Barberry leaves as an alternative to green tea made from indigenous herbal ingredients

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Abstract. In contemporary times, the use of plant-based alternatives for conventional black tea has gained significance as a result of the prevailing clichés around healthy eating. It is suggested to utilise the leaves of barberry (*Berberis vulgaris*) as a raw material for tea production in industries, instead of using berries. Special investigations have demonstrated that some types of woody and shrub plants in Kazakhstan possess the unique ability to accumulate heavy metals in their leaves. These plants serve as bioindicators of pollution in the region. Common barberry (*Berberis vulgaris)* does not possess a notable capacity to absorb heavy metals. The authors have formulated the raw material composition and brewing process, elucidated the health-enhancing properties of tea, and evaluated the potential of barberry leaves *(Berberis vulgaris)* as a substitute for green tea. An analysis was conducted to determine the microelement composition of barberry leaves in terms of mineral elements. The investigation of using indigenous wild and cultural flora as a possible supply of essential raw materials for the development of tea substitutes and tea beverages is a topic of study in several places worldwide.

1 Introduction

Tea holds significant importance in the culinary traditions of several countries, resulting in a vast array of tea varietals and an unimaginable number of recipes for its preparation. The consuming culture of herbal tea beverages is intricately linked to the national and historical traditions of many ethnic groups. Tea is an essential commodity in many nations, like Kazakhstan, and cannot be replaced by other beverages.

The term "tea" has dual connotations. Primarily, it refers to a botanical species cultivated in Asia for the production of the popular hot beverage. Furthermore, the term "tea tree" refers to the beverage itself, which, it should be noted, is not exclusively derived from tea tree leaves. It can also be prepared with mint, chamomile, or other fruits, depending on the

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botanical ingredients employed. There are several methods for preparing tea, which involve the incorporation of different enhancers, spices, berries, and fruits. The tea drinking traditions in the East have a history of five millennia, whereas in the West, they have only been practiced for four centuries. The Irish and British are widely regarded as the most avid consumers of tea worldwide. Black tea is the most prevalent kind. There are some types of tea that are unfamiliar to most individuals: "Gemmaitya", which is Japanese tea blended with rice; "Puerh", a compressed tea that may be steeped up to 10 times; and oolong, a tea variety with a high caffeine content. Additionally, there are teas that are exceedingly costly. The Chinese Da-Hong Pao is the most costly tea in the world.

Herbal teas frequently use berries in their production. After conducting a comprehensive analysis of various characteristics of Berberis vulgaris, it is suggested to utilise barberry leaves instead of berries for industrial purposes in the production of tea. Barberry leaves possess favourable sensory qualities and include a diverse spectrum of physiologically active compounds. Barberry leaf herbal tea may serve as a refreshing morning tonic or a delightful dessert beverage, thanks to its tangy-sweet flavour and berry scent.

The beverage may be advised for the treatment and prevention of bile stasis, cholecystitis, prolonged menstruation, menopausal bleeding, colds, infectious diseases, asthenia, loss of appetite, intoxication, hangover syndrome, susceptibility to tumours, and individuals exposed to hazardous working conditions. Barberry leaf tea enhances alertness and improves focus among individuals working during nocturnal hours. It is advised against consuming a beverage made from barberry leaves during the nighttime hours to prevent the occurrence of sleep disturbances.

In order to validate the characteristics of herbal tea and barberry leaves and assess their potential for extensive utilisation in the food business, we performed a research study on Berberis vulgaris.

Herbal teas are prepared from one or more combined components. The published literature documents the use of various plant materials as substitutes for tea or other cultural drinks. Among the plant materials used in the preparation of tea drinks mostly used flowers of white acacia (*Robinia pseudoacacia*), panicles of amaranth (*Amaranthus dubius*); Bergenia (*Bergenia crassifolia*) and birch *(Betula pendula)* leaves; lingonberry (*Vaccinium vitis-idaea*) leaves, black elderberry (*Sambucus nigra*) leaves; camel thorn (*Alhagi pseudalhagi*) flowers; *Veronica officinalis;* walnut (*Juglans nigra*) leaves, cherry (*Prunus cerasus*) leaves, *Bupleurum aureum*, sweet clover flowers and leaves, common oak acorns, aerial part of (*Origanum vulgare*), roots and flowers of *Angelica officinalis*, calendula flowers, *Viburnum* flowers; fruits and leaves of *Schisandra chinensis*; root, flowers of *Primrose officinalis* [1].

Several alternatives to leaf and herb green tea frequently possess distinct flavours and typically necessitate the addition of sweeteners, such as sugar or sugar replacements. Several fruits from cultivated or wild plants that are utilised in the preparation of tea beverages possess a pleasant sweetness and a very evocative fragrance. Nevertheless, the availability of some fruits, even in dried form, is not constant throughout the year. This brings up concerns about the economic viability of widespread consumption of such teas. Moreover, infusions and decoctions derived from fruits and berries sometimes possess a saccharine or too tart flavour, which may not always be appealing to customers. Certain kinds of wild plants face challenges in obtaining raw materials, making it difficult to include a large number of mass-produced beverages into their manufacturing.

Barberry berries are extensively recognised for their utilisation in medical, as well as in the culinary and confectionary sectors [2, 3]. These ingredients are used in the production of confectionary and beverages, as well as in the seasoning of Uzbek pilaf and several other cuisines. The industrial use of flowers or vegetative components of barberry is quite seldom.

In particular, a syrup based on the phyto-substance of the Ili barberry is known. Berberis iliensis M.Ror contains sugar, purified water and an active ingredient, which as an active ingredient contains a phyto-substance from flowers and/or fruits of the Ili barberry (Berberis iliensis M.Rop), additionally contains citric acid, in the following ratio, %:

Flower and/or fruit of the Ili barberry - 1.12%;
Citric acid - 0.05%;
Sugar - 58.33%;
Water is the rest.

