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Mini Review

Rhubarb: A Potent Medicinal Herb Linking Traditional Medicine Research Between Uzbekistan and China

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Abstract

Rhubarb has a vast distribution across Asia and has significant importance as a medicinal plant. China and Uzbekistan have a long tradition of using rhubarb species as medicinal and food plants. Both nations' traditional medicines strongly agree on the effectiveness of rhubarb. In this mini-review, we summarized the existing knowledge on the plant distribution, genetic diversity, reported active ingredients with their biological efficacy, and suggest a set of research activities to combine the benefits of both nations in utilizing medicinal rhubarb resources. Conducting such systematic research in both countries according to the traditional medical knowledge of China and Uzbekistan, and using modern molecular biology and analytical bioscience technology, will significantly enhance the research level of medicinal rhubarb, also enhance further research and medicinal usage of rhubarb as healthy products, as well as the development and utilization of rhubarb resources.

Keywords: Chemical composition; Biological activity; Processing technique

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1. Genus *Rheum*: distribution and medicinal usage

Rheum, know as rhubarb, a genus within the family Polygonaceae, has a prominent position as a globally recognized for its medicinal properties and extensively utilized herb (Shahrajabian et al. 2022). Rhubarb is mostly represented in Asia (Mohtashami et al. 2021) with the largest number of species in China (*ca*. 35 species), Central Asia (ca. 15 species) and Iran (*ca*. 8 species) (Figure 1). Their medicinal and edible uses are summarized in Table 1**.** Among the known *Rheum* species, five are listed as having therapeutic effects in Uzbekistan (*R.cordatum, R.tataricum, R. wittrockii, R. turkestanicum* and *R. maximowiczii*) and three species are listed in the latest version of Chinese Pharmacopoeia (Chinese Pharmacopoeia Commission 2020) (*R. tanguticum*, *R. palmatum*, and *R. officinale*). In this mini-review, we summarize the existing knowledge on the main geographical distribution of these eight species of genus *Rheum*, genetic diversity, reported active ingredients, and biological efficacy, using the traditional medical knowledge of China and Uzbekistan, and this knowledge should enhance further research and medicinal usage of rhubarb resources.

Table 1. The global distribution and medicinal and edible uses of the rhubarb species

Rhubarb Species	Distribution	Used as medicine	Used as food
Rheum acuminatum Hook.f. & Thomson	China, Myanmar, Nepal	yes	no
Rheum alexandrae Batalin	China	yes	yes
Rheum australe D.Don	East Himalaya, Myanmar, Nepal, Pakistan, Tibet, West Himalaya	yes	yes
Rheum austroiranicum Taheri & Assadi	Iran	no	no
Rheum compactum L.	Kazakhstan, Russia, Mongolia, China	no	yes
Rheum cordatum Losinsk.	Kazakhstan, Kirgizstan, Uzbekistan	yes	yes
Rheum coreanum Nakai	Korea	yes	no
Rheum darvasicum V.S.Titov ex Losinsk.	Uzbekistan	no	no
Rheum delavayi Franch.	China, Bhutan, Nepal	yes	no
Rheum fedtschenkoi Maxim. ex Regel	Uzbekistan, Tajikistan	no	no
Rheum forrestii Diels	China	yes	no
Rheum glabricaule Sam.	China	yes	no
Rheum globulosum Gage	China, Bhutan	no	yes
Rheum hissaricum Losinsk.	Tajikistan	no	yes
Rheum hotaoense C.Y.Cheng & T.C.Kao	China	yes	no
Rheum inopinatum Prain	China	yes	no
Rheum iranshahrii Taheri & Assadi	Iran	no	no
Rheum	Iran	yes	no

