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STUDY ON THE CONTENT OF POLYPHENOLS IN SOME PLANTS FROM THE SPONTANEOUS FLORA FROM THE MOUNTAINOUS AREA OF SUCEAVA COUNTY

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Abstract: *In recent years, there has been a growing trend towards natural remedies and treatments, based on plants and plant extracts.*
In the mountain area of Suceava county there are plants that the locals use for therapeutic purposes, but which are very little known, or are not known as medicinal plants. Among them are Sorbus aucuparia, used as a tonic and energizer, in the form of wine, Carlina acaulis, popularly used to relieve coughs or the Centaurea Jacea, used as a remedy for liver diseases.
Among the recently researched bioactive compounds are polyphenols, a large category of natural organic compounds, characterized by multiple phenolic groups. Recent studies associate the presence of polyphenols in medicinal plants with a multitude of health benefits, many of them due to the antioxidant potential of polyphenols, which explains their role in the prevention of several major chronic diseases associated with oxidative stress, such as cardiovascular diseases, cancers, type II diabetes, neurodegenerative diseases, age-related cognitive disorders or osteoporosis, along with the anti-inflammatory, antiviral, antibacterial effects of polyphenols.
The aim of the study is to identify and determine the content of polyphenols in ethanolic, ethereal and benzene extracts of fruits of Sorbus aucuparia, of Carlina acaulis flowers and leaves and Centaurea jacea, flowers, leaves and stems.
The fruits of Sorbus aucuparia contain significant amounts of polyphenols: gallic acid, 4-hydroxybenzoic acid, caffeic acid, p-coumaric acid, rosmarinic acid, myricetin and a very high amount of quercetin, surpassed only by black elderberry, according to current data. Gallic acid and vanillic acid also occur in the aerial parts of Carlina acaulis, along with chlorogenic acid, p-coumaric acid, rosmarinic acid, quercetin and kaempferol, in varying proportions between flowers and leaves. The presence of gallic acid and vanillic acid is noted in all aerial parts of Centaurea jacea, as well as chlorogenic acid, p-coumaric acid and kaempferol. Significant amounts of rosmarinic acid, myricetin and quercetin occur in greater quantity in the flowers and less in the other aerial parts.
The determinations made recommend the advanced study of these plants in order to use them as health remedies.

Keywords*: Sorbus aucuparia, Carlina acaulis, Centaurea jacea, poliphenol, quercetin, myricetin, rosmarinic acid, gallic acid.*

1. Introduction

Since ancient times humankind has been using plants, to feed itself or for other material needs, to prevent and treat various diseases. Empirical discovered cures along millenia were temporary forgotten as synthetic drugs appeared, but currently the plants return to human attention because their usage present a series of undisputed advantages among them being: they stood the test of time - scientific research often confirms already known effects, the human body is one hundred percent compatible

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with natural products, plants active substances act in a holistic and synergistic way, they have a low side effects risk, detoxify the body and work on different levels.

Phenolic compounds are a large group of plants secondary metabolites [1], which play relevant parts being involved in natural resistance mechanisms against biotic and abiotic stress. They contribute to plants structural integrity, UV photoprotection, cold protection, pollinators attraction or as fitoalexine against patogenic agents and herbivores [2]. Some of them are coloured, and therefore were used in history as dyes [3]. To some authors, poliphenols are divided in four categories: flavonoids, lignans, stilbene and phenolic acids [4].

Flavonoids, which represent almost 60% of all poliphenols, include flavone, flavanols, flavanones, isoflavones, proantocianidine and anthocyanins [5].

Polyphenols are important parts of vegetal origin food products. Fruits, vegetables and drinks are the main sources of phenolic compounds from human diet. These compounds are directly linked to sensorial traits of foods such as: flavour, astringency and colour [6].

Due to the presence in their structure of one or more phenolic groups, polyphenols are capable to reduce oxygen reactive species from different mineral and organic substrates, therefore being antioxidants [7-9]. Due to their capacity of inhibition of the free radicals formation, reducing oxidative stress level, antioxidants can prevent major chronic diseases associated with oxidative stress [8] and aging linked damages, so they can prolong healthy longevity. [10].

