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MULTI-USE OF CRANBERRIES (*VACCINIUM* SPP.): HERITAGE AND PHARMACEUTICAL RESULTS

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Abstract: The European cranberry (*Vaccinium oxycoccus* L., syn. *Oxycoccus palustris* Pers.) has a wide geographical distribution in natural bogs of Europe, Asia, and North America. The American cranberry (*Vaccinium macrocarpon* Aiton, syn. *Oxycoccus macrocarpos* (Aiton) Pursh) is more easily cultivated in the northern regions of the world and is therefore an available source of bioactive compounds. They are both rich in polyphenolic compounds (i.e., flavonoids, anthocyanins, and phenolic acids), which have significant antioxidant and anti-immflamatory properties.

The cranberry fruits and their preparations represent important natural preservatives used against bacterial and fungal pathogens. Heritage related to its usage refers to the cranberry as a food plant and multiuse ethnomedical remedy. The results of the modern phytochemical and pharmaceutical research suggest using cranberry against urinary tract infections and as a preventive or curing plant against many other diseases. Today there are many new opportunities to draw attention to this plant, including cranberry tourism. In food and pharmaceutical industry the fruits are used most often, but leaves are also rich in biologically active substances, which can be sources for creating new medicines.

Keywords: cranberry, ethnobotany, ethnomedicine, pharmacology, phytochemical research, plant names, *Vaccinium oxycoccus, Vaccinium macrocarpon*

INTRODUCTION

Due to changes in environmental conditions in accordance with the increase in anthropogenic influence, a reduction in the areas of growth of (medicinal) plants was noted everywhere in the world. Marsh cranberries were no exception: they are a valuable source of various biologically active compounds, important as medical plants, as well as a valuable source of vitamins and food.

The purpose of this paper is to discuss two species of the subgenus Cranberry of the genus *Vaccinium* belonging to the family *Ericaceae*, and to evaluate their use as important natural preservatives against bacterial and fungal growth, and folk and economic use as food plants in ethnomedicine and pharmaceutical industry.

The European cranberry (marshberry, bog cranberry, swamp cranberry – *Vaccinium oxycoccus* L. (syn. *Oxycoccus palustris* Pers.) that grows in Estonia is the most common in folk traditions. The American cranberry (large cranberry, bearberry - *Vaccinium macrocarpon* Aiton (syn. *Oxycoccus macrocarpos* (Aiton) Pursh) is of great interest in scientific research as a source of biologically active substances in not only the fruits but also the leaves (Fig. 1).

V. oxycoccus plants include forms such as the little-leaf cranberry and the larger-leaf form. However, the taxonomic relationship between the cytotypes is uncertain, and nowadays *Vaccinium oxycoccos* is considered as a complex of diploid and polyploid plants (Côté et al. 2010).

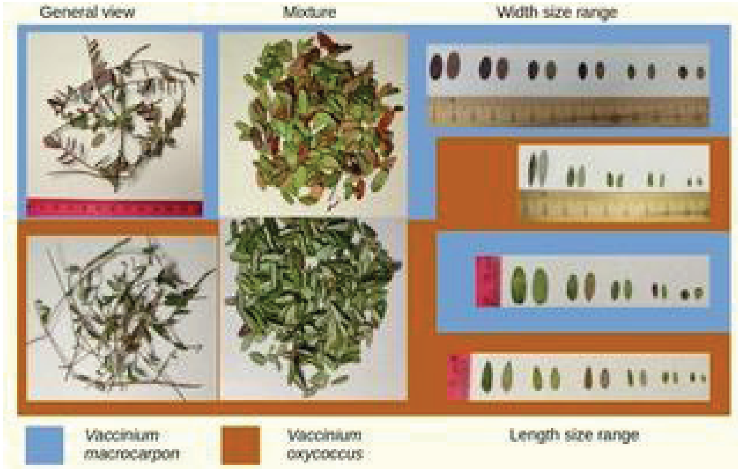

Figure 1. *American cranberry (*Vaccinium marcocarpon*) and European cranberry (*Vaccinium oxycoccus*).*

The American or large cranberry (*V. macrocarpon*) is mainly cultivated as an industrial crop in North America (Canada and north-eastern regions of the USA) since peat soils and wetlands, commonly occurring there, constitute the optimum substrate for cranberry cultivation; the crop is also grown in Europe, mainly in Latvia and Belarus, and, in recent years, in south-eastern Poland (Krzewińska & Smolarz 2008). The largest harvest in 2019 was recorded in the USA and amounted to 359,110 tons from a cultivation area of 15,580 ha. In Canada 172,440 tons were harvested from an area of 6393 ha, and in Belarus 235 tons of cranberries from an area of 101 ha (see FAOSTAT n.d.). There are approximately 200 varieties of the plant, and they mainly differ in terms of shape, size, colour of fruit, appearance of leaves, and fertility. The most widely grown cranberry crops are cvs "Ben Lear", "Stevens", and "Pilgrim" (Hołderna-Kędzia & Kędzia 2006). The cultivation of the American cranberry has been repeatedly tested, but it does not grow in the Estonian climate and does not bear berries.

In comparison with the American cranberry, the European cranberry has a considerably wider distribution. It occurs in forest areas in Europe, Asia, and North America. The species of this shrub are commercially widely cultivated in Russia and Estonia, and also in Lithuania (Česonienė et al. 2013). It is an evergreen shrub with creeping stems, which grows on peat in low drained sites. In European conditions it usually appears on sphagnum bogs in the north-western part of the European continent as far as North Asia and Japan. Cranberries ripen during late August and through September and can persist on plants until spring. The berries have pink, red or dark red colour, strong acidic flavour, and can be pear- or egg-shaped, round, oval, oblate, or cylindrical (Jurikova et al. 2018; Česonienė et al. 2006, 2013; Jacquemart 1997). In Ukraine it can be found in swamps and in swampy pine and mixed forests in Polissia, in the Carpathians, and in Prykarpattia. *O. palustris* is included in the *Red Book of the Ukrainian SSR*.

For medicinal purposes ripe berries are used, which are collected from the onset of the first frosts and before the formation of a snow cover, and collection is resumed after the snow melts. Fresh berries are stored at a temperature of about 0º or poured into tubs filled with water. Berries can be stored for a long time, almost without changes in their qualities (Pro korisni 2021; Koshovyi et al. 2023).

Northern peoples used cranberries for food – they made pies with them, added them to pastries, sweetened with maple syrup, and fermented cabbage with cranberries. In 1683, in America, they began to make juice from them. Other parts of the plant are not used in officinal medical practice, but they are rich in phenolic compounds and can be prospective agents for creating new medicines. However, standardization parameters of *V. macrocarpon* and *V. oxycoccus* leaves were developed and proposed (Vlasova et al. 2022).

Unfortunately, cranberry-based preparations (i.e., tablets, capsules) and juice available on the European market most often originated from *V. macrocarpon*, and the fruit of *V. oxycoccus* was used very rarely (Witkowska-Banaszczak & Studzińska-Sroka & Bylka 2010).