khorasanicum Baradaran & Jafari			
Rheum kialense Franch.	China	yes	no
Rheum kordestanicum Taheri & Assadi	Iran	no	no
Rheum laciniatum Prain	China	yes	no
Rheum lhasaense A.J.Li & P.K.Hsiao	China	yes	no
Rheum likiangense Sam.	China	yes	no
Rheum lucidum Losinsk.	Tajikistan	no	no
Rheum macrocarpum Losinsk.	Tajikistan, Uzbekistan, Kyrgizstan	no	yes
Rheum maculatum C.Y.Cheng & T.C.Kao	China	no	no
Rheum maximowiczii Losinsk.	Afghanistan, Kazakhstan, Kirgizstan, Tadzhikistan, Uzbekistan	yes	yes
Rheum moorcroftianum Royle	Nepal, Tibet, West Himalaya	yes	yes
Rheum nanum Siev.	China, Kazakhstan, Mongolia, Russia	yes	yes
Rheum neyshabourense Baradaran & Jafari	Iran	no	no
Rheum nobile Hook.f. & Thomson	Afghanistan, East Himalaya, Myanmar, Nepal, Pakistan, Tibet	yes	no
Rheum officinale Baill.	China	yes	yes
Rheum palaestinum Feinbrun	Iraq, Palestine, Saudi Arabia	yes	yes
Rheum palmatum L.	China, Vietnam	yes	yes
Rheum persicum Losinsk.	Iran	no	no
Rheum platylobum Rech.f.	Afghanistan	no	no
Rheum przewalskyi Losinsk.	China	no	no
Rheum pumilum Maxim.	China	yes	yes
Rheum racemiferum Maxim.	China, Mongolia	no	no
Rheum rhabarbarum L.	China, Russia, Mongolia	yes	yes
Rheum rhaponticum L.	Bulgaria	yes	yes
Rheum rhomboideum Losinsk.	China	no	no
Rheum ribes L.	Afghanistan, Iran, Iraq, Lebanon-Syria, Pakistan, Palestine, Transcaucasus, Turkey	yes	yes
Rheum spiciforme Royle	Afghanistan, Bhutan, Kazakhstan, Kyrgizstan, Nepal, Pakistan, China, Tajikistan, West Himalaya	yes	yes
Rheum subacaule Sam.	China	no	no
Rheum sublanceolatum C.Y.Cheng & T.C.Kao	China	yes	no
Rheum × svetlanae Krassovsk.	Turkmenistan	no	no

Rheum tanguticum (Maxim. ex Regel) Balf.	China	yes	yes
Rheum tataricum L.f.	Russia, Kazakhstan, Ukraine, Uzbekistan, China	yes	yes
Rheum telianum İlçim	Turkey	yes	yes
Rheum tibeticum Maxim. ex Hook.f.	Afghanistan, Pakistan, China, West Himalaya	yes	yes
Rheum turkestanicum Janisch.	Iran, Kazakhstan, Tajikistan, Transcaucasus, Turkmenistan, Uzbekistan	yes	yes
Rheum uninerve Maxim.	China, Mongolia	no	no
Rheum uzengukuushi Lazkov & H.J.Choi	Kyrgyzstan	no	no
Rheum webbianum Royle	Nepal, Pakistan, China, West Himalaya	yes	yes
Rheum wittrockii C.E.Lundstr.	Kazakhstan, Kirgizstan, Pakistan, Tajikistan, Uzbekistan, China	yes	yes
Rheum yunnanense Sam.	China, Myanmar	yes	no