The present study evaluates polyphenols content in three plants from spontaneous flora in mountain area of Suceava county, plants used by the locals as medicinal plants, respectively rowan berry (*Sorbus aucuparia*), a wild fruit tree, dwarf carline thistle or silver thistle, (*Carlina acaulis*), which was used in the past as medicinal plant presently forgotten and brown knapweed (*Centaurea jacea*), a plant on which there are no studies about its chemical composition or its health potential.

2. Polyphenols effects

Degenerative diseases

Phenol compounds draw a lot of attention lately because their food intake was associated with degenerative and chronic diseases prevention, diseases that are major causes of death and incapacity in developed countries and also with diminishing major damages responsible for ageing [11]. In the present, it is considered that these compounds are responsible, at least partially, for protecting effects of rich fruits and vegetable diets, as a result the study regarding their role on human nutrition became a central issue in foods research [12].

Epidemiological evidences were gathered that indicate the existence of reverse correlations between the food intake and the dropping in incidence and mortality rate due to numerous degenerative diseases [13].

It was shown polyphenols beneficial potential in preventing neurodegenerative diseases such as Alzheimer and Parkinson [12], and also in prevention and improvement of cognitive decline [14-16].

Some polyphenols compounds regulate glucose metabolism in blood through amplifying the cell resistance to insulin. Their antioxidant nature and metal chelation activity, their capacity to catch intermediary dicarbonil compounds could be possible mechanisms against glication and advanced glication end products formation [18].

Cardiovascular system

In the last years, a number of studies supported the beneficial effects of

polyphenols intake on health, especially on the cardiovascular system, in the context of cardiovascular diseases being the main cause of death worldwide [19]. Due to their antioxidant properties, these compounds show vasodilatory effects and can improve the fat profile by reducing low density lipoproteins oxidation [19].
Mediterranean diets and the „French paradox" phenomenon and also the clinical and experimental studies show polyphenols antihypertensive effect, either in prevention or in therapy [20].
Furthermore, through proven anti-inflammatory effects they can modulate apoptotic processes in the vascular endothelium [21, 22].

Anti-cancer effects

Polyphenols antioxidant properties reduce oxidative stress caused by ROS and as such they reduce the risk of developing cancer [23, 24]. Furthermore, polyphenols modulate epigenetic activity [25, 26], playing a major role in regulating mammals epigenome [27]. There is clear evidence that indicates their anti-cancer direct activities in certain types of cancer such hepato-carcinoma, prostate cancer, leukemia and limfoma, breast and ovarian cancer and gastrointestinal cancer [28]. Various studies conducted all over the world suggested that polyphenols can inhibit tumor apparition, can induce apoptosis in cancerous cells and can interfere in tumors progression [29].
Natural flavonoids have anti-inflammatory and antioxidant activities and also anti-cancer activities through various ways, being efficient in breast cancer, colorectal and prostate cancer (through cell apoptosis), in pulmonary cancer, bladder and colon cancer, etc [30-32].
More, natural polyphenols act synergistically with clinically approved present drugs, making them more efficient [33, 34] and can be used to design a potential treatment in combination with existing drug cancer schemes or chemotherapy or radiotherapy [35]. Also, the phytochemicals from plants have biological compatible properties to using them as adjuvant therapy in reducing side effects of cancer therapy, including antioxidation, antimutagenic, anti inflammation, myelin protection and immunomodulation [28, 36].

Metabolic syndrome

Modern pharmacological studies have shown that polyphenols can reduce blood pressure, can improve fats metabolism, can lower the glycemic levels and can reduce body weight, preventing and improving the effects of metabolic imbalances [37].
Taking into consideration their free radicals captation and anti-imflamatory properties, these substances can be used to treat different types of disorders associated with metabolic problems. Lots of metabolic syndromes, including obesity, dyslipidemia, atherosclerosis, high blood level of sugar, diabetes, acceleration of ageing process, liver intoxication, high blood pressure, cancer and neurodegenerative disorders are substantially improved by food polyphenols [38, 39].

Other actions

Significant evidence shows that polyphenols protect against mitochondrial lesions in different experimental models of kidneys diseases. From a mechanical point of view, polyphenols regulate mitochondrial redox state, apoptosis and numerous intercellular signaling ways in preventing and treatment of kidney diseases [40].
A study proves some polyphenols' role in mitigation of the ulcerative colitis severity in humans. Polyphenols are used as alternative therapy because most conventional drugs have quite severe side effects [41].

