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Chemical Studies of *Artemisia santolinifolia* Turcz. ex Bess Cultivated in the Open Field

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Abstract

The Artemisia species have wide and various applications to the plant and human disease control, as well as in the pharmaceutical industry. The study's objective was to analyze macro, micro and ultra micro elements from *Artemisia santolinifolia* Turcz. ex Bess grown in Mongolia. The macro, micro and ultra micro elements were determined by using x-ray fluorescence. Cultivated *Artemisia santolinifola* Tturcz. ex Bess sample (October) has a relatively high content of calcium oxide—19.64%, magnesium oxide—6.75%, siliga oxide—6.06% and phosphorus oxide—8.956%. Cultivated *Artemisia santolinifola* Turcz. ex Bess /October/ cultivated have stable potassium oxide. The cultivated *Artemisia santolinifola* Turcz. ex Bess /October/ mainly contain elements such as barium, copper, zinc, and strontium. Yttrium and zirconium levels of cultivated *Artemisia santolinifola* Turcz. ex Bess natural *Artemisia santolinifola* Turcz. ex Bess is 1.75 and 4.77 times more, taking into account the amount of yttrium and zirconium. Cultivated *Artemisia santolinifola* Turcz. ex Bess contains antimony and rubidium at levels 50.58 and 1.23 times higher, respectively, than those in the natural *Artemisia santolinifola Turcz* ex Bess.

Keywords

Artemisia santolinifolia Turcz. ex Bess, Antimony, Zinc, Arsenic, Chromium

1. Introduction

Artemisia L has been widely used in various forms since the 9th century. Mongolian nomads of Central Asia have a long-standing tradition of using wormwood to treat various ailments.

Artemisia santolinifolia Turcz. ex Bess has traditionally been used to treat anthrax, tumors, and intestinal parasites [1].

In Tibetan medicine, *Artemisia santolinifolia* Turcz. ex Bess has been used to treat tumors and inflammation because its essential oil has bactericidal properties and the ethanolic extract contains hepatoprotectors and antioxidant [1] [2].

In Tibetan medicine, the essential oil of *Artemisia santolinifolia* Turcz. ex Bess exhibits antibacterial properties, while its ethanol extract has hepatoprotective and antioxidant effects and has been used to treat cancer and inflammation [3].

The leaves and flowers of *Artemisia santolinifolia* Turcz. ex Bess are used in Higashi and Altai to treat heart and nervous disorders [4].

In traditional Mongolian medicine, the leaves, buds, and flowers are used to treat stomach cramps, appendicitis, acute respiratory infections, inflammation of the nasal and oral mucosa, gingivitis, and to stop bleeding.

The decoction is used as a gargle, a poultice for purulent wounds and boils, and a poultice for skin diseases such as syphilis [5].

In Mongolian folk medicine, yang worms are used alone or as part of a prescription to treat headaches, encephalitis, itching, sores, redness and swelling, blisters, yellow discharge, scabies, indigestion, chills after sweating, pain under the fingertip, vomiting, diphtheria, anthrax, and tumors [6].

Some compounds of *Artemisia santolinifolia* Turcz. ex Bess exhibit herbicidal and fungicidal activities [7].

Experimental studies have demonstrated that this plant possesses sedative and anti-inflammatory properties and can be used as a cardiotonic drug [8].

It was determined by 2D paper chromatography method that *Artemisia santolinifolia* Turcz. ex Bess contains flavonoids, phenolic acids, amino acids, coumarins, and tannic substances.

The presence of (E)-3-(3,4-dihydroxybenzylidene)-5-(3,4-dihydroxyphenyl)-2(3H)-furanone in the root ethanol extract of *Artemisia santolinifolia* Turcz. ex Bess was investigated by column chromatography [9].

The most abundant components of the herb of *Artemisia santolinifolia* Turcz. ex Bess were α-thujone—47.9%, E-nerolidol—13.9%, α-thujone—13.1%, sabinene ketone—11.8%, spathulenol—4.5%, terpinen-4-ol—2.5%, p-cymene—2.1%, camphor—1.9%, myrtenol—1.8%, copaene—1.4%, borneol—1.4%, bicyclogermacrene—1.2%, germacrene-D—0.9%, caryophyllene oxide—0.8%, menthylacetate—0.7%, with lesser amounts of α-thujene, benzylaldehyde, α-terpinene,α-pinene, β-pinene, camphene, sabinene, α-phellandrene, β-terpinene, limonene, terpinolene, menhhone, isopulegol, pinocarvone, neomenthol, p-cymen-8-ol, α-terpineol, nerol, cuminaldehyde, neral, carvon, estragol, bornylacetate, thymol, carvacrol, α-copaene, α-terpenylacetate, eugenol, ylangene, β-longipinene, caryophyllene, humulene, ar-curcumene, β-selinene, Z-calamenene, δ-cadinene, elemicine, viridifloral, α-muurolol and oplopanon [10]. Metals play an important role in the metabolism [11].