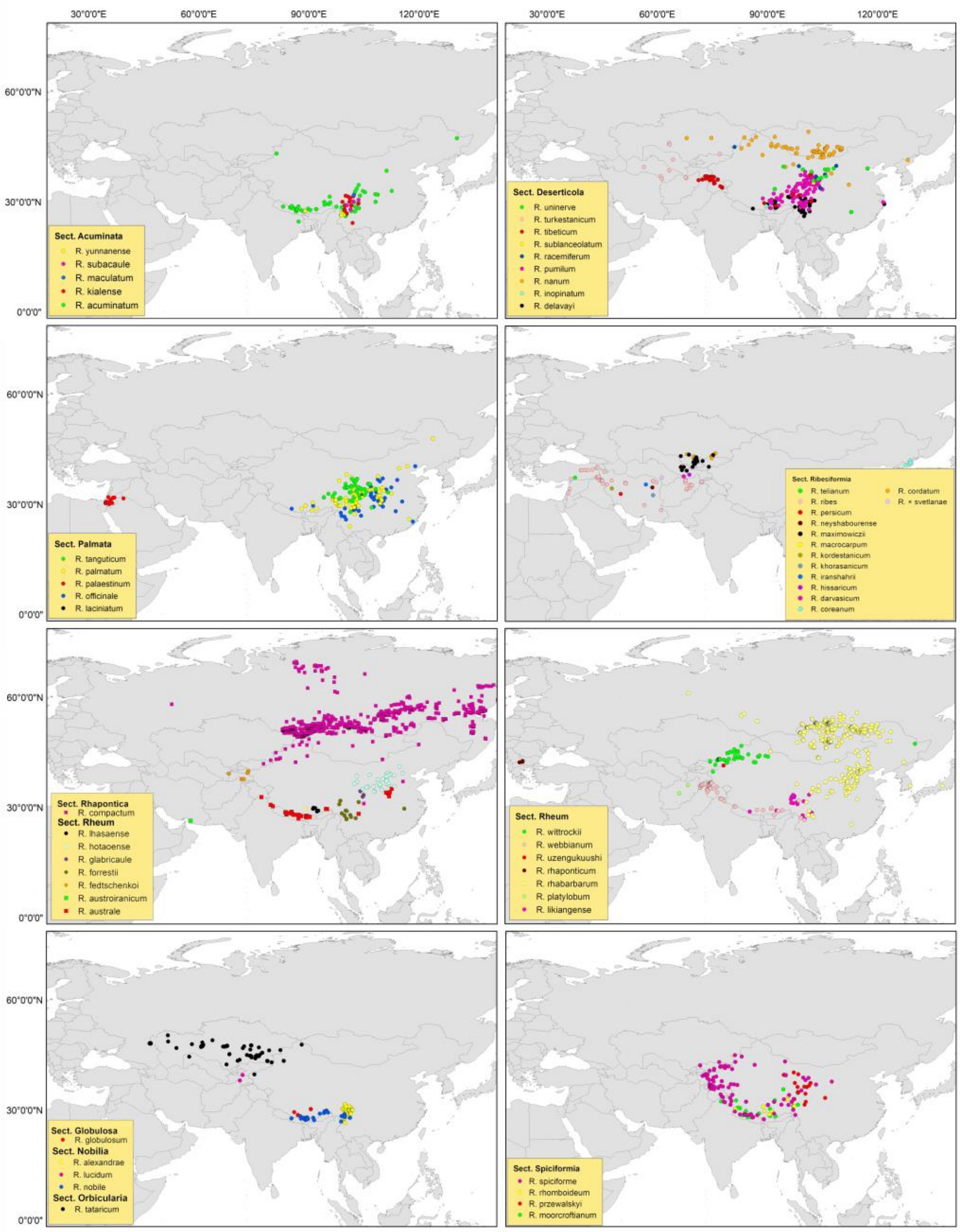

Figure 1 The main geographical distribution of the genus *Rheum* in the world (mapped by sections).

2. Medicinal Rhubarb in China and Uzbekistan

2.1 Chinese medicinal rhubarb resources

Officially certified medicinal rhubarb resources in China consist of three distinct species *Rheum palmatum* L., *Rheum tanguticum* Maxim. ex Balf. and *Rheum officinale* Baill (Chinese Pharmacopoeia Commission 2020). However, western China is home to over twenty other species of medicinal rhubarb which are utilized for folk medicinal purposes, but currently there is lack of data for these species (Kaixan et al. 2022). According to the Chinese Pharmacopoeia as well as the pharmacological studies, the roots and rhizomes of rhubarb in traditional Chinese medicine have many properties including purgation, antipyretic, detoxifying, hemostatic, circulatory, laxative and anti-inflammatory effects (Chinese Pharmacopoeia Commission 2020). The main pharmacological effects of the three officially certified Chinese rhubarb species are summarized in **Table 2,** with their reported main active components.