Among those, one can notice the anti-inflammatory effects of polyphenols. Recent evidence shows these compounds can give anti-inflammatory activity and/or stabilization of inflammatory response which can have important implications in health preservation and disease risk reduction [42].

In attempt to synthesize antiviral agents with effective activity, it was remarked that natural bioactive flavonoids present on a high scale in plants have antiviral activity but they can be concentrated and modified for a more efficient action [42].

Numerous studies show that polyphenols increase the antioxidant capacity of oral fluids, suggesting a preventive effect against tooth decay and inactivate periodontal pathogens, preventing periodontal disease. Other studies claim directly and indirectly the polyphenols effect on oral cancer [43].

There are some evidences that these phytochemicals can improve wounds healing [44].

The polyphenols effects on health depend on the ingested quantity and their bioavailability [6, 9]; the precise action activity of polyphenols compounds is unknown [45]. Diet polyphenols potential to induce therapeutic effects could be attributable, at least partially, to a bidirectional association with gut micro-biome. This is due to the fact that it is known that polyphenols affect gut micro-biome composition in ways that lead to a better human health [4]. More precisely, gut micro-biome transforms polyphenols in bioactive compounds which have therapeutic effects [4, 46], therefore the structural integrity and well function of the digestive tract are essential in optimal absorption of polyphenols [35].

On the other side, polyphenol bio accessibility is highly dependent on food matrix and the way in which the food is processed [47].

Some diet polyphenols can have significant effects on colon flora, giving a prebiotic kind of effect [48].

Although polyphenol intake deficiencies don't result in specific deficiencies diseases, the right polyphenols intake can give health benefits, especially in chronic diseases [49].

3. The description of studied plants

a) ***Sorbus aucuparia*** **b)** ***Carlina acaulis*** **c)** ***Centaurea jacea***

Figura 1 a) ***Sorbus aucuparia – fruits*** **; b)** ***Carlina acaulis*** **; c)** ***Centaurea jacea***

Sorbus aucuparia

Sorbus aucuparia, (Figura 1a) named rowan, bird's eye, Siberian mountain ash, Siberian keirn, cuirn and wiggin witch tree [50], is a deciduous tree (in milder climate grows as a tree) which belong to the *Rosales order, Rosaceae* family, *Maloideae* subfamily.

It grows on rocky places, well drained, in deciduous or even softwood forests, even in peatland from mountain level to subalpine level, on sunny slopes, throughout entire Northern hemisphere, in low and high altitudes from Atlantic coasts of Europe to Peninsula Kamchatka and East China [51, 52]. It is stress tolerant species, frost and shadow resistant. It bears well drought if it is not prolonged [53, 54].

The bark is first smooth, grey (hence its name) and later it forms a slim rhytidoma and cracked in wide strips.

The leaves are oddly composed, long up to 10-25 cm, with 9-19 leaflets pairs and shared petiole which become orange in autumn. The inflorescences are corymb, multiflora, thick, (approx. 250 flowers), 10-15 cm wide, white, with pleasant smell [54, 55].

The fruits are false drupe, globular, more long than wide, ovate, rarely ellipsoidal, of 8-10 mm din diameter, red, rarely red-orange. They stay in the tree in the winter, giving food to the birds. the seeds are narrow, elongated, reddish, 2-3 in each fruit [56].

Among the fact that *Sorbus aucuparia* is an ornamental plant, the nutritive and biopharmaceutical of *Sorbus aucuparia* fruits are known since ancient times. They were used as food ingredients fresh in juices, jellies, alcoholic drinks, but also as remedies for some diseases and disorders: gastrointestinal blockages, constipation, liver and gallbladder problems, respiratory system infections, kidney problems, rheumatism, scurvy or as diuretics, anti inflammatory, vasorelaxation and vitamin products [57-63].

Due to their bitter tangy taste, presently they are underused, although there is a series of studies on chemical composition and biopharmaceutical effects of rowan berries in different parts of the world [64, 65]. In Dorna area they are used for their tonic and restorative effect, as wine.