In the second version of the drink, the product contains a 70% solution of sorbitol as a sugar -forming base and additionally includes citric acid and potassium sorbate , in the following ratio, wt . %:

Flower and/or fruit of the Ili barberry - 1.12%;
Citric acid - 0.05%;
Potassium sorbate - 0.12%;
Sorbitol solution 70% - 58.33%;
Water the rest [4].

The disadvantages of the known syrup based on raw materials from Ili barberry are:

1) The limited range of the plants used by the foothills in the south of Kazakhstan.
2) The mass collection of flowers will lead to disruption of fruiting in the barberry.
3) The drink contains additional chemical preservatives.
4) A drink with a sugar content is contraindicated for a certain circle of people (in particular, those suffering from diabetes), and 70% sorbitol syrup has a significant cost.

It is said to as a herbal tea blend that includes barberry fruits. The ingredients consist of peppermint, raspberry, currant, plantain, wild strawberry, sea buckthorn, cherry, stinging nettle, birch, St. John's wort, oregano, sage, yarrow, elecampane, coltsfoot, lemon balm, thyme, tarragon, linden flowers, calendula; raspberries, strawberries, apple trees, rose hips, Chinese magnolia vine, chokeberry; and the roots and rhizomes of valerian officinalis and dandelion. The composition also includes: Verbena officinalis herb (Verbena officinalis), British elecampane (Inula britannica), ziziphora (Ziziphora sp), narrow-leaved hyssop (Hyssopus angustifolius), catnip (Nepeta), meadowsweet (Filipendula vulgaris), shrub cinquefoil (Kuril tea) (Pentaphylloides fruticosa), primrose (Primula sp), wormwood (Artemisia absinthium), agrimony (Agrimonia eupatoria), spotted thistle (Silybum marianum), leaves of initial chemist (Betonica officinalis), hawthorn (Crataegus sp), ginkgo biloba (Ginkgo biloba), blueberry blackberry (Rubus caesius), willowherb (Chamerion angustifolium), Schisandra chinensis (Schisandra chinensis), common cuff (Alchemilla vulgaris), longleaf mint (Mentha longifolia), Caucasian blueberry (Vaccinium arctostaphylos), blueberry (Vaccinium myrtillus), wild rose (Rosa); birch buds (Betula sp), pines (Pinus silvestris); hawthorn flowers (Crataegus sp.), bright red hibiscus (Hibiscus coccineus), medicinal dandelion (Taraxacum officinale), purest cladochaeta (Cladochaeta candidissima), mullein (Verbascum), chamomile (Matricaria chamomilla), an annual dried flower (Xeranthemum annuum), inflorescences of Lankaran albizia (Albizia julibrissin), red clover (Trifolium pratense), linden (Tilia cordata); fruits of quince oblongata (Cydonia oblonga), Japanese quince (Chaenomeles japonica), common barberry (Berberis vulgaris), hawthorn (Crataegus), real jujube (Ziziphus jujube), sea buckthorn (Hyppophae rhamnoides), common viburnum (Viburnum opulus), juniper (Juniperus communis), mountain ash (Sorbus aucuparia), Caucasian blueberry (Vaccinium arctostaphylos), blueberry (Vaccinium myrtillus), seeds of common anise (Pimpinella anisum), coriander seed (Coriandrum sativum), wild carrot (Daucus carota), common fennel (Foeniculum vulgare), rhizomes and roots of Valerian officinalis (Valeriana officinalis), licorice (Glycyrrhiza glabra). The subsequent proportion of original constituents: The weight percentage of grass and leaves from the mentioned plants is between 70-90%. The buds, flowers, and inflorescences from the same plants make up 5-20% of the weight. Fruits, seeds, roots, and rhizomes from these plants contribute 5-10% of the weight. The grass, leaves, buds, flowers, and inflorescences comprising the composition underwent fermentation by a well-established process involving twisting, holding, and subsequent drying of the raw materials [4].

The disadvantages of the known composition of herbal tea include:

1) The presence in the composition of several dozen types of plant materials makes it difficult to dose, uniform mixing and homogenization of the composition.

2) Erasing the taste of the finished drink when interacting with numerous types of plant materials.

3) An excessively low dosage of each plant out of many dozens, reduces the biological activity of the components of each type of plant material.

4) The content in the composition of the drink of plant raw materials with both synergistic and antagonistic effects, can devalue the health-improving and therapeutic effectiveness of the composition as a whole.

5) Many types of plants that make up the drink do not grow in one region, which means that the collection and delivery of plant materials may not be economically and organizationally feasible.

The concentrate is a mixture used to make a beverage that contains barberry fruits. It is made up of two main components. The first component is one or more concentrated juices, such as apple, grape, raspberry, blackberry, strawberry, lingonberry, black currant, red currant, blueberry, pear, chokeberry, cherry, lemon, and lime juice. The second component includes at least one of the following ingredients: mint extract (infusion), tarragon infusion, Chinese magnolia vine infusion, barberry infusion (decoction), dogwood infusion (decoction), goji berry infusion (decoction), and tea infusion. The concentrate may furthermore comprise extracts of clove, cinnamon, and cardamom. In addition, preservatives, colours, food additives, water, reconstituted juices, infusions, and decoctions may also be included. This enhances the sensory properties of the resultant concentrate, as well as broadening their variety [5, 6].

The disadvantages of the drink concentrate include:

1) The drink concentrate contains artificial colouring, preservatives, and food additives that serve the purpose of both long-term preservation and enhancing the sensory aspects of the product.

2) Combining juices and decoctions from different cultivated and wild fruit and berry plants with herbs could not enhance the sensory characteristics, but instead, it may diminish the consumer's familiarity with the customary well-known flavours.

3) The drink concentrate has a shorter expiration period in comparison to the dry herbal raw materials specifically designed for making teas and beverages..