This article reviews the results of studies on macro, micro and ultra micro elements in *Artemisia santolinifolia* Turcz. ex Bess cultivated in the open field.

1.1. Distribution of *Artemisia santolinifolia* Turcz. ex Bess

As for Mongolia, it grows in Khentii, southern Khangai, Khovd, Mongolian Altai, Gobi Altai, Mid Khalkh, Great Lakes Depression, and East Gobi, in hollow valleys, gravelly rubble, bottom of canyons, cliffs, coastal salt meadows, lake and river banks [12].

1.2. Traditional Usage

The taste after digestion is bitter as well. The strength is cool and fierce. The action is useful in diphtheria, anthrax, typhoid fever, fever, bleeding, urination, intestinal worms, scurvy, typhoid, jaundice, boils, bacteria and tumors [13].

The elixir of the upper part of *Artemisia santolinifolia* Turcz. ex Bess has anti-inflammatory properties and activities such as gall laxation, relaxation of spasms when the smooth muscles of the internal organs overtightened, killing bacteria, reducing fever, and depleting helminths [6].

In traditional Mongolian medicine, *Artemisia santolinifolia* Turcz. ex Bess flowers and leaves are used to treat nasal colds, respiratory diseases, inflammation of the oral cavity, and hemostasis [14].

1.3. Location and Climatic Characteristics of the Study Area

The research and experiments were carried out at the experimental site of the Western Regional Branch of the National University of Mongolia, located in the Buyant Bag area of Jargalant soum, Khovd aimag.

1.4. Geographical Location of Jargalant Soum, Khovd Aimag

The territory of Jargalant Soum, Khovd Aimag, is located at 48˚01' N latitude and 91˚38' E longitude, 1405 m above sea level. It is surrounded by mountains, covers an area of 70 km^2, and has a population of approximately 70,000 people. It is located 1460 km from Ulaanbaatar and 25 to 375 km from other soums in the aimag [15].

The experimental site of the Western Regional Branch of the National University of Mongolia is located at 47˚58'19" N latitude, 91˚37'22" E longitude, with an elevation of 1430 m above sea level. The experimental site is situated 5 km from Khovd city and covers a total area of 6 hectares.

2. Materials and Methods

2.1. Plant Material

A sample of *Artemisia santolinifolia* Turcz. ex Bess grown in experimental site Western regional branch of National University of Mongolia, located in Jargalant Soum, Khovd Province, in the study on October 3, 2021.

Cultivated *Artemisia santolinifolia* Turcz. ex Bess was collected on October 3, 2021, from the experimental site of the Western Regional Branch of the National University of Mongolia (N 49˚58.866', E 092˚04.340'), at an elevation of 1,407 m above sea level, and used in the study.

Voucher specimens have been deposited in the herbarium of the Western regional branch of National University of Mongolia.

2.2. Methods

The amount of macro, micro and ultra-micro elements contained in plants was determined by the method of quantitative analysis of X-ray fluorescence, ICP-17, ICP-80, and spectrophotometric instruments.

The mechanical composition of the soil was determined by dry sieving, moisture by weight, and the amount of humus by the method of I.V. Tyurin.

2.3. Process of Research

2.3.1. Weather Conditions During the Years of the Survey

The average annual temperature in the Mongolian-Altai mountainous region of Khovd Aimag is −1˚C, while it is +1˚C in the foothills of the Altai Mountains and +2˚C in the Gobi Altai and Great Lakes depressions.

The Altai Mountain and the Great Lakes Basin exhibit similar general climate patterns. However, due to the presence of a large body of water and its enclosure by mountains, the Great Lakes Basin experiences more extreme temperatures, with average winter temperatures dropping below −21.5˚C and summer temperatures exceeding +21˚C [15].

Table 1 presents the temperature data for Jargalant soum, Khovd aimag, recorded from 2019 to 2021.