Carlina acaulis

Carlina acaulis, (Figura 1b) popularly known as the stemless carline thistle, dwarf carline thistle, or silver thistle is a plant from *Asteraceae* family, *Carlina* order, *Carlina acaulis* species. It is an herbaceous plant, without stem (*acaulis*) perennial, temperature and pH amphitolerant, found in grasslands and meadows which it depreciates in quality, more common in mountain area [53, 66]. It loves light, it is resistant to low temperatures and drought. It grows on poor, rocky soils in the mountain region. It renews itself annually through basal buds which appear under the basal leaves' rosette [67].

The rhizome is thick, pivoting, short stem, 1 – 2 cm or absent [53, 66]. The leaves are piled up in rosette, on the surface of the earth, have up to 20 cm, are crusty and deeply divided in 10 – 12 pairs of toothed and spinous divisions. In the middle of rosette one can usually find one single big capitulum (1 – 12 cm), with brown reddish, numerous and tubular flowers. Around the capitulum are gathered, as a star rays, elongated, dried, bright white, sharp at the tip and stinging modified leaves, which give the impression they are the petals of a single flower and make up an inner involucre. Underneath one can find another exterior involucre, made of little thorny, toothed leaves [68]. These leaves close in the evening or during rainy days [69, 70].

Its flowers in July-September. The fruits are small (4 – 5 mm) smooth hairy achenes, with a doll of 3 – 4 times longer than the achene [53, 70].

While the plant is young the flower bud can be eaten fresh like anchovy, this being the reason for its name of „hunter bread" [53].

There are many testimonies about *Carlina acaulis* usage in popular medicine [71-74]. The plant was recognized on a large scale in antic and medieval medicine. Its root was used in the treatment of different dermatological diseases [75], as a diuretic and diaphoretic agent. It is believed that the plant has its name from the Emperor Carol the Vth, as it was presumed that his army was cured from the plague in Berber [68]. Nevertheless, at the end of the XIXth century, the medicinal usage of *C. acaulis* root stopped.

The dried roots of *C. acaulis* contain up to 2 % essential oil, the main component (up to 99%) being carlina oxide [2-(3-fenilprop-1-inil) furan]. This compound has multidirectional biological activity, including antibacterial and anti-fungal [76], but also a certain degree of toxicity with a great potential as bio insecticide. A series of current research is aimed at this potential [77-81].

Although carlina oxide toxicity is selective and there are studies that shows effects on different cancers or infections [75, 82-86], a series of researches regarding the usage of *Carlina acaulis* extracts for therapeutical purpose shows that these should completely lack carlina oxide [87].

There is scarce information on aerial parts of *Carlina acaulis* usage in medicine, but in the Dorna area *Carlina acaulis* herba is prepared as infusion against cold and cough. When they catch a cold in winter time, the peasant search in the hay for silver thistle flower to prepare an infusion and they testify on its efficiency.

Centaurea jacea

Centaurea jacea, (Figura 1c) brown knapweed or brownray knapweed, is a species of herbaceous perennial plants from *Asteraceae* family, in the genus *Centaurea*, spread on the meadows of North Europe [88].

The rhizome is thick, and the stem is erect, 10-80 cm high, beveled, branched. The leaves are hairless, green, basal petiolate, whole, narrow upper, lanceolate. Inflorescences are of the anthodia type, bracted at the base. The flowers are rose or purple, the marginal ones are radiant. Its flowers from June to September. The fruits are 3 mm long achene, without pappus [53].

It is regarded as an invasive plant, which produce a vast number of seeds resistant up to 5 years in the soil [89]. It has few natural enemies and the flowers are eaten by animals only if other food is not available.

There are several references on using some *Centaurea* in European popular medicine such as for the treatment of ophthalmia, fever, gynecological problems, digestive disorders, wounds and skin diseases [90, 91]. In Romania, in Dorna area, it is used as remedy for liver diseases.

The invasive plants cause economical losses in agriculture, therefore the research dedicated to these plants aim more how to destroy them and less their biological properties. As the synthesis antibiotics resistance grows, invasive plants which show a significant antimicrobial activity can be a source of bioactive compounds, especially as they have a rapid growth even on limited resources [92].