The product is designed to enhance health and prevent health issues for workers in hazardous working environments. It is prepared instantly and contains barberry fruits, starch, apples, beets or turmeric, celery juice, oatmeal, green tea, barberry, bay leaf, ground cinnamon, citric acid, ascorbic acid, flavour, water and granulated sugar. The components include the following: The weight percentages of the ingredients are as follows: starch (17.0-27.0%), apples (3.5-7.5%), beets or turmeric (2.0-3.5%), celery juice (0.5-1.0%), oat flakes (1.0-1.5%), green tea (0.1-0.3%), barberry (0.03-0.07%), laurel leaf (0.03-0.07%), ground cinnamon (0.05-0.15%), citric acid (0.6-0.8%), ascorbic acid (0.6-0.8%), flavouring (0.01-0.07%), water (5.0-7.5%), and granulated sugar (the remaining amount, which is in the form of a granular concentrate of compote or jelly [7].

The disadvantages of the known product are:

1) The production process of the product involves labor-intensive and multi-stage techniques, including processing several types of plant materials, grinding, homogenization, and granulation.

2) The use of artificial ingredients in the composition, such as flavours, industrial citric acid, and ascorbic acid.

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3) The mixture of different components with varying tastes might negatively impact the sensory qualities of the beverage and lead to individual reactions among consumers.

4) The presence of several components in the composition poses challenges in assessing the quality and quantity of biologically active substances. It also complicates the processing technologies, such as homogenising a mixture with multiple components, and may diminish the efficacy of each individual component.

5) The suggested product, even when using its concentrates in the form of jelly or compote, is a distinct product that is not suitable for conventional beverages designed for widespread consumption by a diverse group of individuals with varying preferences and lifestyles.

The prevalent disadvantages and attributes of widely used beverages and health products that include barberry are as follows:

1) The labour required and the level of technological sophistication involved in producing food and drinks necessitate the use of specialised and costly equipment.

2) The potential for altering the bioactive qualities of plant compounds by extensive technical processing, such as fermentation, repetitive heating, and exposure to diverse chemicals during manufacturing operations.

3) The intricate and multifaceted composition of many compositions hampers their preventive effectiveness by diminishing the proportion of biologically active substances in each plant. This also worsens the sensory qualities of individual components and the overall drink. Additionally, it makes it challenging to blend a mixture of numerous raw components.

4) Incorporation of various synthetic compounds produced industrially, which have the ability to alter the sensory characteristics and health-enhancing capabilities of natural raw materials.

5) Numerous renowned goods and beverages that incorporate barberry have a specific function as nutritional supplements and therapeutic and preventive items. In other words, they are not designed for regular use as tea beverages.

6) Existing drink recipes typically only utilise barberry berries (in some cases, flowers) while neglecting the plant's vegetative parts. However, these parts are equally abundant in biologically active substances, possess delightful flavours, and are readily available in both natural and cultivated plantations. Moreover, they require minimal technological processing when used as raw materials for beverages. Both the berries and leaves of the barberry plant can be utilised as raw materials for producing herbal teas and beverages. This raw material is not only more affordable but also more readily available, as it may be harvested during the full growing season.

A tincture of Amur barberry leaves, with a ratio of 1:5 in 40% alcohol, is a commercially available formulation [8]. It is employed as a choleretic agent for the treatment of hepatitis, cholecystitis, and cholelithiasis. The tablet medicine berberine sulphate is well-known for its many pharmacological effects. It effectively lowers blood pressure and slows down heart rhythm. Additionally, it induces uterine contractions, improves bile production, and has antiparasitic activity, especially against leishmaniasis and malaria [9].

Nevertheless, it is important to note that some substances, such as bebeerine sulphate which falls under category B, are classified as medications rather than beverages or edibles.

Ecological safety of the raw material collection region. Pavlodar is a prominent industrial hub situated in the northeastern region of the Republic of Kazakhstan. 37 thermal power stations are responsible for the majority of energy generation in Kazakhstan. The GRES-1 power plant located in the city of Ekibastuz is the largest among them. The Aksuskaya (Ermakovskaya) GRES is the most prolific power producer. Within the city's boundaries, there are several industrial facilities, including aluminium and electrolysis plants, CHP-1, CHP-2, CHP-3, and the Pavlodar petrochemical plant. Thermal power stations that burn high-ash Ekibastuz coals in their boiler units are the primary sources of pollution. The majority of emissions originate from industrial companies situated in the cities of Ekibastuz (46%), Aksu

(26.5%), and Pavlodar (25.5%), whilst all other districts in the region contribute to just around 2% of the emissions.

The analysis of hazardous element concentrations in the soil and diverse biosubstrates is necessary for the study of Pavlodar region as an industrial area. Priorly, investigations were conducted on the concentration of certain toxic metals in both soil and plants. According to Ya.V. Linkova and A.A. Snegur [10], the amount of scandium found in the ashes of wormwood varied between 104 and 513 mg/kg in the city of Pavlodar. In rural areas of the Pavlodar region, the range was from 33.67 to 385 mg/kg. The study did not find any correlation between the scandium content and the distance of the settlement from the city. The concentration of antimony in various sections of the city ranged from 0.17 to 0.96 mg/kg, whereas in rural areas it ranged from 0.09 to 0.354 mg/kg. Overall, urban wormwood exhibited a 1.7-fold increase in scandium accumulation compared to rural wormwood, whereas the accumulation of antimony was 2.7 times higher in urban regions. Antimony possesses a low SDA (Specific Danger Assessment) value of 0.53, indicating a significant level of hazard. Antimony is classified as a harmful soil contaminant in both the United States and the European Union. Regarding its toxicity, prevalence, and capacity for accumulation, it ranks among the ten most hazardous contaminants in the biosphere. Technogenic antimony soil contamination is prevalent in the vicinity of non-ferrous and ferrous metallurgy facilities, as well as in the manufacturing processes of cement, bricks, and coal combustion.

In 2020, Yu.M. Kannibolotskaya et al. conducted a study where they examined over 50 sites situated at various distances from the main industrial facilities in Pavlodar [11]. These distances ranged from 1 to 50 kilometres, covering the north, south, east and west directions of Pavlodar. The researchers considered factors such as wind patterns and ease of transportation or walking when selecting the sites. The soil samples for examination were collected from two distinct layers: 0–5 cm and 10–15 cm. The first layer exhibited recent contamination, while the second layer showed evidence of earlier pollution. Simultaneously, plant samples of both the subterranean and aerial components of Agropyron cristatum (a kind of comb wheatgrass) were gathered for study.