The average winter temperature in Jargalant Soum, Khovd Aimag, in 2019 was below −25.1˚C, while the average summer temperature exceeded +19.35˚C.

The average winter temperature in Jargalant Soum, Khovd Aimag, in 2020 was below −22.7˚C, while the average summer temperature exceeded +19.43˚C.

The average winter temperature in Jargalant Soum, Khovd Aimag, in 2021 was below −19.2˚C, while the average summer temperature exceeded +21.5˚C.

Table 2 presents the precipitation amounts for Jargalant Soum, Khovd Aimag, from 2019 to 2021.

The average annual precipitation increased from 147.4 mm in 2019 to 205.6 mm in 2021, with the highest precipitation recorded in 2021 at 205.6 mm.

Table 1. Average monthly temperature values (˚C) for Jargalant Soum, Khovd Aimag, from 2019 to 2021.

Months	January	February	March	April	May	June	July	August	September	October	November	December	Average monthly temperature values (˚C)
2019 year	−25.1	−23.8	−5.51	7.913	10.53	18.39	19.34	19.35	14.56	4.620	−7.61	−17.1	1.3
2020 year	−22.7	−16.2	−3.46	8.043	14.95	17.82	19.43	16.48	10.98	1.61	−6.77	−20.5	1.6
2021 year	−19.2	−6.77	−1.51	5.25	13.28	17.3	21.5	16.74	12.64	1.932	−6.51	−17.6	3.1

Table 2. Precipitation in Jargalant Soum, Khovd Aimag, from 2019 to 2021 (mm).

Months	January	February	March	April	May	June	July	August	September	October	November	December	Annual precipitation (mm)
2019 year	1.8	3.6	0	6.2	23.1	51.9	26.9	15.6	11.3	0.6	3	3.4	147.4
2020 year	0	0	1.8	0	23.8	5.9	51.9	34.3	1.3	0.7	0	0	120.4
2021 year	0.2	0	1.4	4.6	1.8	95.2	15.7	80.6	0.6	0	0	5.5	205.6

2.3.2. Soil Characteristics of the Study Area

A soil survey was conducted at the study site on May 1, 2020.

Phase-A (0 - 22 cm) consists of light-colored soil, rich in plant roots, with a light loam texture while it is compact, dry, and contains small-grained rocks with a carbonate texture. The transition to the underlying layer is gradual, with wavy boundaries, and it shows low reactivity in HCl.

Phase-B (22 - 50 cm) is white-gray in color, devoid of plant roots, and has a sandy texture. It is dense, moist, and contains small-grained rocks with a carbonate texture. The transitions in mechanical composition are clear, with wavy boundaries, and it does not react with HCl.

Phase-C, located at a depth of less than 50 cm, is whitish in color, devoid of plant roots, and consists of compact, moist, small-grained rocks with a carbonate texture. It has abrupt transitions and wavy boundaries, and does not react with HCl. Light brown, dry steppe soils are predominant (See table 3).

Table 3. Physico-chemical indicators of soil.

Undercut	Depth (cm)	pHH_2O (1:2.5)	$CaCO_3$ %	SOM %	$EC_{2.5}$ dS/m	Particle size, % (in mm)		
						Sand (2 - 0.05 mm)	Dust (0.05 - 0.002 mm)	Clay (< 0.002 mm)
Undercut-1	A (0-22)	8.29	1.58	0.69	0.093	83.5	9.5	7.0
	B (22-50)	8.27	0.55	0.12	0.076	80.6	13.8	5.7
	C (50-below)	8.38	0.00	0.03	0.099	68.9	22.8	8.3

Considering the mechanical composition of the soil in the experimental field of the Western Regional Branch of the National University of Mongolia, 83.5% is sand, 9.5% is silt, and 7% is clay.

Phase-A of the soil has a pH of 8.29, indicating a weakly alkaline environment, with a humus content of 0.69% and an electrical conductivity of 0.093 dS/m.

2.3.3. Agrotechnical Practices for Cultivating *Artemisia santolinifolia* Turcz. ex Bess in Open Fields

Results of phenomenological observations of vegetative organs in *Artemisia santolinifolia* Turcz. ex Bess during the 1st and 2nd years.

On April 25, 2020, a fenced experimental site measuring 12 meters in length and 6 meters in width was established at the Western Regional Branch of the National University of Mongolia for the cultivation of *Artemisia santolinifolia* Turcz. ex Bess.