Table2. Chinese officially certified medicinal rhubarb with their distribution, main pharmacological properties and their reported active components

Species	Pharmacological activity	Main active compound (s)	Source
R. Palmatum	Nephroprotective activity	tannins	Lu et al. 2011
	Antidiabetic effect	tannins	Yang et al. 1993; Yokozawa et al. 1991; Yokozawa et al 1984
	Anti-inflammatory activity	Tannins; rhein	Zhou et al. 2015; Abe et al. 2000
	Chronic kidney disease	emodin	Li 1996
	Severe Acute Respiratory Syndrome (SARS)	emodin	Ho et al. 2007
	Prevention and treatment of Parkinson's disease	emodin	Kong et al. 2004
	Anti-viral effect	emodin	Miraj 2016
	Antiulcer activity	chrysophanol	Yusuf et al. 2019; Malik et al. 2016.
R. tanguticum	Anti- colitis efficacy	Polysaccharides	Liu et al. 2005 Zhang et al. 2023
	Immune system protection	Polysaccharides	Liu et al. 2012
	Anti-microbial efficacy	Stilbenes	Yue et al. 2022
R. officinale	Anti-microbial efficacy	Anthraquinones	Liu et al. 2012
	Anti-cancer efficacy	Water extracts	Li et al. 2009
	Immunomodulatory efficacy	Anthraquinones	Song et al. 2020
	Relieving airway inflammation	Emodin	Chu et al. 2012
	Improving wound healing	Water extracts	Yang et al. 2020; Chao et al. 2021

2.1.1 *Rheum palmatum* L.

Phytochemical Profile, Medicinal Compounds and Pharmacological properties: The most vital components from *R. palmatum* are the phenolics, flavonoids, terpenoids, saponins, and anthraquinone derivatives such as aloe-emodin, chrysophanol, physcion, rhein, emodin and glycoside. Rhubarb also contains tannins which include hydrolysable-tannins, containing glycosidic or ester bonds composed of glucose, gallic acid, and other

Distribution: China and Vietnam. Conservation status: EN.

monosaccharide's and condensed tannins, resulting principally from the flavone derivatives leukocyanidin and catechin. In recent years, new components such as revandchinone-1, revandchinone-2, revandchinone-3, revandchinone-4, sulfemodin8-O-b-Dglucoside, and 6-methyl-rhein and aloe-emodin have been reported from the same class. It also encompasses some macro and micro mineral elements such as Ca, K, Mn, Fe, Co, Zn, Na, Cu, and Li.

Although the chemical profile has been well studied, only several chemical compounds (e.g., tannins, emodin, etc.,) have been reported to contribute to its pharmacological properties including nephroprotective, anti-inflammatory, anti-ulcer, anti-vira, anti-diabetic, as well as against chronic kidney disease, severe acute respiratory syndrome and Parkinson's disease.

Genetic diversity: It was found that eight InDels and sixty-one SNPs loci could be used to authenticate the high-quality germplasms of this species in specific areas (Zhai et al. 2023).

2.1.2 *Rheum tanguticum* Maxim. ex Balf.

Distribution: Qinghai–Tibetan Plateau. Conservation status: EN

Phytochemical Profile, Medicinal Compounds and Pharmacological properties: Its dried roots and rhizomes are used as medicine and have been shown to be effective in purging heat, dredging intestines, cooling blood, detoxifying, removing blood stasis and stimulating menstruation (Chen et al. 2022a). The results of modern pharmacological studies have revealed some of its other activities, including anti-inflammatory and anti-bacterial activity, as well as its ability to lower blood fat levels and protect the kidneys (Dong et al. 2016; Jelassi et al. 2013).

Whole genome of this species was sequenced and the evolution of anthraquinone biosynthesis was studied well (Li et al. 2023). Metabolite profiles of *R. tanguticum* grown under different altitudinal gradients was studied by metabolomics analysis (Wang et al. 2024). The results showed that plants grown at lower altitudes had better growth performances than those in higher altitude areas. The yield varied by 2.45–23.68 times with altitude, reaching a maximum of 102.01 t/ha. In addition, total anthraquinone and total sennoside contents decreased with increasing altitude, whereas total tannins increased with increasing altitude. Key metabolites were significantly upregulated in high-latitude cultivation areas. These results provide a scientific basis for quality control and the systematic cultivation of *R. tanguticum*.

Genetic diversity: The matK and rpl32 regions showed discriminatory ability for this species from the others (Chen et al. 2022b).

2.1.3 *Rheum officinale* Baill.

Distribution: North-central and south-central China, China.

