical use, pharmaceutic industry and it is used in many anti-cancerous drugs and as functional food.

In the Korça region horseradish is found naturalized notably in mountainous home gardens in some of the Devoll's villages, where still has a unique interesting tradition for pickled pears. Actually, this practice is neglected and local people might show new attention along with an increasing interest for horseradish as a valuable plant in local cuisine and ethnomedicinal uses. The local users have traditional knowledge to use the plant species, but there is a lack of scientific knowledge on its values both within and outside of the user circle. Cultivation of this wild species is a promising approach in order to

contribution in conservation of local traditional ecological knowledge and in the local biodiversity as well as for exploiting new functional foods.

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