To prepare the planting area, the soil was first dug and loosened, with plant roots and other debris removed, followed by leveling the ground. *Artemisia santolinifolia* Turcz. ex Bess was then planted in a grid pattern, with each plant placed in a 50 × 50 cm box. The soil was enriched with organic manure and irrigated using water from a deep well. The watered soil was left to stand for 24 hours before planting to ensure proper moisture absorption and soil stabilization.

For propagation through rhizomes, 150 rhizomes of *Artemisia santolinifolia* Turcz. ex Bess were collected from Darvi soum, Khovd aimag, on May 7, 2020 (**Figure 1**, **Figure 2**).

Figure 1. *Artemisia santolinifolia* Turcz. ex Bess.

Figure 2. Root branch *of Artemisia santolinifolia* Turcz. ex Bess.

These rhizome samples were subsequently used in the experimental study to evaluate their growth and adaptation under controlled conditions.

From May 1 to May 7, 2020, a study on the propagation of *Artemisia santolinifolia* Turcz. ex Bess through rhizomes was conducted at the experimental site (N 47˚58.373', E 091˚37.436') of the Western Regional Branch of NUM.

The plants were spaced 70 cm apart, and the rhizomes were planted in the open field (Figure 3-5).

Figure 3. The process of *Artemisia santolinifolia* Turcz. ex Bess cultivating in the experimental field of the experimental settlement on May 7, 2020.

Figure 4. The process of preparing the soil for planting *Artemisia santolinifolia* Turcz. ex Bess in the experimental plot.

Figure 5. The process of planting rootstocks of *Artemisia santolinifolia* Turcz. ex Bess on May 7, 2020.

The rhizomes of *Artemisia santolinifolia* Turcz. ex Bess were planted in the soil and continuously watered for 3 days using drip irrigation. Subsequently, the plants were watered twice a week (**Figure 6**, **Figure 7**).

Figure 6. Growth *Artemisia santolinifolia* Turcz. ex Bess in open field on June 7, 2021.

Figure 7. Growth *Artemisia santolinifolia* Turcz. ex Bess in open field on June 13, 2021.

As of May 29, 2020, the growth of *Artemisia santolinifolia* Turcz. ex Bess increased by 20%. On June 12, 2020, and July 16, 2020, growth increased by 24.6% and 34%, respectively. For plants growing in open areas, growth increased by 4.6% and 14%.

The results of monthly growth measurements of *Artemisia santolinifolia* Turcz. ex Bess cultivated in the open field are presented in **Table 4**.

The height of *Artemisia santolinifolia* Turcz. ex Bess grown in the open field increased by 2.92 cm from May to July, rising from 1.66 cm to 4.58 cm, while the width increased by 5.32 cm. This is due to the fact that wormwood is a shrubby plant that grows in clumps.

Table 4. Study on the growth dynamics of *Artemisia santolinifolia* Turcz. ex Bess cultivated in open fields (2020).

№	Year, month	Average plant height, cm	Average plant diameter, cm
1	May, 2020	1.66 ± 0.033	2.20 ± 0.033
2	June, 2020	2.33 ± 0.033	3.20 ± 0.033
3	July , 2020	4.58 ± 0.033	7.52 ± 0.033

2.4. Results of a Dynamic Study on the Growth and Development of *Artemisia santolinifolia* Turcz. ex Bess in the Second Year

Watering, care, and measurements for *Artemisia santolinifolia* Turcz. ex Bess in 2021 began on April 20, 2021 (**Figures 8-10**).

Figure 8. Growth *Artemisia santolinifolia* Turcz. ex Bess in open field on June 29, 2021.

Figure 9. Growth *Artemisia santolinifolia* Turcz. ex Bess in open field on September 17, 2021.

Figure 10. Shedding *Artemisia santolinifolia* Turcz. ex Bess in open field in October, 2021.

Artemisia santolinifolia Turcz. ex Bess began seeding on July 28, 2021, and the partial seed harvest started on September 19, with the final harvest completed by October 3.

Two grams of seeds were harvested from *Artemisia santolinifolia* Turcz. ex Bess, cultivated in the experimental field of the Western Regional Branch of NUM.

As of June 13, 2021, 105 out of 150 *Artemisia santolinifolia* Turcz. ex Bess had grown, representing 70% growth. By July 22, plant growth had increased to 83.33%, with growth continuing normally.