Phytochemical Profile, Medicinal Compounds and Pharmacological properties: In total, 124 compounds were identified in this species, including 31 acylglucosides, 9 phenolic acids, 26 tannins, 53 anthraquinones, and 5 other compounds (Yao et al. 2021). This species has been comprehensively studied for its anti-microbial and anti-inflammatory potential against *Staphylococcus aureus* infected wounds (Yang et al. 2020) and showed good results in treating this kind of wounds. Application of this species extracts may improve wound healing in diabetic conditions (Chao et al. 2021). Transcriptomic profile of important compounds of *R. officinale* was fully described (Zhou et al 2022) and whole genome sequence and anthraquinones biosynthesis were studied (Zhang et al. 2024).

2.2 Rhubarb Plants in Uzbekistan

Five medicinal rhubarbs occur in Uzbekistan including *Rheum maximowiczii* Losinsk., *Rheum cordatum* Losinsk., *Rheum turkestanicum* Janisch, *Rheum wittrockii* C.E.Lundstr. and *Rheum tataricum* L.f.. Among them, extensive records of the folk medicinal use exist for *Rheum maximowiczii* (Kosimov et al. 2023). Furthermore, the other four different rhubarb species exhibit similar medical and dietary characteristics (Sezik et al. 2004; Sitpayeva 2017; Zhumashova et al. 2019; Ghorbani et al. 2019). Table 3 summarizes the medicinal Uzbekistan

Rhubarb with their main pharmacological properties and reported active components.

Table 3. Rhubarb Plants in Uzbekistan with their distribution, main pharmacological properties and their reported active components

Species	Pharmacological activity	Main active compound (s)	Source
R. maximowiczii	Stomach disorders, antioxidant, vitamin deficiency, digestive tract	Phenyl butanoids, stilbene dimers, rhododendrol, epirhododendrin, lindleyin, torachrysone, resveratrol	Rokaya et al. 2012; Khojimatov et al. 2015
R. cordatum	Antioxidant effect	Emodin, Catechin, Chrysophanol	Zhumashova et al. 2019
R. tataricum	Antioxidant effect	Minera zl (Li, Se, Si, Mo, etc.,), polyphenols, carotenoids in roots; proline in leaves; malic acid in stems	Golubkina et al. 2022
R.turkestanicum	Anti-inflammatory, Neuroprotective, Retinoprotective, Cardioprotective, Hepatoprotective	Chrysophanol	Ghorbani et al. 2019
	Neuroprotective, Immunomodulatory, Improving BPH	Daucosterol	Desai et al. 2009; Berges et al. 1995
	Hepatoprotective, Anti-inflammatory, Anti-hyperlipidemic	Emodin	Alisi et al. 2012; Hwang et al. 2013; Dong et al. 2009
	Anti-hypertensive, Angiogenic, Neuroprotective, Cardioprotective, Antiaging	Epicatechin	Schroeter et al. 2006; Gomez-Guzman et al. 2012; Shah et al. 2010; Yamazaki et al. 2010
	Hepatoprotective Antihyperlipidemic Anti-inflammatory Nephroprotective Cardioprotective	Glucogallin	Majeed et al. 2015; Ahad et al. 2015; Ryu et al. 2016
	Anti-inflammatory Neuroprotective Wound healing Hepatoprotective Anti-obesity	Quercetin	Lesjak et al. 2018; Godoy et al. 2017; Polera et al. 2019; Porras et al. 2017; Chen et al. 2016

	Hepatoprotective Nephroprotective Anti-hyperglycemic Anti-hyperlipidemic Anti-fibrotic Anti-aging	Rhein	Zhao et al. 2011; Sheng-Nan et al. 2013; Liu et al. 2013; Zhang et al. 2012; Tsang et al. 2013; Zhen et al. 2016
	Anti-inflammatory Analgesic Anti-psoriasis	Rhododendrin	Fushiya et al. 1998; Kim et al. 2011; Jeon et al. 2013; Jeon et al. 2017
R. wittrokii	Anti- diabetes	Sucrose	State Pharmacopoeia of the Russian Federation 2016
	Anti-inflammatory and resorbing effect, anti-pruritic effect, Anti-eczema effect, Anti-fungal effect, Relieving spasms in the gastrointestinal tract and bile ducts	Chrysarobin, chrysarobinumhydroxyl derivatives of anthracene and dihydroanthracene hydrocarbons	Matsuda et al. 2001; Onoda et al. 2016
	Antioxidant effect,	Chrysophanic acid(1,8-dihydroxy-3-methylanthraquinone) or (dioxymethylanthraquinone)	Choi et al. 2016; Fei et al. 2017
	Anti-cancer effect, anti-bacterial effect, laxative effect	Emodin-3-methyl ether	Huang et al. 2004
	Anti- cancer effect,	Emodin 1,3,8-trihydroxy-6-methylanthracene-9,10-dione	Ramana et al. 2017

2.2.1 *Rheum maximowiczii*

Distribution: Mountainous Central Asia.