Lifestyle changes and a higher proportion of leisure time in the last half-century have encouraged hiking and leisure in nature, including bogs. This has brought people closer to extraordinarily beautiful cranberry flowers and berries and enabled them to admire the bog landscapes. A new type of tourism – bog tourism – has also appeared with a natural and cultural programme. The COVID pandemic gave a boost to being in nature. The purpose of such hikes is not to pick berries or providing subsistence but learning about natural forms. According to the obtained overview of phytochemical and pharmaceutical results, we can expect a decisive expansion of the uses of cranberries in medicine and ethnomedicine.

MATERIALS AND METHODS

The article uses the corpus of plant and calendar literature to characterize the Estonian subject matter, and Ukrainian data to characterize Ukrainian folk uses, as well as the results of the study in the laboratories of the University of

Tartu. We selected data and used mixed methodology: pharmacology, botany, ethnobotany, ethnomedicine, and folkloristic methods. The purpose of the article is to give an overview of the current state and use of the cranberry, as well as the results of the academic study which formulates a ground for the future use of berries. The terminology, harvesting, preservation techniques and uses of cranberries are characterized in more detail, especially the (ethno-)medicinal use. Since this is a broader topic, the breeding and cultivation are introduced, not investigated. The research questions are: What has caused the major changes in attitudes towards cranberries? Whether and how do science and literature influence usage practices? What are the predicted uses of cranberries based on scientific results?

However, both the interpretative and philosophical sides and the determination of natural relations within the framework of the possibilities of folkloristics are as important as the collection. In the 1960s, the focus was on interpreting the relationship between humans and the environment and on making philosophical sense thereof. We point out only one term coined by a notable thinker: Norwegian philosopher Arne Næss started with the concept of 'Deep Ecology' – ecological awareness that goes beyond the logic of biological systems to a deep, personal experience of the self as an integrated part of nature (Næss 1973). From the point of view of our research Taylor's book *Dark Green Religion: Nature Spirituality and the Planetary Future*, published in 2010, is remarkable and still remains an important resource today. Taylor provides an analysis of the processes of sacralizing nature in North America, which took shape in the nineteenth century, accelerated in their impact in the 1970s, and entered a new phase recently –Taylor calls it "the global greening of religion". In his historical reconstruction, the celebration of the first Earth Day in 1970 coincided with the renewal of and upswing in environmental movements in North America, as well as what can be called "nature religion" or "nature-as-sacred religion" (Taylor 2010: 5).

TERMINOLOGY AND DATA RECORDING

The English names of the cranberry refer to the place of growth and/or taste, and like the original Greco-Latin name, they also have additional names such as stork or bear berries. Estonian names are divided quite evenly into two: *kuremari* mainly in eastern Estonia, and *jõhvikas/jõhvik* known all over Estonia (VMR 1982). Similar to the main names are *jõvike / jovike* (Jõhvi, Vaivara), and jühvikas (Risti) as some more dialectal-phonetic variations. In addition, there are many local names (it is not possible to give a complete overview here), for example, *karbala* (Kuusalu) (the same name as Finnish *karpala*), *pluukina* (Seto) (Rus. *клю́ква*), *siilu-arjak* (Karksi) (VMR 1982). Among the plant names by Vilbaste, there are also local ones: *kurvik* (Avinurme), *Pärdiaegsed marjad* (Jaani), and *rabamarjad* ('bog berries') indicating the place of growth – Jõelähtme; *soomari* ('swamp berry') (Tallinn) and even *viinamari* ('grape berry') (Kihnu) (Vilbaste 2014). Other plant names include *karu-mari* ('bear berry') and *(h)undimari* ('wolf berry') (VMR 1982), which are not associated with cranberry. Looking at the names of the Baltic Finns, the similarity of the Estonian-Votian border areas is obvious: *jõvikaz*, *jõvikõz*, *jevikaz*, *jevikõz*, *jeevikas (jõvikkaa)*, also Finnish *karpalo*, *karpolo* (VKS 2013), Livonian *gārban* (LEL 2012–2013); Latvian *dzērvene* (ELS 2015). Russian and Ukrainian *клю́ква* is probably related to the place of growth in the bog (*ключевина* 'bog') (see Etimologicheskie 1910: 320). The Latin name of the *genus oxycoccos* comes from the Greek *oxy* ('sour') and *coccos* ('berry'), referring to the taste of the fruit. In England, they were called *marshwort* or *fenberries*, as well as *cranberry* by the missionary John Eliot in 1647. The name *cranberry* derives from the Low German *kraanbere* ('craneberry'); apparently it is an American English adaptation of *kraan* ('crane') (see Etymonline). The reason for the name is not known; perhaps they were so called due to the fancied resemblance between the plants' stamens and the beaks of cranes. In seventeenth-century New England, cranberries were sometimes called *bearberries*, as people often saw bears eating them. According to the OED, the North American berries, and the name, were imported back to Europe by the 1680s, and the name was applied to the native species in the eighteenth century.

The study of the relationship between humans and nature has taken place throughout centuries. A. Ippolitova has published articles about the botanical illustrations and data in Russian manuscripts between the sixteenth and eighteenth centuries. On the one hand, these are the translations of the European encyclopaedic works in natural sciences, such as Johann von Cube's *Gaerde der Suntheit* and Hieronymus Brunschwig's *Liber de arte distillandi*. On the other hand, there are "folk" herbals of the eighteenth century that represent a "naive" version of botanical data (Ippolitova 2008). Actually, the original sixteenth-century Ukrainian manuscript turned out to be a thirteenth-century translation (Zapasko 1995). The dichotomy and division between the scientific use and popular use have been evident in herbal medicine manuals until today.

The somewhat sporadic collecting of ethnobotany began in the nineteenth century (Hurt 1989 [1888]) and continued only in 1920–1940, when the material was collected by botanist Gustav Vilbaste (1885–1967). In 1923, Vilbaste published a comprehensive questionnaire on ethnobotany, with a goal to fix regional names and especially areas of their use. He sent the questionnaire to schools, and also distributed it through the society of botanists and naturalists (Kalle & Sõukand 2014). The questionnaire materials have largely not been studied, only the collected plant names were published by the Mother Tongue Society in 1993 (Vilbaste 1993).

In the past decade, ethnobotany focused on taxonomy, typology, systematic description of existing data, and interpretation of data. The creation of new methodologies (incl. the introduction of ethnobotany) and the observation of new phenomena played a major role, among which the development of the ecological direction is significant. Kristel Vilbaste in cooperation with Ain Raal authored a series of scientific review works (see Kõiva 2022), which combine pharmacy, botany, ethnobotany, and modern knowledge (Raal & Sarv & Vilbaste 2018; Raal & Vilbaste 2019), and Renata Sõukand and Raivo Kalle created important analytical tools and a database covering the subject (Sõukand & Kalle 2008).