The soil in the study region has been found to be contaminated with chromium (Cr) based on the results of the analytical analysis. The concentration of chromium ranges from 56 to 142 parts per million (ppm) in the soil layer of 0–5 cm, and from 44 to 104 ppm in the layer of 10–15 cm. The concentration of (UFT) is 67 and 68 parts per million (ppm). The concentration range of lead (Pb), which is also abundant in soil, is 12-27 ppm in the 0-5 cm soil layer and 7-20 ppm in the 10-15 cm layer. The presence of elevated levels of iron (Fe) was observed, with a maximum concentration of 27496 ppm (0-5 cm) and 27456 ppm (10-15 cm) at UFT concentrations of 19502 and 19274 ppm, respectively. The concentrations of other metals are within the permissible limits.

The Pb content in the aerial parts of plants in different areas ranges from 0.33 to 5.65 ppm, with an average of 0.3 ppm. In the underground parts, the Pb content ranges from 3.6 to 100 ppm, with an average of 4.9 ppm. The Zn content, which is also classified as a hazardous element, ranges from 4.1 to 120 ppm, with an average of 42 ppm. In the same areas, the Zn content in the underground parts ranges from 30 to 778 ppm, with an average of 104 ppm.

The second hazard class includes the following elements: Nickel (Ni) content in A. cristatum at various distances from plants ranges from 0.2 to 2 ppm in the aerial parts and from 3.3 to 31.7 ppm in the underground parts. Copper (Cu) content in the aerial parts ranges from 0.47 to 1.3 ppm, while in the underground parts it ranges from 1.9 to 7.1 ppm. Chromium (Cr) content ranges from 2 to 12.5 ppm in the aerial parts and from 4.3 to 850 ppm in the underground parts.

The third hazard class includes the following elements: the manganese (Mn) content in A. cristatum plants at different distances from the industrial zone in the northern area ranges from 43.6 to 121 ppm in the aerial parts, with a UFT value of 66; in the underground parts, the range is from 94 to 417 ppm, with a UFT value of 182. The strontium (Sr) content in the aerial parts of A. cristatum ranges from 3.9 to 62 ppm, with a UFT value of 13; in the underground parts, the range is from 19 to 62 ppm, with a UFT value of 30. The Fe concentration ranges from 118 to 646.5 ppm, with UFT values of 102 and 2317 to 13200 ppm, with a UFT value of 3304. The Ti content ranges from 5.4 to 748 ppm (UFT - 2.0) in the aboveground sections and from 295 to 1867 ppm (UFT - 373) in the underground regions of A. cristatum. Overall, the authors find that a significant amount of metal pollution in the soil is frequently detected within a range of 0.5-5 km from active industrial facilities. The coefficient of biological absorption of A. cristatum exhibited its greatest values for several metals at consistent distances from the prominent industrial facilities in the region, namely CHPP-2, CHPP-3, PF Casting LLP, and PPCR.

Yu.M.Kannibolotskaya [12] found that the roots of wheatgrass plants have significantly higher concentrations of metals compared to the aboveground parts. This acropetal distribution of pollutants is consistent with the findings of other researchers, such as Panin [13], Atabaeva [14], and Ilyin [15]. Foliar pollution poses a lesser risk to the plant organism compared to pollution that is absorbed by the roots via the soil. The primary buildup of heavy metals in the root system and restriction of their movement to aboveground organs is a defensive adaptive response of plants, operating at the organismal level.

Examinations specifically focused on trees and shrubs have shown that plants in the industrial and transport zones of the surveyed cities in Kazakhstan acquire higher levels of heavy metals compared to plants in residential and recreational areas. This accumulation is directly related to the degree of soil pollution and the amount of ash present. The study uncovered the phenomenon of species specialisation in the capacity of woody and shrubby plant leaves to accumulate heavy metals [16, 17]. Beiula leaves exhibit the highest storage capacity for zinc and lead among the cities in Kazakhstan. The plants used in this study were pendula Roth, Acer negundo L., Syringa vulgaris L., and leaves from trees of the Populus genus. Copper was found in Acer negundo L., Eleagnus argentea Pursch., and Ulmus minor L. Cadmium was found in leaves of woody plants from the Salicaceae family. These plant species are regarded as bioindicators of heavy metal contamination and also serve as phytofilters for urban areas and industrial zones [18, 19]. Common barberry did not exhibit enhanced capacity for heavy metal absorption, as shown in other plant species.

In a separate investigation, the evaluation of plants' ability to accumulate sulphur and trap dust revealed that balsam poplar and white willow in polluted regions have almost double the capacity to absorb sulphur and catch dust compared to other species of woody plants that were examined. The silver birch, ash-leaved maple, and berry apple had the greatest phenol absorption capacity, as reported in reference [20]. Barberry did not exhibit heightened buildup of harmful chemicals, unlike other plants.

D.V. Yusupov et al. [21] investigated the biogeochemical specialisation of different areas and towns in Kazakhstan and Russia by using black poplar leaves as a bioindicator. The mean ash percentage of poplar leaves was 12%. Simultaneously, the cities of Aktobe and Pavlodar in Kazakhstan exhibit the highest levels of chromium buildup. Aktobe is home to a robust chromite ore processing facility, while Pavlodar boasts a sizable pipe-rolling mill, along with a plant dedicated to producing ferroaluminum alloys for the oil and gas sector, as well as a complex for machine-building. The Aksu Ferroalloy Plant, located 20 km from Pavlodar, is the foremost metallurgical firm in Kazakhstan. Its primary focus is the production of chromium, silicon, and manganese alloys.