Phytochemical Profile, Medicinal Compounds and Pharmacological properties: It is a folk medicine used by the natives of Uzbekistan. The roots, rhizomes, petioles and stems of *Rheum maximowiczii* possess several medical properties, including the ability to cure anemia, reduce fever, and lower blood pressure. It is also recommended for the treatment of stomach disorders, hepatitis, cholangitis, biliary dyskinesia, hemorrhoids, chronic constipation, polyarthritis, and feverish diseases (Shikishima et al., 2001; Khojimatov et al.

2023). The local community consumes the petioles and young stems of this plant as a vegetable. The leaves are occasionally used as a herbal tea and for the purpose of dyeing beer (Khojimatov et al. 2023). Shikishima et al. (2001) isolated and characterized several compounds, including phenyl butanoids, stilbene dimers, rhododendrol, epirhododendrin, lindleyin, torachrysone, resveratrol, and physcion from *Rheum* maximowiczii.

2.2.2 *Rheum cordatum* L.

Distribution: Kazakhstan, Kirgizstan, Uzbekistan.

Phytochemical Profile, Medicinal Compounds and Pharmacological properties: *Rheum cordatum* L. contains a rich array of chemical constituents, with anthraquinones, flavonoids, tannins, stilbenes, and phenolic acids being among the most notable compounds. The plant extracts from the leaves, stems, and seeds can be used as a strong dietary antioxidant. The dominant compounds are rutoside (0.08-4.87%) and epicatechin gallate (0.05-2.16%). In the root extracts, epicatechin gallate (2.23-5.00%) and emodin (0.34-1.06%) have the highest concentrations (Zhumashova et al. 2019).

More than 20 compounds from anthraquinones and phenolics were identified in this species. In addition, the plant has been shown to contain a diverse array of phenolic compounds, including catechins, glucosides. In contrast, its anthraquinone composition is primarily represented by emodin and its analogues. These findings suggest that the plant could be a valuable source of pharmacologically significant polyphenols. (Zhumashova et al. 2019).

Based on flavonoids, catechins and anthraquinones extracted from this species, drugs were developed (Zhumashova et al. 2019). However, these chemical compounds biosynthesis at molecular level have not been studied.

2.2.3 *Rheum turkestanicum* Janisch.

Distribution: Iran, Kazakhstan, Tajikistan, Transcaucasus, Turkmenistan, Uzbekistan.

Phytochemical Profile, Medicinal Compounds and Pharmacological properties: The roots of *R. turkestanicum* are believed to be a remedy for such deseases as diabetes, hypertension, jaundice, and cancer (Amiri et al. 2013). Root extract of *R. turkestanicum* contains a variety of compounds, including alkanes (such as eicosane and heneicosane), anthraquinones (including aloe-emodin, emodin glycosides, physione, and rhein), fatty acids (such as linoleic acid and 9-octadecenoic acid), and flavonoids (such as epicatechin and quercetin). Additionally, the extract was found to contain a high concentration of glucogallin, a phenolic compound derived from β-D-glucose and gallic acid. (Jahani et al. 2020). Dehghan et al. (2018) successfully isolated several compounds, including chrysophanol, daucosterol, emodin, physcion, and rhododendrin. .

2.2.4 *Rheum wittrockii* C.E.Lundstr.

Distribution: Kazakhstan, Kirgizstan, Pakistan, Tadjikistan, Uzbekistan, Xinjiang

Phytochemical Profile, Medicinal Compounds and Pharmacological properties: Several bioactive components have been identified from this species including sucrose, levoglucose, chrysarobin, chrysophanic acid, emodin-3-methyl ether, emodin-1,3,8-trihydroxy-6-methylanthracene-9,10-dione etc., providing antioxidant, anti-septic and anti-cancer effects, and also can help in the removal of toxins from the body, which has a beneficial effect on the liver, increasing the level of glycogen (Kobylina et al. 2020).