The results of monthly growth measurements of *Artemisia santolinifolia* Turcz. ex Bess cultivated in the open field are presented in **Table 5**.

The height of *Artemisia santolinifolia* Turcz. ex Bess cultivated in the open field increased by 15.67 cm, while the average diameter increased by 4.78 cm from May to July.

Table 5. Growth dynamics of *Artemisia santolinifolia* Turcz. ex Bess cultivated in open fields (2021).

№	Year, month	Average plant height, cm	Average plant diameter, cm
1	May, 2021	7.39 ± 0.033	11.03 ± 0.033
2	June, 2021	10.20 ± 0.033	14.55 ± 0.033
3	July, 2021	23.06 ± 0.033	15.81 ± 0.033

2.5. Experimental

The air dried above-ground parts of cultivated *Artemisia santolinifolia* Turcz ex Bess was pulverized and put for elemental analysis. The instrument XSeries2 ICP-MS**,** XRF was used.

SPSS software was used to process the research results.

The macro elements refer to the main elements that are required by the plants for their basic functions. Microelements are also known as trace elements.

The total forty-three elements were detected. They were composed of macro elements, microelements, trace elements & heavy elements. The details are reported.

2.5.1. Chemical Composition of *Artemisia santolinifolia* Turcz. ex Bess Ash

The plant was ashed at a temperature of 450˚C and the ash was extracted. The chemical composition of the ash is shown in **Table 6**.

Cultivated *Artemisia santolinifola* Tturcz. ex Bess sample (October) has a relatively high content of calcium oxide—19.64%, magnesium oxide—6.75%, silicon oxide—6.06% and phosphorus oxide—8.956%.

The composition of cultivated *Artemisia santolinifolia* Turcz. ex Bess ash was compared with the chemical composition of a plant ash from *Artemisia* L species **Table 7**.

Table 6. Ash composition of *Artemisia santolinifolia T*urcz. ex Bess cultivated in the open field (%).

Sample type	SiO_2	TiO_2	AI_2O_3	$\sum Fe_2O_3$	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	combustion waste
*Artemisia santolinifolia T*urcz. ex Bess cultivated in the open field	6.84 ± 0.78	0.008 ± 0.001	1.52 ± 0.096	0.008 ± 0.001	22.10 ± 2.46	6.64 ± 0.10	0.41 ± 0.06	>8	0.077 ± 0.35	8.23 ± 0.72	23.33 ± 0.66

Table 7. Comparison of chemical composition of *Artemisia santolinifolia* Turcz. ex Bess ash (%).

Sample type	SiO_2	TiO_2	Al_2O_3	$\sum Fe_2O_3$	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	combustion waste
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	6.84 ± 0.78	0.008 ± 0.001	1.52 ± 0.096	0.008 ± 0.001	22.10 ± 2.46	6.64 ± 0.10	0.41 ± 0.06	>8	0.077 ± 0.35	8.23 ± 0.72	23.33 ± 0.66
Artemisia santolinifola Turcz. ex Bess	11.02	0.149	2.35	1.17	11.26	3.76	0.14	>8	0.119	7.648	23.78
Artemisia santolinifola Turcz. ex Bess	8.42	0.085	1.33	0.64	27.04	6.43	<0.01	>8	0.147	6.794	0.22
Artemisia frigida Willd /in September/ [16]	11.37	0.153	2.45	1.24	16.82	4.83	0.12	>8	0.168	5.506	23.11

2.5.2. The Results of Micro-Elements Content Determination in Cultivated *Artemisia santolinifola* Turcz. ex Bess

The content of micro elements in the plant is shown Table 8.

Cultivated *Artemisia santolinifola* Turcz. ex Bess /October/ is rich in elements such as barium, copper, zinc and strontium.

The composition of microelements of cultivated *Artemisia santolinifolia* Turcz. ex Bess was compared with the content of microelements of *Artemisia* L species Table 9.

Content of microelements cultivated *Artemisia santolinifola* Turcz. ex Bess was compared to the microelement content of some types of *Artemisia* L (Table 10, Table 11).

The content of arsenic, chromium, tin, lead, and zinc did not exceed the standard amount in the samples of cultivated *Artemisia santolinifola* Turcz. ex Bess.

Table 8. Micro-element composition of cultivated *Artemisia santolinifolia* Turcz. ex Bess (mg/kg).