CRANBERRY AS A LIVELIHOOD

In the twentieth century, walking in the nature became more popular, including hiking in swamps and bogs at different times of the year and admiring nature, not to mention the continuation of berry picking as a livelihood at the beginning of the century. Wild berries were a source of livelihood for poorer people, and the same characterized the years after the Second World War as well as the times of economic recession in the 1950s, 1990s, 1998, etc. Seasonal income from forest products and logging was important for subsistence and meant being in a closer relationship with nature. A significant part of the food and dietary supplements was obtained by making use of nature or directly from nature. Before independence, swamps and bogs, along with forests, were part of manor lands, and picking berries required agreements. After Estonia gained independence in 1918, people continued picking berries mainly in the bogs nearest to home. More detailed data on picking and selling cranberries date from the 1930s; for example, in 1938 and 1939, data on the harvesting of wild berries, nuts and mushrooms were examined by the State Forest Service by using questionnaires. Of the total harvest of wild berries, cranberries accounted for almost a half – 44%. It is estimated that the possible cranberry harvest from across Estonia was more than 2 million litres, or almost 1500 tons. Cranberries were sold to the townspeople in the market; they were used by confectionery, chocolate and candy factories, juice and soft drink factories and alcohol industries, as well as canneries and hospitals; berries were also sold for export (to Germany, England, the USA, less to France, Denmark, Finland, etc.) (Vilbaste 2014).

After the Second World War, picking berries in the forest to sell them was also an important financial support for those made to work on collective farms as there was no financial reward at all. People often went to harvest in an organized way, that is, they used cars or lorries to get to the bog. In the 1960s, about 1000 tons of berries were harvested per year. In the Soviet era, according to Vilbaste, a total of 1300 tons of cranberries were bought up per year. Starting from 1975, it remained below 200 tons, as purchasing prices were low and people's living standards improved (Vilbaste 2014).

In 1991, after the restoration of independence, it was the only source of income to alleviate unemployment in south-eastern Estonia and Ida-Viru County. In 1994–1998, companies bought 200 tons of cranberries or even more every year (Kalle & Sõukand 2014: 51). The small amount bought in was partly due to the fact that large-fruited cranberries had become more popular, while, on the other hand, the former system of buying and distributing had disappeared. The drainage of the swamps was most disastrous for cranberry swamps, because the edges of the swamps are the best habitats for cranberries. It had intensified in the nineteenth century, with the purchase of farmland, as ownership meant the desire to improve the land. During the Soviet regime, the development of new lands continued along the former edges of the swamps, but this time with more powerful machines. The land belonged to the state, and the creation of large agricultural arrays was considered promising; besides, larger machines also required larger areas of land to work on.

In 1910 the first nature protection area in Estonia was established, and after an interval, in the 1960s, the implementation of previous practices continued: nature conservation areas were established, and an inventory of existing natural resources was taken. In 1965, the topic of the inventory of prospective cranberry products of the Estonian SSR was included in the plan of scientific works of the Nigula National Nature Reserve. In 1973, after extensive research, 2.4% of Estonian swamps were taken under protection, and so were 22,705 hectares of cranberry bogs. In 1981, 30 swamps were protected on the initiative of Estonian botanist and ecologist Viktor Masing.

BREEDING OF CRANBERRY CULTURES

The beginning of the breeding of cranberry cultures in the world was the year 1810, when the first experimental plots were established in the US State of Massachusetts; near Berlin plots for the industrial production of cranberry were established in 1860.

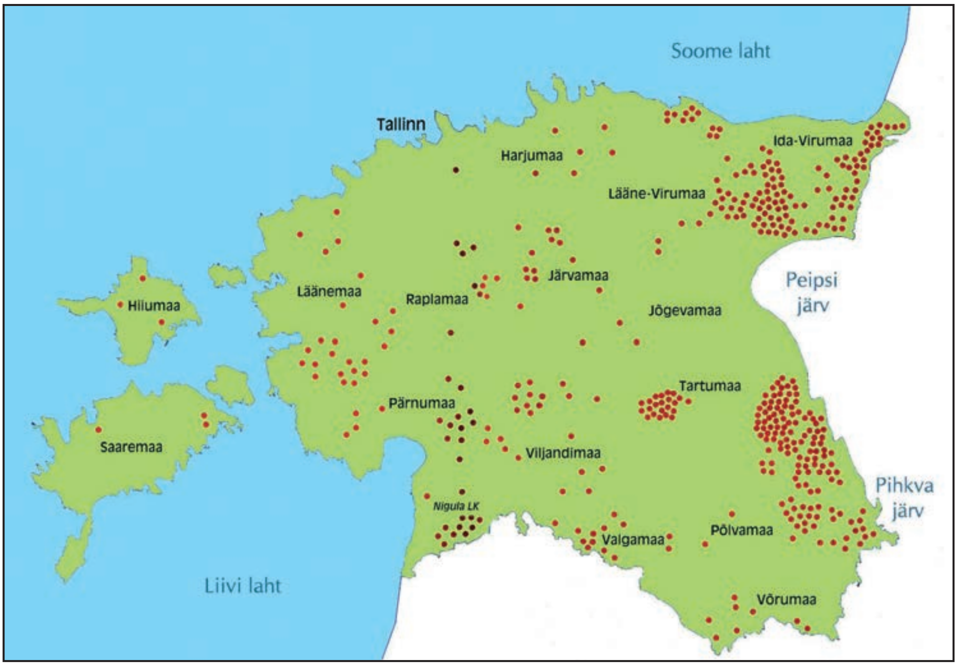

Figure 2. *The best cranberry bogs in Estonia by REGIO map published in Vilbaste 2014, adapted by A. Kuperjanov.*