Centaurea is still a less studied gender, from chemical and pharmacological point of view. There are some *Centaurea* species used in pharmacology and cosmetics (*C. cyanus, C. nigra, C. orientalis, C. phrygia*) [93, 94]. *Centaurea jacea* is a perennial plant often used in popular medicine for skin diseases and fever. More, there are

reported anticancer, antioxidant, antibacterial and antiviral properties of its bioactive compounds [95].

A study made on several *Centaurea* species in Russia shows that *Centaurea jacea* had the most powerful antioxidant effect and was ranked first regarding the total content of flavonoids (11.9 mg/L quercetin in flowers) but also the highest toxicity [96].

A series of studies shows a significant activity of *C. jacea* extracts of inhibition the growth of some type of cancer cells with 57-58% [90], centauredeine being the compound with the highest activity [97]. Other bioactive compounds responsible for medicinal characteristics identified in *Centaurea gender* are sesquiterpene lactones and flavonoids [98].

4. Materials and methods

Harvested plants from Coșna commune, Suceava county, situated at 860 m altitude were used:

Sorbus aucuparia: area located at 47,372834 latitudes and 25,179667 long, GPS 70 stereo coordinates: x = 513691.543 m, y = 652618.786 m,

Carlina acaulis: area located at 47,374281 latitudes and 25,179233 long, 70 stereo coordinates: x = 513671.261 m, y = 652765.628 m și

Centaurea jacea: area located at 47,387437 latitudes and 25,149068 long, 70 stereo coordinates: x = 511283.397 m, y = 654175.209 m.

Aerial parts from plants were used for determinations during flowering period and dried through natural means, in shadows and solvent extracts: ethanol, ether and benzene.

For *Rowan berries* 5 g sample was added, fruits for 100 ml solvent, respectively alcohol, ether and benzene, resulting a 20 dilution factor.

For *Carlina acaulis* 2.5 g sample was added, flowers and fruits for 100 ml solvent, respectively alcohol, ether and benzene, resulting a 40 dilution factor.

For *Centaurea jacea* 2.5 g sample was added, flowers, fruits and stemsc for 100 ml solvent, respectively alcohol, ether and benzene, resulting a 40 dilution factor.

The identification and determination of polyphenols content

Phenolic extracts were analysed using a HighPerformance Liquid Chromatography System (HPLC) (Shimadzu, Kyoto, Japonia) equipped with a LC-20 AD liquid chromatograph, SIL-20A autosampler, CTO-20AC column oven and an SPD-M-20A diode matrix detector. The separation was made on Phenomenex Kinetex® 2.6 μm Bifenil 150 × 4.6 mm column, with 0.5 ml/min debit, thermostated at 25°C.

Sample injected volume was of 10 μL. A solvent system consisting of 0.1% acetic acid in water (solvent A) and acetonitrile (solvent B) was used with the following gradient: starting with 100% A and installing a gradient to obtain 5% B at 6.66 min, 40% B at 66.6 min and 80% B at 74 min, according to the method previously described with some modifications [99]. Solvent debit was of 1 ml/min.

Phenols compounds were identified based on retention times of the standard materials and the quantification was made through absorbance recorded in chromatograms against the external standards, at 280 nm for gallic acid, protocatechuic acid, vanilic acid, p-hidroxibenzoic acid and 320 nm for chlorogenic acid, caffeic acid, p-cumaric acid, rosmarinic acid, miricetin, quercetin, luteolin and kaempferol. All standard calibration curves presented a high degrees of linearity [100].

5. Results and discussion

The identified polyphenols contents in *Sorbus aucuparia* fruits is shown in table 1.

These fruits contain a significant quantity of gallic acid 1181.332 mg/kg, but what attracts most the attention is the quercetin content, 35.126 mg/kg, much higher in comparison with other North European fruits: 12.75 mg/kg in blueberries and 5.15 mg/kg in cranberries [101]. Elder fruits, the richest fruits in quercitin, contain 27-45 mg/kg from this compound [102].

Table 1.