The uranium geochemical composition of the Ekibastuz region is influenced by the activities of the "Bogatyr" and "Vostochny" coal mines, which are the largest in the world. Additionally, the presence of the GRES-1 and GRES-2 power plants, which utilise over 9 million tonnes and about 4 million tonnes of coal per year respectively, further contributes to this specialisation. The mean uranium concentration in the coals of the Ekibastuz coal basin is 0.9 grammes per tonne, whereas in coal ash it is 2.5 grammes per tonne. The uranium concentration in the ashes of poplar leaves is typically around 1.2 grammes per tonne, which is considered to be at a similar level.

2 Materials and methods

Barberry (*Berberis vulgaris L.*), is a member of the *Barberryaceae* family within the *Buttercupaceae* group. The plant is a tall shrub that may reach a height of 2 metres. It has thorny branches and spreads by rhizomes that are not woody and grow horizontally. The exterior of the bark has a light brown colour, while the inside is a dark yellow hue. The shoots are coarse, upright, yellowish or yellowish-purple, and subsequently become whitish-grey. Flowers blossom throughout the spring season, namely in the months of April to May. The fruits reach maturity over the months of September to October. Barberry berries are extensively recognised for their utilisation in medical, as well as in the culinary and confectionary sectors. It serves as a primary ingredient for confectionary items and beverages, and is an essential flavouring agent for Uzbek pilaf. Raw materials can be collected during the whole duration of the cultivation period.

A comprehensive study was conducted to explore the qualities of barberry Berberis vulgaris and evaluate its availability and potential for use in the creation of a wider variety of natural beverages. The research was conducted at the "Centre of Biocenology and Environmental Research" of Alkey Margulan Pavlodar Pedagogical University.

A preliminary phase of the project involved conducting a patent search in the databases of the Commonwealth of Independent States (CIS) countries, with a primary focus on Kazakhstan and the Russian Federation. The patent study was conducted in accordance with the guidelines specified in GOST 15.011-96.

The creation of a tea beverage from barberry leaves involved evaluating the flavours of different concentrations of plant elements. Professionals in the field of food technology and participants from various backgrounds took part in the tasting, in accordance with the idea of voluntary participation. Details on the safety and health-enhancing impact of the suggested herbal raw ingredients acquired from reliable sources.

A survey was conducted to evaluate the feasibility of gathering plant materials in forest plantations, specifically in areas with abundant reserves of barberry. It should be noted that barberry is found naturally only in artificial forest plantations in the Pavlodar region and neighbouring areas of Northern Kazakhstan.

Analysing the chemical composition of the plant samples is an intricate and multifaceted procedure. It is important to adhere to each stage in order to achieve the most precise analysis. Typically, the job encompasses the subsequent steps. The plant samples undergo a process of dehydration and subsequent pulverisation. The resultant powder is inserted into specialised cuvettes, which are then put into the apparatus. The study of plant samples will be conducted utilising a BRA-18 Burevestnik X-ray fluorescence analyzer for spectral examination. To ensure the precision of the analysis, each sample is duplicated. Initially, the most suitable research mode is chosen. Subsequently, the spectrum is obtained for every individual sample. A qualitative examination of the composition of the researched plants is conducted based on the acquired spectra. The subsequent phase of the investigation involves doing a quantitative examination of the identified components. This experiment is also conducted with the designated apparatus. The process involves determining the concentrations of chemical components present in the sample and turning the findings into percentages.

Subsequently, the samples undergo a qualitative investigation. The chemical elements present in the sample are identified using specialised software. The gadget has a high level of sensitivity, allowing it to detect elements ranging from Na to U.

Once the qualitative makeup of the samples has been established, the concentrations of certain elements are computed using a designated programme and a reference sample, which serves as a benchmark. The data are consolidated into a single comprehensive table of metrics. Consequently, the acquired data is analysed and a conclusion is drawn in accordance with the study's goals. X-ray spectral analysis data are presented in the form of standardised methods, which include a spectrum graph that represents the level of fluorescence accumulation in the sample, as well as a table containing the mass fractions of elements in the samples expressed as percentages.

3 Results and discussion

3.1 Creation of a tea beverage derived from barberry leaves as an entirely novel tea intended for widespread consumption

The authors aimed to produce a widely consumed tea drink made from barberry, employing its vegetative portions (leaves), in order to broaden the selection of herbal teas available for public consumption. This objective was based on established literature data and patent documents. By using little economic investment and labour expenditures, one may produce a drink at home that contains a complex of physiologically active compounds derived from vegetable raw materials. This method is both easy and economical.

In order to address this issue, it is suggested, for the first time, to utilise barberry leaves as a raw material for the production of a tea beverage in industrial settings. These leaves possess favourable sensory characteristics and are rich in a variety of physiologically active compounds. To make tea at home, it is recommended to brew barberry leaves with boiling water instead of making an alcohol tincture, which was previously done for medicinal purposes. It is also advised not to preserve the plant materials or their extracts in sugar syrup or dry granular concentrates, as some popular methods suggest.

The advantages of the recently suggested tea are as follows:

1) The leaves of the common barberry, a widely found plant species, may be used as a raw material for a popular tea drink. These leaves can be harvested during the full growing season.

2) The accessibility and cost-effectiveness of obtaining the necessary raw ingredients and preparing the specified herbal tea.

3) Convenience and efficiency of beverage preparation in a domestic setting.

4) The herbal tea has desirable sensory features, including a lovely golden colour, a sweet and sour taste, and a berry scent. These attributes are appealing to most people and do not create any adverse reactions among customers.

The tea drink contains various flavours, flavour boosters, chemical preservatives, and other xenobiotics.

6) The tea drink contains a special combination of physiologically active compounds found in the vegetative sections of barberry. This combination is unique and does not have any negative interactions with other raw materials, thanks to its one-component makeup.

7) The absence of powerful and harmful components allows for a wide variety of health-improving benefits that benefit people of all ages.

The authors' herbal tea formulation consists of the following raw ingredients and their respective percentages:

The leaves of the common barberry plant (Berberis vulgaris) are dried and crushed, resulting in a quantity of 100.0.