Sample type	As	V	Cu	Zn	Cr	Co	Mo	Ni	Sn	F	Ba	Bi	Pb
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	43.89 ± 0.11	<15	165.66 ± 0.66	253.66 ± 0.66	7.33 ± 0.66	<5	11.67 ± 1.67	8.78 ± 0.78	<30	<0.05	233.23 ± 1.33	<5	<5

Table 9. Comparison of microelements in *Artemisia* species (mg/kg).

Sample type	As	V	Cu	Zn	Cr	Co	Mo	Ni	Sn	F	Ba	Bi	Pb
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	4.89 ± 0.11	<15	165.66 ± 0.66	253.66 ± 0.66	7.33 ± 0.66	<5	11.67 ± 1.67	8.78 ± 0.78	<30	<0.05	233.23 ± 1.33	<5	<5
Artemisia frigida Willd [16]	11	80	218	783	19	10	<5	21	<30	<0.05	736	<5	

Table 10. Comparison of microelements in *Artemisia* species (mg/kg).

Sample type	As	V	Cu	Zn	Cr	Co	Mo
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	4.89 ± 0.11	<15	165.66 ± 0.66	253.66 ± 0.66	7.33 ± 0.66	<5	11.67 ± 1.67
A*rtemisia santolinifola T*urcz. ex Bess	11	99	109	608	8	9	5
A*rtemisia santolinifola T*urcz. ex Bess	4.67	4.1 4	229	584	6.01	1.99	15.02
Artemisia rutifolia Steph. ex Spreng [17]	6	67	93	345	84	16	6
Artemisia albicerata [18]			58.9	182			
Artemisia annua L [19]	<20		250 ± 30	270 ± 20			
Artemisia herba alb [20]				798.21			
Artemísia absínthium L [18]	<0.01		5.3	15	1.2	0.35	6.2
Artemísia absínthium L [21]			5.2	12	2.9	0.3	
Artemisia frigida Willd [22]			9.4	4.646	1.93		
Artemísia absínthium L [23]	3			406.92	2.94	11	
Artemisia vulgaris L [24]	9			421	9.2	23.16	
Artemisia sieversiana Willd [24]	10.9			607.17	10.2	4.0	
Artemisia vulgaris L [23]			4.64 ± 0.64	114.99 ± 10.27			
Artemisia ausrriaca [25]			3.29	33	22.9		
Artemisia frigida Willd [16]	11	80	218	783	19	10	<5
Artemisia frigida Willd [26]			11.22 ± 0.25	26.83 ± 0.57			
Artemisia jacutica [26]			5.79 ± 0.17	57.34 ± 2.68			
Artemisia scoparia [22]			9.525 ± 1.64	35.730 ± 0.90	10.250 ± 0.09	0.400 ± 0.35	
MNS 5744:2007 [27]	10		100				
Standard sample [28]	0.1	0.5		50	1.5	0.2	0.5
Standard of macro and micro elements of medicinal plants [29]				15-100	5-30		100 - 800
Cultivated *Artemisia scoparia* Waldst. et Kit [30]	11	30	129	239	37	<5	21
Artemisia scoparia Waldst. et Kit [31]	11	57	191	270	8	9	<5
Artemisia scoparia Waldst. et Kit [22]	10		2.2	3.3	4.34	7.3	22

Table 11. Comparison of microelements in *Artemisia* species (mg/kg).

Sample type	Ni	Sn	F	Ba	Bi	Cd	Pb
Artemisia santolinifolia Turcz. ex Bess cultivated in the open	8.78 ± 0.78	<30	<0.05	233.23 ± 1.33	<5	-	<5
A*rtemisia santolinifola T*urcz. ex Bess	20	<30		382	<5	-	<5
A*rtemisia santolinifola T*urcz. ex Bess	10.34	<0.5		516	0.63	5.42	37.92
Artemisia rutifolia Steph. ex Spreng [17]	40	<30	<0.05	2213	13		<5