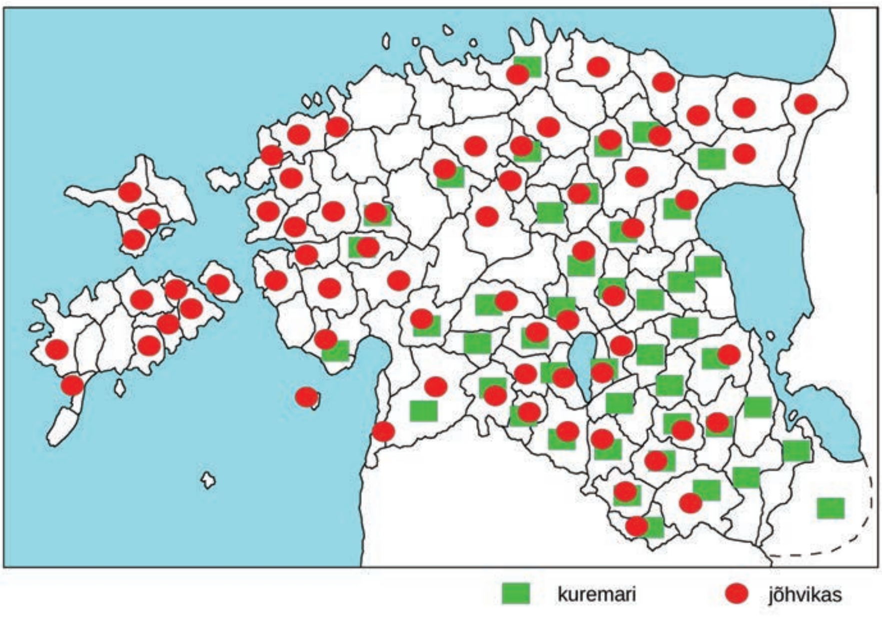

Figure 3. *Names of cranberry based on VMR (1982). Map by A. Kuperjanov 2023.*

The first attempts to cultivate domestic cranberries were made in 1966; a year later the Rahesaare test area was completed, which was modelled according to the plan for the establishment of a plantation and its irrigation system in America. The following year, Henn and Juta Vilbaste established the first test plot in Kilingi-Nõmme, with the plants brought in during the inventory of Estonian cranberry products. Initially, there were only cuttings from ordinary cranberry plants brought from Nigula and Rahesaare bogs. They were pricked into milled peat and given fertilizers necessary for growth. The cuttings took root within two weeks. By the next spring, the plants, about 20 cm long, were there. The plants were grown in 14-square-meter trays filled with peat and covered with glass sheets on top, from which plants were obtained for many years. In 1969, plants from there were planted in a single field in Rahesaare bog, located on 7 hectares near the border with Latvia, and until 1971 also in other fields.

The breeding of cranberries in Estonia can be divided into stages, where important dates are the following: 1967 – Henn and Juta Vilbaste established the first fields in Kilingi-Nõmme, with the cuttings from ordinary cranberry plants; 1973 – the establishment of cranberry crops on the sowing route (Alu bog) began; 1985 – 276.4 ha of cranberry crops were established in the remaining bogs in Estonia; the establishment of the Viira collection field for the preservation of the Estonian cranberry gene pool was started; 1989 – cranberry varieties bred at Nigula were officially approved in Moscow; 1992 – the Viira collection field had more than 800 different cranberry cultivars. Crops bred during the Soviet era spread all over Estonia; they were grown in many parts of the former Soviet Union, using the results and advice from the Estonian test areas.

Currently, several Estonian berry farms have cranberry fields, but the only special cranberry farm by Lake Võrtsjärv belongs to Toomas Jaadla.

FOODWAYS AND USE IN FOLK AND TRADITIONAL MEDICINE

Cranberries were stored dry in a pantry or storage place, also in the attic on top of a layer of soil (E. Ernits' data, oral communication with M. Kõiva), but also in water (source, well, later in a bottle). Today homemade juices or berry jam, which can be stored in the refrigerator, is more widespread. Eating berries raw was limited to a few berries a day during the winter months and early spring. Berry drink and juice have been especially important in catering establishments from the second half of the twentieth century to this day, and industrially produced juices, jams, and other products to supply schools and hospitals have also found their way into homes.

In the home kitchen, cranberries were used with sauerkraut and fried meat, and later also as a salad with meat dishes. The periods of preparation of copious gourmet dishes remain in the twentieth century (the 1930s, and again from the 1960s). Today the uses have especially expanded, and the same is typical of Ukraine.

In the eighteenth–nineteenth centuries the cranberry was used as a medicinal plant in the fleet against scurvy, in severe cattle and human diseases (Wilde 1766), or against fever associated with several severe infectious diseases (typhus, scarlet fever, smallpox) (Jannau 1857).

It is interesting to note that the beloved Estonian folk writer Oskar Luts (1887–1953) was a pharmacy assistant in the Vitebsk military pharmacy in Belarus during the First World War. In September 1915, he was ordered to fetch from Tartu a health drink made from cranberry extract, which hospitals and taverns used as a precaution against typhus. Even before setting off, it was clear to the apothecary that if Russia had run out of this extract, it would hardly be available in Tartu, but the week-long business trip offered a great opportunity to see the family and friends. Luts returned without the extract (Kahu 1996), but the great importance of such a prophylactic against typhus is proved by the fact that he had to travel nearly 1,200 kilometres to fetch it.

After a long interval, the book *Eesti NSV ravimtaimed* (Medicinal plants of the Estonian SSR) was published in 1962 (Kook & Vilbaste 1962), which, among other herbs, introduces also bog cranberry. It is mentioned that cranberry berries (*fructus Oxycocci*, *baccae Oxycocci*) are used as a medicine, and extract (juice) is made from them, but it is no longer sold in pharmacies, but rather in food stores. This edition also introduces the folk use of cranberries: the juice drink is given to patients with high fever, and berries sweetened with sugar are eaten to lower high blood pressure.

After Estonia regained independence in 1991, the publication of medicinal plant books compiled by herbalists and naturopaths increased exponentially. In her book, T. Gorbunova (1993) pointed out that cranberry juice strengthens the effect of sulfanilamides (etazol, biseptol, urosulfan, etc.). Aleksander Heintalu or Vigala Sass (1941–2015), one of Estonian best-known healers, doctor of agricultural sciences, mentions cranberry (2003: 41) only in connection with its ability to neutralize the effect of penicillin and reduce the effect of blood pressure-lowering drugs. Alfred Vogel (1902–1996), a famous Swiss herbalist, naturopath and writer, mentioned that cranberries are excellent sources of vitamin C, and they are the only berries that contain an excess of acid (Vogel 2003 [1952]).

In the Estonian calendar literature, cranberry recommendations appear in the period 1739–1917 only in four publications, which is a very modest number. There is also surprisingly scant folk medicine data on cranberry in the archives we are using; most of the data comes from the twentieth century and rather from its second half. Below we give an overview of the use of cranberries in ethnomedicine and draw attention to some possible influencers.

Cranberry juice as a remedy against fever is still in use in folk medicine today. Since smallpox did not occur in the twentieth century, and the spread of many serious infectious diseases is prevented by vaccination, its use in this field is fading. Only measles is mentioned, which spread more widely in children's collectives. Cold berry drink and kissel were used in the treatment: "Measles is a childhood disease. Signs of measles: red spots on the skin, with a slight fever. Where the sick lay, the room was made dark. Cranberry drink was given to drink. A cold-water cloth was kept on the head, the cloth was often changed" (Text 13).[1]

Eating berries helps against sore throat and angina, and raw berries also help to lower high blood pressure (ICD I 10 et seq. Hypertension).

Raw berries are eaten to cure dental inflammations (K05) and digestive diseases (K 00), for example stomach acidity, and to promote appetite (Text 34). In addition to skin inflammations (L20), cranberries were also suitable for treating wounds (I 33.0) and bedsores, as well as parasitic scabies (B88.0); also, cranberry juice sometimes exterminated lice: "Lice were killed with sauna steam. Cranberry juice took away the lice from the head (according to the words of my mother-in-law Minna Trubok from Rakvere). Hair had to be completely wet with cranberry juice and kept under a towel for 0.5–1 hour" (Texts 27, 35). Cranberry juice was used against diabetes (D10) and as a headache relief (R51), as well as for the treatment of ear pain, or even carbon monoxide poisoning.