***Sorbus aucuparia* polyphenols content in mg/kg dw, in different solvents**

λ	Polyphenols	ethanol extracts	ether extracts	benzene extracts
280 nm	Gallic acid	1181.332	0	0
	Protocatechuic acid	0	0	0
	4-hydroxibenzilic acid	8.437	0	0
	Vanilic acid	0	0	0
320 nm	Caffeic acid	5.499	0	0
	Chlorogenic acid	0	0	0
	p-coumaric acid	76.780	0	0
	Rosmarinic acid	2.840	0	0.881
	Miricetin	2.215	0	0
	Luteolin	0	0	0
	Quercetin	35.126	0	0
	Kaempferol	0	0	0
	Total	**1312.230**	**0**	**0.881**

Quercetin, a flavonoid found in many fruits and vegetables, has unique biological qualities which are supposed to improve mental and physical performance [103]. Quercetin can play an important role in the treatment of many degenerative diseases, including Alzheimer, Parkinson disease and cerebral disorders linked with ageing, improving neurogenesis and neuronal longevity [104-106], without side effects or with insignificant side effects.

It was shown that quercetin and others flavonoids prevent the formation of the atherosclerotic plague, by preventing aggregation of platelets. It is a good antihypertensive and has anti-arrhythmic effects, [107] it is also beneficial in relieving hypotension [108]. It is known that quercetin has beneficial effects in limiting the diabetes complications [106, 107].

Among its anti-inflammatory effect, [109], quercetin has carcinostatic effects [107, 110].

Quercetin antiviral effects were investigated and proved on a great number of flu virus strains, [111] herpes virus, cytomegalovirus and varicella-zoster virus [112], also being beneficial in AIDS treatment [107]. Recent studies show quercetin anticoronavirus effect [113, 114].

P-coumaric acid can be found in large quantities 76.78 mg/kg, in comparison with other North European fruits: 20,28 mg/kg in cranberries, 17,1 mg/kg in cowberry, 6.0 mg/kg in blueberries [101].

The identified polyphenols contents in *Carlina acaulis* aerial parts is shown in table 2.

Tabel 2.

Polyphenols contents in *Carlina acaulis* aerial parts, in mg/kg dw, in different solvents

λ	Polyphenol	ethanol extracts		eter extracts		benzene extracts	
		Flower	Leaves	Flower	Leaves	Flower	Leaves
280 nm	Gallic acid	2490.293	2422.408	0	0	0	0
	Protocatechuic acid	0	0	0	0	0	0
	4-hydroxibenzilic acid	0	0	0	0	0	0
	Vanillic acid	104.652	247.890	0	0	0	38.158
320 nm	Caffeic acid	0	0	0	0	0	0
	Chlorogenic acid	22.200	61.628	0	0	0	0
	p-coumaric acid	9.513	0	0	0	0	0
	Rosmarinic acid	119.830	11.477	0	0	0	0.703
	Miricetin	0	4.233	0	0	0	0
	Luteolin	0	0	0	0	0	0
	Quercetin	5.973	7.890	0	0	0	0
	Kaempferol	3.515	4.205	0	0	0	0
	Total	**2755.976**	**2759.733**	**0**	**0**	**0**	**38.861**

One can notice a large quantity of gallic acid, 2490.293 mg/kg in flowers and 2422.408 mg/kg in leaves.

Gallic acid can be found in very large quantities in a small number of plants, up to 1% in tea dry leaves (*Camelia sinensis*) [115], in clove, up to 7835 mg/kg [116]) and in some species of chestnuts, around 5000 mg/kg [117], while in other plants the quantity is much smaller, chicory leaves contain 258.4 mg/kg gallic acid [118], bitter cucumber 267 mg/kg [119], sage contains 52.5 mg/kg from this acid, and other plants even less [120], taking into consideration plants reported as being rich in this acid. As a result, *Carlina acaulis* can be a valuable resource of gallic acid in cold areas from Northern hemisphere.

Gallic acid, known as trihydroxybenzoic acid, has pharmacological activities, such as strong antimicrobial, anti-inflammatory and anticancer activities due its remarkable antioxidant properties. Studies were conducted on oral and pulmonary cancer cells, colorectal cancer, prostate cancer, breast and cervix, epithelial carcinoma, liver cancer and this acid showed a powerful effect in shrinking cancerous tumors. Likewise, it enhanced the efficiency of anti-cancer medication combined with gamma irradiance [121-123].