Continued

Artemisia albicerata [18]	38.2					1.2	11.4
Artemisia annua L [23]							50 ± 10
Artemisia herba alb [20]				207.12		20.58	
Artemísia absínthium L [18]	3.9			67			
Artemísia absínthium L [19]	5.4						
Artemísia absínthium L [19]				76			
Artemisia vulgaris L [24]				85			
Artemisia ausrriaca [25]	7.0						6.83
Artemisia frigida Willd [16]	21	<30	<0.05	736	<5		6
Artemisia frigida Willd [26]	0.58 ± 0.01					0.10 ± 0.001	0.10 ± 0.002
Artemisia jacutica [26]						0.30 ± 0.007	0.87 ± 0.07
Artemisia scoparia [22]	11.300 ± 0.21					0.950 ± 0.75	13.200 ± 0.23
MNS 5744:2007 [27]		10					<5
Standard sample [28]	1.5				0.2		
Standard of macro and micro elements of medicinal plants [29]	100 - 800			65 - 250			
Cultivated *Artemisia scoparia* Waldst. et Kit [30]	18	<30		321	<5		7
Artemisia scoparia Waldst. et Kit [31]	12	30		107	<5		5
Artemisia frigida Willd [26]	2.85 ± 0.06						2.28 ± 0.06
Artemisia jacutica Drob [26]							5.20 ± 0.59
Artemisia scoparia Waldst. et Kit [31]	16			5.09			

2.5.3. The Results of Ultra Microelement Content Determination of Cultivated *Artemisia santolinifola* Turcz. ex Bess

The content of ultra-microelements in cultivated *Artemisia santolinifola* Turcz. ex Bess sample is shown (**Table 12**, **Table 13**).

The content of rubidium, yttrium, tungsten and antimony of cultivated *Artemisia santolinifola* Turcz. ex Bess /October/ is relatively high.

The ultra-microelement content of cultivated *Artemisia santolinifola* Turcz. ex Bess was compared with the ultra-microelement content of *Artemisia* type plants (**Table 14**, **Table 15**).

Table 12. The ultra micro-element composition of cultivated *Artemisia santolinifolia* Turcz. ex Bess (mg/kg).

Sample type	Ce	Cs	Ga	Ge	Hf	La	Nb	Rb	Sb	Sc	Ta
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	<30	<30	<3	<3	<15	<30	<3	64.61 ± 4.38	43.66 ± 0.66	<10	<10

Table 13. The ultra micro-element composition of cultivated *Artemisia santolinifolia* Turcz. ex Bess (mg/kg).

Sample type	W	Y	Zr	Th	U	Sm	Nd	Pr	Sr
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	<38	6.00 ± 1.00	19.33 ± 0.66	<5	<5	<30	<50	<30	1071.66 ± 0.66

Table 14. Comparison of ultra microelements in *Artemisia* species (mg/kg).

Sample type	Ce	Cs	Ga	Ge	Hf	La	Nb	Rb	Sb	Sc	Ta
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	<30	<30	<3	<3	<15	<30	<3	64.61 ± 4.38	43.66 ± 0.66	<10	<10
A*rtemisia santolinifola* Turcz. ex Bess	<30	<30	7	<3	<15	<30	3	72	<40	<10	<10
A*rtemisia santolinifola* Turcz. ex Bess	5.01	2.25	0.99	<0.5	-	4.75	<0.1	55.85	0.85	1.79	<10
Artemisia rutifolia *Steph.Ex* Spreng [17]	37	<30	<3	<3	<15	30	<5	89	<40	<30	<10
Artemisia annua L [23]								50 ± 10			
Artemísia absínthium L [18]								22			
Artemisia vulgaris L [24]								10.44			
Artemisia sieversiana Willd [24]									10.49		
Artemisia frigida Willd [16]	<30	<30	7	<3	<15	<30	3	97	<40	<10	<10
MNS 5744:2007 [27]		400									
Standard sample [32] [28]		0.2			0.05	0.2		50	0.1	0.02	0.001
Cultivated *Artemisia scoparia* Waldst. et Kit [30]	<30	<30	7	<3	<15	<30	4	69	<40	<10	<10
Artemisia scoparia Waldst. et Kit [31]	<30	<30	4	<3	15	<30	1	189	<40	<10	10
Artemisia scoparia Waldst. et Kit [33]											4

Table 15. Comparison of ultra microelements in *Artemisia* species (mg/kg).