A separate group is made up of herbal mixtures, ointments, tinctures, and other multicomponent folk remedies, which were written down in home medicine compilations and from there they also entered the archives. Their origins and modes of transmission also need to be clarified, with a hypothetical possibility of transmission via the media, for example radio. For instance, components of the drug against hypertension (ICD I 10) are: 1/2 litre of cranberries, 100 grams of garlic, or 100 grams of horseradish, to which half a litre of hot water is added, strained, and taken 1 tablespoonful three times a day (Text 39). Another recipe includes honey, lemon, nuts, and cranberries, which are chopped into small pieces, fermented, and taken 1 teaspoonful in the morning (Text 52).

Honey, horseradish, garlic, and onions were favourites in the home treatment of the twentieth century, which is why they were recommended, for example, against influenza (J09): a mixture of 500 gr of honey, 250 gr of garlic, onions, horseradish, and cranberries as a dosage of 1–2 tablespoonfuls per day (Text 40). Against rheumatism (RHK I00-102), a mixture of cranberries, horseradish as well as garlic and honey were recommended. Against several diseases (fever, kidney and bladder diseases, lack of sleep, nervous diseases, rheumatism, etc.), for example, a decoction of water and oats was prepared, to which cranberry juice was also added – this is the only recipe that was recommended to drink several glasses a day.

A totally new layer is formed by modern home treatment recommendations in online publications and books, which highlight medical indications and share recommendations. This is a completely independent type of publications – teachings relating to health science, that is, medical educational literature that raises awareness of health. To give an example here, we introduce a Ukrainian web page.

In Ukraine berries are consumed fresh or processed into juices, syrups, drinks, extracts, kvass, mors, jellies, marmalades, jams, etc. Juice diluted with water is used as a means to quench thirst in feverish conditions, and juice with honey – for cough, sore throat, rheumatism, and hypertension. Berries have tonic, refreshing, and invigorating properties, they improve mental and physical performance, and increase the secretion of pancreatic and gastric juice. They are used as an antipyretic and vitamin remedy, especially for hypo- and vitamin deficiency. As a remedy with diuretic and antimicrobial properties, cranberries are used for the prevention and treatment of kidney, urinary tract and bladder diseases, hypoacid gastritis, and initial forms of pancreatitis. Cranberry is contraindicated for patients with peptic ulcer disease and acute inflammatory processes of the gastrointestinal tract (Pro korisni 2021; Komarnytsky 2023).

CRANBERRY IN PHARMACOPOEIAS

The United States Pharmacopoeia includes Cranberry Liquid Preparation which must contain a certain amount of quinic, citric, and malic acids, as well as dextrose, fructose, sorbitol, and sucrose. The Canadian governmental organization Health Canada has accepted the preparation Dried Cranberry Juice which most complies with the U.S. Cranberry Liquid Preparation (Monagas 2018). Cranberry is also included in the American Herbal Pharmacopoeia (Cranberry fruit) and Martindale's 37th edition (Herbal Medicines 2013). The American Herbal Pharmacopoeia (2011: 689) describes a microscopic characterization of cranberry fruits and contains the following short statement: "Cranberry juice, powder and powdered concentrates are common ingredients in herbal supplements used for supporting a healthy urinary system."

It is logical that the use of cranberry is approved by the American Botanical Council (Engels 2007: 1):

> *Moving from beverages and mineral waters into dairy and confectionary products, cranberry is now also recognized as a key ingredient in the dietary supplement market. Because of the increased awareness of the importance of healthy nutrition, the future of cranberry as a food and dietary supplement appears certain, and it may eventually become a recognized medicinal product.*

But this is not concerned with bog cranberry.

The European Medicines Agency worked out a draft (2021) on the American cranberry, quoting expressed juice from the fresh fruit (DER 1:0.6–0.9) for herbal preparations. The drug extract ration means that 0.6–0.9 parts of extract (juice) is expressed from 1 part of fresh fruits. There are two rather similar indications: 1) the traditional herbal medicinal product is used for the relief of symptoms of mild recurrent lower urinary tract infections such as burning sensation during urination and/or frequent urination in women, after serious conditions have been excluded by a medical doctor (50–80 ml 2–4 times daily; 2) the traditional herbal medicinal product is used for the prevention of recurrent uncomplicated lower urinary tract infections in women, after serious conditions have been excluded by a medical doctor (15–80 ml twice daily).

Special warnings and precautions for use deserve serious attention and cast doubt on the traditional use of cranberries: the use in children and adolescents under 18 years of age is not recommended because the data is not sufficient and medical advice should be sought. The use in men and pregnant women is not recommended because lower urinary tract symptoms in these populations require medical supervision. Cranberry concentrate has a high content of oxalate, and there may be an increased risk of stone formation in the urinary tract in patients with stone history.

The antibacterial activity of cranberry works due to the inhibition of bacterial adhesion to mucous membrane of the urinary tract (Capasso et al. 2003). The adhesion activity of *Escherichia coli* is inhibited by fructose and by a polymer of a procyanidin type. The adhesive effect is associated with the content of proanthocyanidins in cranberries. It also inhibits the adhesion of *Helicobacter pylori* which causes many ulcers. Also, cranberry is suggested for kidney and bladder stones, incontinence, and for problems associated with enlarged prostate (Foster & Johnson 2006).

Information about American cranberry products on the market in the EU/EEA member states is given in Table 1 (Assessment Report 2021).

Table 1. *The American cranberry products on the market in the EU/EEA member states*

Active substance	**Indication**	**Pharmaceutical form, strength, posology, duration of use**	**Regulatory status (year, member state)**
Dried cranberry juice	To prevent and treat mild, recurrent urinary tract infections	2 capsules 3 times daily. 1 capsule contains 405 mg of dried juice from American cranberry	1996, Denmark, Iceland, MA
Dry extract, extraction solvent ethanol 70%	To help prevent recurrent uncomplicated acute urinary tract infections such as cystitis in women only, based on traditional use only	1 capsule daily. 1 capsule contains 195–216 mg of dry extract from the juice of American cranberry fruits corresponding to 36 mg of proanthocyanidins	UK (2016), TUR
Dry extract, extraction solvent ethanol 70%	To prevent the recurrence of acute uncomplicated lower urinary tract infections (cystitis) based solely on traditional use	1 capsule daily. 1 capsule contains 195–216 mg of dry extract from the juice of American cranberry fruits corresponding to 36 mg of proanthocyanidins	Spain (2017), TUR
Dry refined extract. DER 250:1	To prevent the recurrent urinary tract infection in healthy non-pregnant women	1 capsule contains 195–216 mg of dry extract from the juice of American cranberry fruits corresponding to 36–40 g cranberry juice and 36 mg of proanthocyanidine	NL (2019), TUR

Many EU countries indicated that there are no medicinal cranberry products on the market, but only a food supplement and/or food. These products are based on cranberry juice which is predominately made from fresh or frozen fruits either by extracting in water or pressing. Juice concentrate is made by hot mash depectinization of fresh or frozen fruits. For example, dietary supplement Urinal (made by Walmark) contains capsules of dried cranberry juice (200 mg/cps) which helps maintain the urinary tract before or at the time of feeling signs of infection. The food supplements of the American cranberry are available in the USA, Argentina, Australia, Canada, Singapore, and elsewhere.