Gallic acid can be effective for cognitive decline due to age and diseases, food supplementing with gallic acid (100 mg/kg) slows hypocampal neurodegeneration and cognitive impairment [124].

Some studies show that by improving fat metabolism, diabetes and its complications

are significantly attenuated 125]. It was proved very effective in ulcerative colitis [126].
Through its antioxidant, anti inflammatory and neuroprotective activities, contribute at kidney, heart, liver and stomach health protection [127], without showing any toxicity [125]. Along with gallic acid, it is observed a high content of vanilic acid in flowers, 104.625 mg/kg but mostly in *Carlina acaulis* leaves, 247.890 mg/kg, much higher than in reported content of other rich plants in this acid: 140 mg/kg in sweet basil, 61 mg/kg in thyme [120, 128].
Polyphenols content identified in aerial parts of *Centaurea jacea* is shown in table 3.

Table 3.

Polyphenols contents in *Centaurea jacea* aerial parts, in mg/kg dw, in different solvents

λ	Polyphenol	Ethanol extracts			Eter extracts			Benzen extracts		
		Flowers	Leaves	Strains	Flowers	Leaves	Strains	Flowers	Leaves	Strains
280 nm	Gallic acid	2322.190	2328.859	2295.532	0	0	0	0	0	0
	Protocatechuic acid	0	0	0	0	0	0	0	0	0
	4-hydroxibenzilic acid	0	0	0	0	0	0	0	0	0
	Vanilic acid	70.720	167.961	103.187	0	0	0	0	0	0
320 nm	Caffeic acid	0	0	0	0	0	0	0	0	0
	Chlorogenic acid	8.978	9.878	13.539	0	0	0	0	0	0
	p-coumaric acid	18.387	12.187	15.105	0	0	0	0	0	2.732
	Rosmarinic acid	404.645	18.341	21.020	0	0	0	0	0	0
	Miricetin	963.121	311.937	254.153	0	0	0	0	11.517	0
	Luteolin	0	0	0	0	0	0	0	0	0
	Quercetin	469.100	486.841	72.726	0	0	0	403.695	330.427	44.219
	Kaempferol	15.276	21.819	2.639	5.288	75.976	90.375	207.307	1418.088	1087.790
Total		**4272.418**	**3357.823**	**2777.901**	**5.288**	**75.976**	**90.375**	**611.002**	**1760.032**	**1134.741**

Ethanolic extracts are the richest in polyphenols, in benzenic extract appear only quercetin and kaempferol and in etheric extract only kaempferol.
A small quantity of gallic acid is found in all aerial parts of *Centaurea jacea*, respectively 2322.19 mg/kg in flowers, 2328.859 mg/kg in leaves and 2295.532 mg/kg in stems.
Likewise, the quercetin content is remarkable, especially in flowers, 469.100 mg/kg and in leaves 486.841 mg/kg, even higher than in red onion, regarded as the richest in this compound 390 mg/kg [129].
One can find a high quantity of miricetin, especially in flowers 963.121 mg/kg dw.
According to USDA 2018 [129], the richest plants in miricetin are some aromatic herbs: parsley 148.4 mg/kg, oregano 21 mg/kg, bay 36. 5 mg/kg and some forest fruits: aronia 185.3 mg/kg, cranberry 56.7 mg/kg, ribes nigrum 61.8 mg/kg. Mirecitin is found in high quantity in fresh onion 70 mg/kg [130].

Our results show a significantly higher content in miricetin than all the reported data.

Miricetin is a polyphenol with a similar structure like the one of quercetine, reason for it is also called hidroxiquercetin but is less frequent than quercetin [131]. It is a critical nutritive component of diet, as being a strong antioxidant offers free immunological protection and it is beneficial in maintaining health. Numerous studies show the efficiency of miricetin in different types on cancer: colorectal, ovarian, thyroid, cervical, liver carcinoma by inducing apoptosis and inhibiting the proliferation of cancer cells, as well as in leukemia [131, 132]. Miricetin has powerful anti-diabetes properties [131, 133], anti-inflammatory and against obesity properties [131]. It is a strong hepatoprotective [134] and has several cardiovascular effects [135], being efficient in atherosclerosis, thrombosis, cerebral ischemia [132] and others.