2.2.5 *Rheum tataricum* L.f.

Distribution: East European Russia, Kazakhstan, South European Russi, Ukraine, Uzbekistan, Xinjiang.

Phytochemical Profile, Medicinal Compounds and Pharmacological properties:

R tataricum contains stilbenes and polyketides (Samappito et al. 2003). In addition, extremely high levels of antioxidant activity (148–155 mg GAE/g dry weight), polyphenols (24.6–25.1 mg GAE/g dry weight), and carotenoids (1.94 mg-eq β-carotene/g dry weight) were found in the roots (Golubkina et al. 2022). Additionally, proline was significantly present in the leaves (71.1 ± 6.2 mg/kg dry weight), and malic acid was abundant in the stems (3.40 ± 0.50 mg/g dry weight). In traditional medicine, decoctions made from the roots and fruits of Rheum tataricum are employed to stop internal bleeding, reduce fever, and act as astringents or laxatives for stomach issues. The plant's ash is used to help heal wounds by promoting scarring. *Rheum tataricum* is also seen as a promising source for formulations with antioxidant, antitumor, and vitamin P activities (Zhumashova et al. 2016).

3. Perspectives

3.1 Gaps in knowledge

For Chinese rhubarb species, the studies should explore the whole genome sequence, rather than focusing just on anthraquinones, to uncover the molecular basis of additional bioactive chemicals' biosynthesis. It is necessary to identify the genes responsible for the variations in the production of active compounds in the three rhubarb species. Additionally, we need to determine if these gene sequences can serve as indicators of quality differences among these rhubarb species through biological activity experiments *in vivo*. Next, there is a need to enhance research efforts on the chemical composition and biological activity of Chinese rhubarb stems in order to fully exploit rhubarb resources and prevent unnecessary waste.

For the five Uzbek species mentioned above, the general knowledge of chemical compounds and their bioactivity should be supplemented with further research of harvesting practices, human utilization, and assessments of variation in the desired properties among extant populations.

A comparative study of Chinese and Uzbek rhubarbs focusing on the comparison of chemical composition and biological activities of rhubarb roots and stems across species and populations, as well as under different planting treatments can be very fruitful for development of the herbal medicinal resources including food supplements and health products.

3.2 Future collaboration perspectives

We plan the following directions of collaborative China-Uzbekistan research on rhubarb.

Firstly, a thorough literature review to examine the historical usage of rhubarb in traditional medicine practices of both nations including folk medicine traditions, dietary habits, distribution patterns, chemical composition, and pharmacological characteristics associated with rhubarb.

Next, the possible association of environmental factors with the chemical composition and bioactivity will be investigated studying variation in these properties among populations of the same species. Abundance and distribution of medicinal rhubarb species in Uzbekistan will be studied in detail. The availability and sustainability of rhubarb resources in different regions, considering factors such as habitat degradation, overharvesting, and land-use changes will be evaluated, as well as possible conservation means to preserve threatened rhubarb species, including the establishment of protected areas and on farm cultivation programs..

Thirdly, applying and optimizing traditional Chinese processing techniques to Uzbek medicinal rhubarb samples for comparative studies with processed Chinese rhubarb.

Furthermore, comprehensive studies on the biological activity of medicinal rhubarb stems from both countries will include focus on promoting the production of nutritious food products in Uzbekistan and optimizing rhubarb resource utilization. For this part of work, exploring innovative methodologies such as zebrafish models for evaluating safety and bioactivity of processed rhubarb and rhubarb stem samples, as well as functional foods or herbal preparations (*e.g.,* syrup, teas, or capsules, tablets, etc.,) will provide systematic, dynamic and visible insights into the medicinal properties of rhubarb and facilitate the development of novel therapeutic applications.

By integrating traditional medicine practices and modern research methodologies from both China and Uzbekistan, the collaborative effort will improve our understanding of medicinal rhubarb and unlock its full potential for therapeutic use**.**

Competing interests

Authors declare no conflict of interest.

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