The process of preparing herbal tea from barberry leaves is as follows. The process involves pouring boiling water over dry crushed raw ingredients at a ratio of 1-3 teaspoons (1-2 g) per glass. The mixture is then left to infuse for 5-10 minutes until it turns a golden yellow colour, as described in the RoK Patent for utility model No. 6479 [22].

3.2 The healing effect of tea from the leaves of barberry

The pharmacokinetics and pharmacodynamics of the health-enhancing action of barberry leaf tea are determined by the specific qualities of the biologically active chemicals present in the raw material.

1) Vitamin C and flavonoids, which have a synergistic impact, enhance the integrity of blood vessel walls and decrease capillary permeability, resulting in reduced edoema and inflammation.

2) During periods of limited availability of fresh vegetables and fruits, consuming a beverage made from barberry leaves might help decrease the likelihood of developing winter hypovitaminosis, including the prevention of scurvy.

3) The presence of succinic, ascorbic, fumaric, malic, and other organic acids stimulates redox reactions in the body and decreases intoxication from any cause, including hangovers.

4) Barberry leaves include a combination of water-soluble vitamins and succinic acid, making them a non-specific biostimulant that enhances the body's ability to resist colds, respiratory illnesses, and intestinal infections.

5) The alkaloid berberine and organic acids function as antiseptic agents that control the population of opportunistic microorganisms in the mouth and digestive system.

6) Succinic acid and a vitamin complex enhance cognitive focus and memory, even during nighttime hours and for individuals engaged in night shift work.

7) The choleretic characteristics of barberry alkaloids, when combined with organic acids, aid in the liquefaction of stagnant bile, promoting the healing of the liver and bile ducts in individuals suffering from biliary dyskinesia, chronic cholecystitis, and hepatocholecystitis.

8) Barberry leaf tea possesses the capability to stimulate uterine contractions, making it effective in addressing many gynaecological conditions such as pathological menopause, dysfunctional uterine bleeding (including menopausal haemorrhage), and protracted and painful menstruation.

9) The presence of alpha-tocopherol (vitamin E) in the leaves inhibits premature decline in reproductive function in both males and females (menopause and andropause), avoids excessive thinness, and stimulates muscular growth in those engaged in sports and hard labour.

10) Barberry tea is a natural hepatoprotector due to the synergistic interplay between tocopherol's antioxidant effects and flavonoids and water-soluble vitamins.

11) Barberry leaf tea can be suggested as a secure preventive anticancer drug that inhibits the development of tumours, particularly for those working in dangerous environments exposed to carcinogens and radionuclides. Berberine, an alkaloid, has anticancer and antileukemic properties. However, synthetic production of berberine has not been achieved thus far. The tea prepared from barberry leaves contains this chemical in amounts that are considered safe.

Organic acids enhance hunger and enhance the secretory and motor function of the gastrointestinal system, when combined with vitamins that enhance metabolism and redox activities.

13) The intake of tea made from barberry leaves effectively relieves thirst because it counteracts the irritating action of organic acids on the mucosal membranes of the oral cavity. When a diet that restricts liquid intake is advised, consuming barberry tea might alleviate thirst and hence minimise psychological distress caused by the enforced limitations.

14) The tea made from barberry leaves has a tonic and bio-stimulating effect, but it does not cause an elevation in blood pressure like most medicines, nutritional supplements, and herbal teas with a tonic effect.

Barberry tea possesses diuretic and diaphoretic properties, making it beneficial for treating colds, viral disorders, drunkenness, preventing weight gain (by stimulating redox processes), and reducing edoema.

According to the available literature, we have discovered the following contraindications for consuming a tea made from barberry leaves:

1) It is advisable to avoid consuming tea made from barberry leaves in the evening due to the bio-stimulating properties of the combination of vitamins and succinic acid, which can potentially disrupt sleep patterns.

2) The use of tea should be restricted during pregnancy because the alkaloid bebeerine present in tea might stimulate uterine contractions and perhaps lead to a miscarriage.

3) Individuals with cholelithiasis, who have a medical condition that prohibits the use of choleretic medications, should seek medical advice prior to consuming tea.

Barberry leaf herbal tea is consumed as a morning tonic and dessert beverage because of its pleasant sweet and tart flavour and aromatic qualities derived from the berries. The drink can be suggested for therapeutic and preventative objectives, such as treating extended menstruation, menopausal bleeding, colds, infectious disorders, asthenia, loss of appetite, drunkenness, hangover, predisposition to neoplasms, and for those working in hazardous situations. Barberry leaf tea enhances vitality and improves focus for individuals working during the night shift. It is advisable to refrain from consuming a beverage made from barberry leaves during the nighttime hours to prevent any disruptions in sleep.

Barberry leaves have medicinal properties that can be beneficial for many health conditions such as bile stasis and cholecystitis (by dissolving and thinning even old bile), uterine bleeding, gastrointestinal problems, colds, and infectious infections. Additionally, they contain the berberine alkaloid, which makes them a safe anti-cancer agent. Barberry leaves possess a combination of vitamins and succinic acid, making them an effective non-specific biostimulator and immunogenic agent. They have the ability to counteract intoxications of several sources, including hangovers. Tocopherol (vitamin E) emerges in the leaves throughout the fruit development and maturation phase. This antioxidant aids in safeguarding the liver and promoting muscular growth, so preventing premature reproductive decline in both males and females.

3.3 Assessment of the stocks of common barberry and the possibilities of collecting plant materials

Simultaneous achievement of the extensive utilisation of local plant materials and the increase of the variety of health tea beverages may be accomplished by considering the indigenous and introduced flora of certain places in Kazakhstan. Barberry species, namely Ili barberry, are found in hilly regions, although their distribution is restricted to the lower slopes. Siberian barberry is occasionally planted in certain artificial plantings and botanical gardens, although its spread is limited in most parts of Kazakhstan.

The common barberry in many parts of Kazakhstan, particularly the northern areas, is a naturalised species that has adapted to the local climate. It has not only established itself but also expanded autonomously from forest plantations and nurseries for many years. This shrub has high resilience to disturbances such as cuts and fires, since it may readily regenerate by root progeny and seeds, which are dispersed by overwintering avian species.