In 1997, the American cranberry was in top 10 of the preparations (fresh berries, juice products, gelatinized products, capsules, etc.) sold by herbalists in the USA. Both medicinal and dietary products of cranberry are sold outside the EU/EEA. The content of biologically active compounds differs markedly between products and is affected by the processing method (Assessment Report 2021).

CRANBERRY IN SCIENTIFIC MONOGRAPHS

On an international scale, it is important to take a look at the WHO compendium of medicinal plants, which essentially expresses the opinion of experts from around the world. A total of four collections of WHO monographs on selected medicinal plants (1999, 2002, 2007, 2009) contain the herbal drug *Fructus Macrocarponi*, which is fresh or dried ripe fruit of the large cranberry *V. macrocarpon* (WHO 2009: 149–166). As is typical of the publication, apart from the pharmacognostic aspects, among other things, the pharmacological properties of the drug are discussed in depth, including antimicrobial and antiadhesive activity, antioxidant activity, clinical pharmacology, paediatric populations, urolithiasis, adverse reactions, contraindications, etc. The section "Uses" supported by clinical data states (WHO 2009: 153): "Orally as adjunct therapy for the prevention and symptomatic treatment of urinary tract infections in adults." Results from clinical trials do not support the use of cranberry in paediatric population. However, bog cranberry (*V. oxycoccus*) is not included in the four volumes of monographs.

The E/S/C/O/P monographs (2003, 2009) combine the efforts of the experts of the European Scientific Cooperative on Phytotherapy, as a result of which, similar to the WHO monographs, the herbal drug *Vaccinii macrocarpi fructus* (ripe, fresh or dried fruits of the large cranberry) has been included in the collection of herbal monographs. The therapeutic indication of fruits of the American cranberry is the prevention of urinary tract infections. The recommended dosage for adults is 300–750 ml per day of the cranberry liquid preparation containing 25–100% of cranberry juice, divided into 2–3 portions; 200–500 mg of cranberry dry extract or juice concentrate twice daily (E/S/C/O/P 2009: 255).

The overall rating given to the juice and capsules of the American cranberry by the Natural Standard Herb & Supplement Handbook for urinary tract infections prevention is grade B (good scientific evidence); other possible activities have received just grade C (unclear or conflicting scientific evidence) or even D (fair negative scientific evidence) (Basch & Ulbricht 2005: 162–167). The Physicians' Desk Reference for Herbal Medicines mentions as "probable efficacy" of the American cranberry (PDR 2007: 239) the preventive use of urinary tract infections. All other uses (anorexia, blood disorders, cancer treatment, diabetes, diuresis, nephrolithiasis prevention, radiation damage to the urinary system, scurvy, stomach ailments, and wound care) have been listed as "unproven uses".

The comprehensive monograph titled *Herbal Medicines* (2013: 227) is more critical: there is some evidence to support the efficacy of cranberry juice for the prevention of urinary tract infections in women; all others have been mentioned as the traditional usage of cranberry. The term 'cranberry' refers to both the American cranberry and bog cranberry, which equalizes the possibilities of their use. In the academic publications on pharmacognosy and phytotherapy (Heinrich et al. 2004: 250–251; Mahady & Fong & Farnsworth 2001) only the American cranberry has been mentioned.

PHYTOCHEMICAL RESEARCH

The main part of experiments and research is done with the American cranberry and it is proven that the active substances of cranberries are tannins, flavonoids, glycosides (vaccinin and ethers), pectins, 3–4% of organic acids (ursolic, chinic, citric, benzoic, and others), 10–22% of ascorbic acid, 2.3–4% of sugars (glucose and fructose), micro- and macroelements, including iodine, copper, manganese, molybdenum, iron, etc. The phytochemical profile of cranberry fruits includes three classes of flavonoids (flavonols, anthocyanins, and proanthocyanidins), catechins, hydroxycinnamic and other phenolic acids, and triterpenoids (Neto 2007; Česonienė et al. 2006; Oszmiański et al. 2017). Among other constituents are catechin, triterpenoids, and organic acids. Cranberries, both fresh and dried, are a great source of vitamins (provitamins A, C, B1, B2, and B3), organic acids, mineral salts (potassium, sodium, calcium, phosphorus, magnesium, and iron, sugars (glucose 3.1% and fructose 1%), dietary fibre, and pectins. The European varieties have a lower content of ascorbic acid than the American cranberries; however, the results for vitamin C amounts in these fruits are quite dissimilar (Povilaitytė et al. 1998). According to other data (Tikuma et al. 2014), on the contrary, the amount of ascorbic acid is higher in fresh berries of *V. oxycoccus* in comparision to several cultivars of *O. macrocarpus*. By Viskelis et al. (2009), the amount of ascorbic acid in American berries increases during ripening, from the beginning of ripening with white berries to 50% in reddish berries (9.3–14.2 mg/100 g), but slightly decreases in overripe berries (10.3 mg/100 g).

The content of polyphenols, carotenoids, chlorophylls, and triterpenoids was determined with the use of Ultra Performance Liquid Chromatography – Photodiode Array Detection – Tandem Mass Spectrometry method, although antioxidant activity was examined with 2,2-diphenyl-1-picrylhydrazyl, 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid, and ferric reducing antioxidant powder assays in six cultivars of cranberry fruit grown in Poland. Anthocyanins (delphinidin, cyanidin, peonidin and malvidin derivatives), phenolic acids (*p*-coumaroyl, caffeoyl derivatives and chlorogenic acid), flavonols (sinapoyl, myricetin, quercetin and metoxy-quercetin derivatives), flavan-3-ols and procyanidins ((+)-catechin (–)-epicatechin and their di-, tri- and tetramers), carotenoids (lutein, 13 *cis*-lutein, all-*trans* ß-carotene, 9-*cis* ß-carotene), chlorophylls (chlorophyll b, pheophytin b and a) and triterpenoids (betulinic, oleanolic and ursolic acids) were identified and assayed in 6 cranberry cultivars. Also, analysis of their antioxidant activity was carried out with the use of ABTS, DPPH, and FRAP assays (Oszmiański et al. 2017). Procyanidin A2, B2, cyanidin-3-arabinoside, cyanidin 3-galactosideand peonidin-3-glucoside, peonidin 3-galactoside, myricitrin, myricetin, astragalin, quercetin, *p*-coumaric acid, protocatechuic acid, chlorogenic acid, ferulic acid, caffeic acid and benzoic acid were found in cranberry fruits (Han et al. 2019; Howell et al. 2005).

The amount of biologically active compounds among 40 genotypes (13 certified cultivars and 27 wild clones) of *V. oxycoccus* fruit of different origins (Estonian, Russian, and Lithuanian) was compared (Česonienė et al. 2015). A great variation was found in anthocyanin content, organic acids, and sugar content in fruits of cultivated types and wild clones; therefore, the content of presented compounds differs depending on the cultivars. Analogously to the berries of *V. macrocarpon*, the *V. oxycoccuss* berries also contain citric acid (10.8 to 54.3 g/kg), and malic (14.1 to 43.3 g/kg) and quinic (3.81 to 13.3 g/kg) acids as the main organic acids (Česonienė et al. 2015; Jurikova et al. 2018).