Sample type	W	Y	Zr	Th	U	Sm	Nd	Pr	Sr
Artemisia santolinifolia Turcz. ex Bess cultivated in the open field	<8	6.00 ± 1.00	19.33 ± 0.66	<5	<5	<30	<50	<30	1071.66 ± 0.66
A*rtemisia santolinifola* Turcz. ex Bess	122	9	30	<5	<5	<30	<50	<30	333
A*rtemisia santolinifola* Turcz. ex Bess	0.87	4.0	4.19	3.74	2.08	1.31	1.18	2.29	728
Artemisia rutifolia Steph. ex Spreng [17]							<50	<30	928
Artemisia annua L [19]									20 ± 10
Artemísia absínthium L [18]									270
Artemísia absínthium L [24]				2.18	0.6				447
Artemisia vulgaris L [24]				5.3	0.7				432

Continued

Artemisia sieversiana Willd [20]				7.18	0.65				401
Artemisia ausrriaca [25]									35
Artemisia frigida Willd [16]	<8	9	30	<5	<5	<30	<50	<30	544
Standard sample [32] [28]	0.2		0.1	0.005	0.01	0.04	0.2		50
Cultivated *Artemisia scoparia* Waldst. et Kit [30]	<8	17	78	11	<5		<50	<5	1389
Artemisia scoparia Waldst. et Kit [31]	8	3	<3	6	5	30	50	<30	804
Artemisia scoparia Waldst. et Kit [33]				6.8	2.4	23.8	105		47.4

3. Result and Discussion

The elemental compositions present in the medicinal plants have great importance to understand their functions in the human body. Phosphorous, potassium, calcium, iron, zinc, manganese, magnesium, silicon are the chief elements that contribute to the metabolism in human body and affect the total health to a remarkable extent.

In this study, the concentrations of forty-three elements elements were determined in the above-ground parts of cultivated *Artemisia santolinifolia* Turcz ex Bess by using XRF spectroscopy.

The result showed various concentrations of five macro elements: K, Ca, Mg, Si, P.

Twenty four (trace elements): Na, Al, V, Ga, Ge, Rb, Sr, Y, Zr, Nb, Mo, Cs, Ba, La, Hf, Ta, W, Ti, Th, F, Sc, Sm, Nd, Pr.

Fourteen heavy elements: Cr, Co, Ni, Cu, Zn, As, Sn, Sb, Mn, Fe, Ce, Pb, Bi, U.

The analysis indicated the higher concentration of K, Ca, Mg, Si, P elements.

Thus above-ground parts of cultivated *Artemisia santolinifolia* Turcz ex Bess can be used to overcome these deficiencies, as these are not only a rich source of calcium, phosphorous, silicon and magnesium but also provides other micronutrients like sodium, iron, zinc, copper, and manganese.

The amount of lead, arsenic and tin in cultivated *Artemisia santolinifola* Turcz. ex Bess meets the technical requirements of biologically active products /MNS 5744:2007/ [27].

The amount of nickel in cultivated *Artemisia santolinifola* Turcz. ex Bess does not exceed the standard for medicinal plants [29].

Amount of germanium, cesium, gallium, hafnium, lanthanum, scandium and tantalum in cultivated *Artemisia santolinifola* Turcz. ex Bess has a value close to that of germanium, cesium, gallium, hafnium, lanthanum, scandium, and tantalum [32].

Cultivated *Artemisia santolinifola* Turcz. ex Bess samples contain zinc, arsenic, chromium, tin, and lead within standard range [34].

The amount of cesium in cultivated *Artemisia santolinifola* Turcz. ex Bess meets the technical standard requirements for biologically active products /MNS

5744:2007/ [27].

The amounts of tantalum, tungsten, uranium, thorium, samarium, neodymium, hafnium, lanthanum and scandium in cultivated *Artemisia santolinifola* Turcz. ex Bess meet the International Commission on Radiological Protection (ICRP) reference requirements [28].

Amount of lead in cultivated *Artemisia santolinifola* Turcz. ex Bess meets the technical requirements of biologically active products /MNS 5744:2007/, so it does not have a negative effect on people and the environment.

4. Conclusions

The cultivated *Artemisia santolinifola* Turcz. ex Bess sample mainly contains elements such as barium, copper, zinc and strontium.

Cultivated *Artemisia santolinifola* Turcz. ex Bess has stable potassium oxide.

The above results indicate that the cultivated *Artemisia santolinifola* Turcz. ex Bess above-ground parts are a good source of essential nutrients required for the well-being of human body.

The result indicate the presence of potassium, phosphorus, iron, calcium, magnesium, copper etc.

Thus the presence of the nutraceutically valued minerals in the plant points toward the possibility of their use to restore the different imbalances caused in the body.

The technology for cultivating of *Artemisia santolinifolia* Turcz. ex Bess using natural seeds was developed and 150 plants were planted in open fields, increasing the number of cultivated essential oil plants.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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