The suggested beverage can be economically feasible in all or many regions of Kazakhstan due to the utilisation of abundant native plant materials that are widely available across the country. Raw material acquisition is feasible for the whole duration of the growth period, while the expenses associated with drying and packing will be minimal. The widespread distribution of tea made from barberry leaves will lead to an increase in the variety of beverages made from natural ingredients. Additionally, it will provide a wider range of therapeutic and preventive remedies for various ailments such as colds, infectious diseases, liver and gastrointestinal disorders, asthenic conditions, and appetite disorders.

The genus Barberry consists of around 200 woody-shrub plant species that are mostly found in America [23]. Based on further data, there are about 500 barberry species worldwide, which may be found in America, North Africa, and Eurasia, including the post-Soviet republics. Among them, 17 species are mostly dispersed in the wild flora of Central Asia and the Caucasus [24]. The prevalent kind of barberry is the common one, which is frequently cultivated for decorative purposes in addition to its natural distribution. Ili barberry and Karkaralinsky, which are found in the southern region of Kazakhstan, are classified as protected species. They were included in the Red Book of the USSR in 1989 and continue to be protected. As a result, it is not advisable to promote their widespread commercial use.

The Siberian barberry is found in the natural flora of Siberia, including the northern portions of Kazakhstan. It is believed to have more potent therapeutic effects compared to the common barberry [25]. Furthermore, the Siberian barberry has a reduced level of prickliness compared to the ordinary barberry, with instances where the plants do not produce spines at all. This characteristic enhances the ease of gathering leaves from this species for both culinary and medicinal applications.

The common barberry may be found in every hamlet or its surrounding areas in the Pavlodar region. Small clusters of barberry bushes, ranging from 2-3 to 5 dozen plants, may be found in all horticultural areas around the regional centre. They are also present in the forest nursery of Gorzelenstroy and in some man-made forest plantations, primarily along roads.

Based on our data, each shrub measuring between 0.7 to 2.2 metres in height, covering an area of approximately 1 square metre, yields a harvest of 350-400 grammes of fresh leaves. To ensure the plant's well-being, it is recommended to collect only 30-33% of the leaves. Once dried, these leaves will result in 120-150 grammes of air-dry raw material. Consequently, a yield of 35-40 kilogrammes of unprocessed leaves may be obtained from every one hundred square metres, which translates to 35-40 centners per hectare. The yield of dried leaves suitable for tea substitute production will be 12-15 quintals per hectare.

The drying process of this shrub's leaves is highly technical because to their low moisture content, which contributes significantly to the output of dried leaves from fresh raw materials. The sole issue is in the extended drying time of barberry leaves, which can be attributed to the presence of organic acids and threose sugars that effectively hold moisture. Based on our observations, drying can be expedited by utilising street drying, where the raw material is shielded from direct sunlight yet exposed to natural air currents. When arranging conveyor drying, it will be feasible to utilise methods of artificial air circulation.The results of studies of potential raw materials presented in table 1.

Table 1. Estimation of stocks of barberry leaves with the prospect of using green tea as a surrogate.

Indicators	**Trial site numbers**					
	I	II	III	IV	V	VI
Area (sq.m.)	1	1	0.7	0.7	0.7	0.7
Collected raw leaves, g	400	320	280	240	240	240
Raw leaves per 1 sq.m.	400	320	400	343	343	343
Dried leaves, g	140	130	116	110	110	90
Dry leaves from 1 sq.m.	140	130	165.7	157.1	157	128.6

Yield of dry leaves, %	35.0	40.625	41.43	45.83	45.83	37.5
plant height	1.4 m	1.45 m	1.8 m	2.2 m	1.8 m	1.85 m
Number of trunks per bush	43	32	48	26	35	30

Based on our observations, the barberry plants in the forest nursery of Gorzelenstroy had a height range of 140 to 170 cm, with individual bushes reaching a height of 2-2.2 m. The plants in long-standing thickets reached a height of 1.8-2 metres. A single square metre is typically occupied by one barberry bush, including anything from 25 to 60 separate stems. The barberry plant consistently takes the shape of a shrub rather than a tree, without a distinct primary trunk.

In order to streamline the process of manually gathering raw materials, while considering the presence of thorns on the barberry branches, the following device might be suggested. A thick elastic material is used to create a circular shape with a diameter ranging from 12 to 15 cm. This shape includes a smaller circular hole in the centre with a diameter of 1 to 2 cm. The circular is bisected using scissors at the central aperture. When gathering leaves, the apparatus is positioned at the bottom of a branch covered with leaves, wrapped around it in a conical shape, shielded with a hand, and dragged along the branch from the bottom to the top. Simultaneously, the assembler's hands remain unharmed, and the gadget is protected from damage caused by spikes. This is because the spikes are "smoothed out" in the natural direction, from the base to the top of the branch, when the funnel is in motion. The detached leaves, resulting from the tight compression of the funnel and the action of the brush, are collected in the funnel and subsequently transferred into a shared receptacle.

3.4 Study of the microelement composition of barberry leaves as a potential raw material for the production of a drink for mass consumption.

The content of mineral elements (toxic and non-toxic), as well as the total ash content of barberry leaves The data gathered in 2020 and 2021 exhibit negligible disparities. Both years had pronounced aridity, a reduction in summer precipitation, and elevated summer air temperatures.

The high levels of potassium, calcium, and phosphorus in barberry leaf drink make it suitable as a dietary food product for preventing cardiovascular illnesses, osteoporosis, and age-related changes in the body.

Table 2. The content of toxic and undesirable elements in plant materials collected in the snowless period of 2020.