The total phenolic content varied from experiment to experiment: Borowska et al. (2009) showed that the total phenolic contents for American cultivars were in the range of 192.1–372.2 mg/100 g, and in European cranberry cultivars 288.5 mg/100 g. Also, the fruits of *V. oxycoccus* contained more trans-resveratrol (712.3 mg/g) than *O. macrocarpon* (533.4–598.2 mg/g). Povilaityté et al. (1998) got results that the berries of European cultivars accumulated 100.4–154.8 mg/100 g, whereas the American cultivars had a higher content (192.3–676.4 mg/100 g) of phenolic compounds. The main phenolic compound, trans-resveratrol, is an important antioxidant (Ehala & Vaher & Kaljurand 2005).

The main representatives of phenolic acids in cranberries belong to cinnamic and benzoic acid derivatives. Hydroxybenzoic acid derivatives such as gallic acid (3,4,5-trihydroxybenzoic acid), dihydroxybenzoic acids (vanillic), 2,3-dihydroxybenzoic, 2,4-dihydroxybenzoic acids, p-hydroxyphenylacetic, hydroxycinnamic (coumaric) acids such as m-coumaric and p-coumaric acids, caffeic (3,4-dihydroxycinnamic), and ferrulic (4-hydroxy-3-methoxycinnamic) acids are presented (Abeywickrama et al. 2016; Taruscio & Barney & Exon 2004).

Flavonols including myricetin-3-galactoside, myricetin-3-arabinofuranoside, quercetin-3-galactoside, quercetin-3-glucoside, quercetin-3-rhamnospyranoside, and quercetin-3-O-(6″-p-benzoyl)-galactoside belong to the predominant flavonoids in cranberry fruit (Singh et al. 2009; Jurikova et al. 2018).

In cranberries, the amount of anthocyanins is much lower than in bilberries and significant genetic variability was found especially in the levels of total and individual anthocyanins (i.e., cyanidin-3-galactoside, cyanidin-3-glucoside, cyanidin-3-arabinoside, peonidin-3-galactoside, peonidin-3-glucoside, and peonidin-3-arabinoside) (Česonienė et al. 2015). Juices of cranberry fruit cultivars could be distinguished by prevailing individual anthocyanins with thermostable galactoside and glucoside conjugates (Jurikova et al. 2018). Four anthocyanin compounds – cyanidin-3-galactoside, cyanidin-3-arabinoside, peonidin-3-galactoside, and peonidin-3-arabinoside – predominated in the fruit samples of American cranberry cultivars grown in Lithuanian climatic conditions (Urbstaite & Raudone & Janulis 2022).

Proanthocyanidins belong to the class of polyphenols with repeating catechin and epicatechin monomeric units. Proanthocyanidins are the leading compounds of the phenolic compounds of European cranberry (Česonienė et al. 2015). The European cranberry accumulates 1.5–2.0 mg/100 g of proanthocyanidins (Määttä-Riihinen et al. 2004). Proanthocyanidins are responsible for organoleptic, anti-inflammatory, antibacterial, and antiviral properties of cranberry fruits (Jurikova et al. 2018; Česonienė et al. 2015). The three A-type trimers and procyanidin A2, which are the major bioactive compounds in the American cranberry, are present only in trace amounts in the European cranberry, and they are responsible for different biological activities and clinical effects of both cranberries, especially on the urinary tract (Jungfer et al. 2012). On the other hand, the losses of proanthocyanidins A2 and B1 that may occur during manufacturing processes and storage of cranberry extracts were detected by Boudesocque et al. (2013).

Both the American and European cranberry as traditionally used crops accumulated a high level of polyphenols. The results of the studies also pointed out that the fruits of the European cranberry represent a more valuable source of caffeic acid and quercetin, with higher values of total flavonols in comparison to the American cranberry (*Vaccinium macrocarpon*) (Jurikova et al. 2018; Stobnicka & Gniewosz 2018; Marzullo et al. 2022; Gniewosz & Stobnicka 2018).

Berries of the European cranberry grown in colder climates, without fertilizers or pesticides, are characterized by a higher content of phenolics than the cultivars grown in milder climates. The differences in the accumulation of phenolic compounds can also be explained by various conditions of cultivation, region, weather conditions, harvesting time, and maturity stage (Häkkinen & Törrönen 2000; Viskelis et al. 2009).

The technological processes related to the storage of cranberry (*V. oxycoccus*) products also exert influence on the content of phenolics. Thus, in frozen fruits the content of phenolics is much lower than in freeze-dried fruits. Lyophilization of the fruits of this species resulted in the phenolic content reduction compared to fresh fruits (Mazur & Borowska 2007).

The peel of cranberry fruits contains a substantial amount of pentacyclic triterpenoid ursolic acid (Neto 2007). There are many fatty acids and phytosterols in fresh berries (Klavins et al. 2016). The GC-MS analyses showed main compounds such as benzyl alcohol, α-terpineol, 2-methylbutyric, malic, citric, benzoic, and cinnamic acids in addition to fatty alcohols and acids (Lyutikova & Turov 2011).

PHARMACOLOGICAL RESEARCH

Cranberry juice (450–720 mL daily) lowered urinary pH (Fellers & Redmon & Parrott 1933; Kahn et al. 1967; Kinney & Blount 1979; Jackson & Hicks 1997; Nahata et al. 1981), but it could not exert a bacteriostatic effect because it was not a rich enough source of hippuric acid (Bodel & Cotran & Kass 1959; Avorn et al. 1994).

The inhibition of bacterial adherence after the use of cranberry juice was first reported in 1984 (Sobota 1984). Since then, several studies have confirmed that the presumed efficacy of cranberry in preventing urinary tract infections (UTI) is related to its antiadherent properties (Schmidt & Sobota 1988; Zafriri et al. 1989; Ofek et al. 1991; Howell et al. 1998, 2005, 2010; Foo et al. 2000; Howell & Foxman 2002; Lee et al. 2000; Amin et al. 2022).

Further antibacterial adhesion studies demonstrated that cranberry constituents also inhibit the adhesion of *Helicobacter pylori*, a major cause of gastric cancer, to human gastric mucus (Burger et al. 2000). A subsequent randomized, double-blind human trial found significantly lower levels of *H. pylori* infection in adults consuming cranberry juice (Zhang et al. 2005).

The results of clinical studies evaluating the effect of cranberry on urinary tract suggest a possible clinical benefit of cranberry juice in preventing the UTI or that it is effective in the prophylaxis of recurrent UTI (Raz & Chazan & Dan 2004; Stothers 2002; Kontiokari et al. 2001; Jepson & Williams & Craig 2012; Kiel & Nashelsky 2003). Another nonrandomized study (Terris & Issa & Tacker 2001) found decreased leukocyte counts in urine samples obtained from handicapped children (most with indwelling catheters) who drank cranberry juice. Nevertheless, ingesting large quantities of cranberries over a long duration may increase the risk of some types of urinary stones in high-risk patients because of the increased urinary excretion of oxalate and slight urinary acidification (Harkins 2000; Howell et al. 2010; Kim et al. 2012).