In vitro and in vivo studies show miricetin protective effect against osteoporosis [133]. Other studies show miricetin is efficient in eye problems such as cataracts or glaucoma [131].

More, miricetin has an efficient analgesic effect proven in vivo [131]. Other studies show that miricetin can be efficient against some resistance bacteria, but also against human papiloma viruses and even against HIV [131].

Rosmarinic acid is another compound with significant content, especially *Centaurea jacea* flowers 404.645 mg/kg. Rosmarinic acid is found in high quantity in aromatic herbs from lamiaceae family: rosemary, mint, sage, thyme, oregano, up to 8700 mg/kg [136], not being reported the quantity from other plants.

Rosmarinic acid is a molecule of high value for pharmacology, cosmetic products and food industry, being approved to be use as natural anti oxidant and/or preservative in food industry [137].

Rosmarinic acid inhibits adipogenesis and increases lipolysis in human adipocytes, prevents inflammation, showing potential for the treatment of obesity and inflammation linked to obesity [138]. Several studies showed its efficacy in the fight against of oral, pulmonary, colorectal, prostate, hepatocellular, breast cancer, ovarian, malignant bone tumors, pancreatic tumors, melanoma and leukemia [35, 122]. Rosmarinic acid supports hepatic function in liver failure or liver damage induced by various factors, producing liver detox and its regeneration [139-141]. Likewise, it alleviates hepatic steatosis and strongly counteracts high levels of total cholesterol [142].

Rosmarinic acid has neuroprotective effects in different patterns of neuroinflammation, neurodegeneration, neurotoxicity, oxidative stress, degenerative diseases [143, 144].

Other proved effects: antiaging, hepatoprotective, anti-inflammatory, anticancer, anti-diabetes, antimicrobial, antiviral, cardioprotective, antiallergic, antidepresive, neuroprotector, antihipertensiv [145, 146]. It is easily absorbed through gastrointestinal tract and also through skin [143].

Rosmarinic acid and miricetin can be, at least partially, responsible by the popular known beneficial effects of de *Centaurea jacea* flowers on the liver.

Benzenic extract contains an important quantity of kaempferol, 1418.088 mg/kg in leaves and 1087.790 mg/kg in stems, comparable with the quantity found in some capers sorts, on average 1042.9 mg/kg, the richest foods in this polyphenol after the existing data [147], way higher than in other greens.

Like others polyphenols, kaempferol has numerous biopharmaceutical properties, shown in many studies. It has proven to be effective especially in preventing cancer of different types, including skin, liver and colon, breast, ovarian or cervical cancer

[148-151]. Next to quercetin, kaempferol is cardioprotective and lowers the blood pressure, even in low dosage, thanks to its high bio disponibility [152].
Kaempferol delays the start and progression of neurodegenerative disorders, acting as a captor of free radicals and preserving the activity of various antioxidant enzymes. It is a potential food supplement in preventing and treating degenerative diseases such as Parkinson, Alzheimer and Huntington [153, 154]. Like all the others polyphenols, kaempferol has a strong anti-diabetes effect [155] and it is hepato-protective [156].
Kaempferol has a strong anti-inflammatory effect, acting inside the body on various ways [157]. It is proven also its osteoprotective action [158].
Kaempferol and its associated compound present antibacterial, antifungal and antiparasitic activities [159].
Numerous preclinical studies showed that kaempferol and some kaempferol glycosides have a wide range of pharmacological activities, including antioxidants, anti-inflammatory antimicrobials, anticancer, cardioprotective, neuroprotective, antidiabetics, antiosteoporotics, estrogenic / antiestrogenic, anxiolytics, analgesics and antiallergic [160].

6. Conclusion

The results show the presence of polyphenols with proven sanogenic properties, in large quantities in the studied plants and their possible use as sources of polyphenols for the preparation of food supplements or their introduction into functional foods, especially since these plants are found in abundance in the spontaneous flora of all Europe. These results explain, at least in part, the use of these plants in ethnomedicine.
It is also necessary to continue research in order to discover other phytoconstituents of these plants, which could have a synergistic or potentiating action with the polyphenols present, with considerable effects in the prevention and treatment of the various ailments that humanity is currently facing.

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