Element	**Mass fraction of elements, in %**			**Mean**	**Measurement error**
Sample: barberry 2020 collection					
Cl	0.0035	0.0035	0.0030	0.0034	0.0003
Na	0.0727	0.0773	0.0720	0.0740	0.0029
sn	0.0006	0.0006	0.0006	0.0006	0.0000
Sb	0.0046	0.0057	0.0046	0.0050	0.0006
As	0.0017	0.0016	0.0019	0.0017	0.0002
Pb	0.0049	0.0042	0.0051	0.0047	0.0005
Ti	0.0034	0.0032	0.0027	0.0031	0.0004
Ba	0.0016	0.0015	0.0014	0.0015	0.0001

Cs	0.0070	0.0079	0.0064	0.0071	0.0008
hg	0.0017	0.0018	0.0018	0.0018	0.0001
CD	0.0048	0.0051	0.0050	0.0050	0.0002
U	0.0061	0.0057	0.0062	0.0060	0.0003
Sample: barberry 2021 collection.					
Cl	0.0031	0.0034	0.0036	0.0034	0.0003
Na	0.0627	0.0795	0.0728	0.0717	0.0085
Sn	0.0005	0.0005	0.0005	0.0005	0.0000
Sb	0.0067	0.0058	0.0067	0.0064	0.0005
As	0.0017	0.0018	0.0015	0.0017	0.0002
Pb	0.0049	0.0053	0.0040	0.0047	0.0007
Ti	0.0035	0.0036	0.0030	0.0034	0.0003
Ba	0.0016	0.0017	0.0014	0.0016	0.0002
Cs	0.0070	0.0076	0.0062	0.0069	0.0007
Hg	0.0016	0.0016	0.0016	0.0016	0.0000
Cd	0.0050	0.0048	0.0050	0.0049	0.0001
U	0.0064	0.0056	0.0063	0.0061	0.0004

Table 3. The content of non-toxic elements in the leaves of the common barberry in the Pavlodar region in the collections of 2020-2021

Element	Mass fraction of elements, in %			Mean	Measurement error
Sample: barberry 2020 collection					
K	1.3520	1.7536	1.4588	1.5215	0.2080
Ca	0.8037	0.8095	0.7998	0.8043	0.0049
V	0.0021	0.0094	0.0067	0.0061	0.0037
Cr	0.0064	0.0056	0.0061	0.0061	0.0004
Mn	0.0063	0.0059	0.0062	0.0061	0.0002
Fe	0.0895	0.0892	0.0898	0.0895	0.0003
Co	0.0016	0.0015	0.0014	0.0015	0.0001
Ni	0.0000	0.0000	0.0000	0.0000	0.0000
Cu	0.0062	0.0062	0.0060	0.0062	0.0001
Zn	0.0023	0.0024	0.0023	0.0023	0.0001
P	0.2923	0.2698	0.2924	0.2848	0.0130
S	0.1942	0.1785	0.1915	0.1881	0.0084
Mo	0.2597	0.2498	0.2586	0.2560	0.0054
Al	0.0393	0.0385	0.0370	0.0383	0.0012
Sample: barberry 2021 collection					
K	1.1588	1.2263	1.2307	1.2053	0.0403
Ca	0.8721	0.8942	0.8881	0.8848	0.0114
V	0.0049	0.0062	0.0067	0.0059	0.0009
Cr	0.0057	0.0054	0.0060	0.0057	0.0003
Mn	0.0063	0.0062	0.0060	0.0062	0.0002
Fe	0.0900	0.0902	0.0904	0.0902	0.0002

Co	0.0015	0.0015	0.0014	0.0015	0.0001
Ni	0.0000	0.0000	0.0000	0.0000	0.0000
Cu	0.0061	0.0059	0.0060	0.0060	0.0001
Zn	0.0026	0.0023	0.0027	0.0025	0.0002
P	0.3071	0.3154	0.3078	0.3101	0.0046
S	0.1785	0.1795	0.1916	0.1832	0.0073
Mo	0.2498	0.2510	0.2551	0.2520	0.0028
Al	0.0340	0.0470	0.0371	0.0393	0.0068

The content of toxic elements (maximum permissible concentrations)

Element	**Sample: barberry**	**Mass fraction of elements, in ppm**
Pb		10.0
As		1.0
Cd		1.0
Hg		0.1

4 Conclusion

1. A novel formulation of barberry leaves (Berberis vulgaris) as a green tea alternative has been created. This formulation possesses a pleasant combination of sour and sweet taste, along with a delightful berry scent. Importantly, it does not require the addition of sweeteners or flavourings. Barberry leaf herbal tea may be easily prepared both at home and in outdoor settings. In order to do this, one must pour boiling water over dried and crushed raw materials, using a ratio of 1-3 teaspoons (equivalent to 1-2 grammes) each glass. The mixture should then be left to infuse for a duration of 5-10 minutes, until it reaches a golden yellow colour.
2. The suggestion to consume herbal tea made from barberry leaves as an invigorating morning beverage with a diverse array of health-enhancing properties, such as being rich in vitamins, promoting bile secretion, activating biological processes, boosting the immune system, preventing cancer, regulating metabolism, and removing different types of intoxication (including alcohol-related), was supported by evidence. An absolute contraindication for consuming the drink is during the evening, pregnancy, and in the presence of cholelithiasis, a condition in which choleretic drugs should not be used.
3. An assessment has been conducted on the available supply of common barberry leaves as a potential alternative to green tea. Barberry is extensively dispersed in forest plantations in all areas of Kazakhstan. The moisture removal process from the leaves results in a yield of dry raw materials ranging from 35% to 45%. Each weave yields around 35-40 kg of undamaged raw leaves, resulting in a yield of 35-40 c/ha per hectare. The yield of dried leaves specifically utilised for producing tea substitute will be 12-15 quintals per hectare.
4. The sophisticated evaluation approach for determining the ash content of plant raw materials was examined, and it was found that the levels of both hazardous and non-toxic constituents remained rather stable between 2020 and 2021. Barberry is a valuable source of essential trace elements, including potassium, calcium, and phosphorus. This makes it a suitable choice for dietary nutrition when selecting a beverage. The concentration of harmful

trace elements remains within the hygienic requirements prescribed for food goods and medicinal plant materials.

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