European cranberry extracts inhibited the growth of a wide range of human pathogenic bacteria, both Gram-negative (*Escherichia coli* and *Salmonella typhimurium*) and Gram-positive (*Enterococcus faecalis, Listeria monocytogenes, Staphylococcus aureus,* and *Bacillus subtilis*) (Jurikova et al. 2018; Lian & Maseko & Rhee 2012; Lacombe et al. 2013). Moreover, berry juice of *V. oxycoccus* displayed a binding activity of *Streptococcus agalactiae* and *Streptococcus pneumoniae* (Toivanen et al. 2010).

Cranberry fruit extracts possess anti-influenza viral effects (Sekizawa et al. 2013) and rank high among fruit in both antioxidant quality and quantity (Vinson et al. 2001) because of their substantial flavonoid content and a wealth of phenolic acids. Cranberry extracts rich in these compounds reportedly inhibit oxidative processes including oxidation of low-density lipoproteins (Yan et al. 2002; Porter et al. 2001), oxidative damage to rat neurons during simulated ischemia (Neto 2007), and oxidative and inflammatory damage to the vascular endothelium (Youdim et al. 2002). The antioxidant properties of the phenolic compounds in cranberry fruit may contribute to the observed antitumor activities of cranberry extracts, but recent studies suggest that cranberry's anticancer activity may involve a variety of mechanisms.

Because of the high antioxidant activity of *Vaccinium* species, especially due to the anthocyanins content, cranberry is able to inhibit the oxidative process related to tumorigenesis. Furthermore, the in vitro model experiment showed direct antiproliferative or growth-inhibitory properties of the in vitro model (Jurikova et al. 2018; Neto 2007; Weh & Clarke & Kresty 2016).

Cranberry powder obtained from fresh cranberry fruits by freeze-drying showed promising anti-inflammatory and anti-colon-cancer potential in HCT116 cells (Han et al. 2019). Also, anticancer properties of cranberry phytochemicals were confirmed by in vitro studies (Neto 2007).

The IC_{50} values obtained for cranberry juice concentrate (CJC) were 847.9, 637.4, and 440.6 μg/mL for 24, 48, and 72 hrs respectively. Change in the mitochondrial membrane potential and nuclear morphology was observed following incubation with the CJC. Flow cytometric analysis shows cells detected at early and late apoptotic stages after treatment with the CJC. Thus, the CJC has significant effects on MG-63 osteosarcoma cells and can be considered to supplement conventional therapeutic strategies (Hattiholi et al. 2022).

Dietary supplementation with cranberries (a product rich in antioxidants) in breastfeeding mothers during 21 days improved the oxidative status of milk. Several specific markers increased in the milk samples from mastitis-affected women, providing a protective mechanism for the newborn drinking mastitis milk. Cranberry supplementation seems to strengthen the antioxidant system, further improving the antioxidative state of milk (Valls-Bellés et al. 2022).

Cranberries are promising in reducing the risk of cardiovascular diseases (Ruel et al. 2005), atopic dermatitis, Alzheimer's disease, macular degeneration, neurodegenerative diseases, and diabetes (Krishnaiah & Sarbatly & Nithyanandam 2011; Hannoufa & Hossain 2012; Gasmi et al. 2023), and show antimutagenic, anti-inflammatory and anti-bacterial properties (Vattem et al. 2006; Mueller et al. 2013).

The regular consumption of cranberry fruits has a positive effect on hypertension, inflammation, oxidative stress, endothelial dysfunction, arterial stiffness, and platelet function. Polyphenols in cranberries reduce ROS (reactive oxygen species), decrease the concentration of inflammatory cytokines, and enhance endothelium – dependent vasodilation and inhibited platelet activation (Blumberg et al. 2013). The anti-inflammatory effect of the European cranberry could have a positive effect on blood pressure and vascular function (Kivimäki et al. 2011, 2012).

Cranberries could be effective also in the prevention of heart diseases and ulcer illnesses of the digestive system (Vattem et al. 2005). However, antiadhesion and anti-platelet bioactivities do not correlate directly with total phenolics, anthocyanins, or proanthocyanidin content, and the beneficial effect of fruit phenolics can be realized only after their digestion and absorption in the body (Kalt et al. 2007).

Daily cranberry supplementation (equivalent to 1 small cup of cranberries) over a 12-week period improves episodic memory performance and neural functioning, providing a basis for future investigations to determine efficacy in the context of neurological diseases (Flanagan et al. 2022).

Cranberry juice slightly improves the rotenone-induced behavioural deficit by protecting from apoptosis and α-synuclein accumulation in the midbrain of rotenone-treated rats, demonstrating its neuroprotective efficacy for Parkinson's disease. These findings suggest that cranberry preparations may have a potential application in clinical practice or dietary guidelines for the prevention and/or adjunctive treatments of Parkinson's disease (Witucki et al. 2022).

CONCLUSIONS

The European cranberry (*Vaccinium oxycoccus* L.) has been less studied from the phytochemical and pharmacological point of view than the American cranberry (*Vaccinium macrocarpon* Aiton). Cranberry-based preparations (i.e., tablets, capsules) and juice available in the European market most often originate from *O. macrocarpon*, and the fruit of *V. oxycoccus* is used very rarely. On the other hand, the geographical distribution of the European cranberry is wider (in natural bogs of Europe, Asia, and North America) and it is less demanding in comparison with the American cranberry.

The European and American cranberries are excellent sources of bioactive compounds, especially polyphenolic compounds (i.e., flavonoids, anthocyanins, and phenolic acids), which have significant antioxidant properties.

Popular use refers to cranberry as a food plant and as such it has been used in homes and catering establishments, schools, hospitals, etc. In ethnomedicine, it has the surest place as a reliever of certain symptoms – for example, fever – in the treatment of serious diseases. In the twentieth century, the uses expanded, but in Estonia they did not include urinary diseases, which are recognized by official phytochemistry and pharmacy. Obviously, the everyday use of cranberries as effective medical plants will increase in the near future.

Cranberry fruits and their preparations represent important natural preservatives against bacterial and fungal growth. Also, their anti-inflammatory properties can be helpful in the prevention and treatment of cardiovascular problems and several types of cancer and neurological diseases. Considering various beneficial effects of cranberries on human health, also in folk medicine, the consumption of these fruits and their products is widely recommended.

Other parts of the plant, such as leaves, are also rich in biologically active substances, which can be sources for creating new medicines, so they require further in-depth phytochemical and pharmacological research.

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NOTE

1 Hereinafter the data are available at https://www.folklore.ee/rl/fo/tegevus/wp/ressursid/Raal et al. Cranberry_final_AR_edit_AR_MK.pdf, last accessed on 20 July 2023.

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