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STUDY OF THE ALKALOID COMPOSITION OF BARBERRY (*BERBERIS VULGARIS* L.)



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Abstract

Barberry (*Berberis vulgaris* L.) is a medicinal plant belonging to the family Berberidaceae and is widely recognized as a valuable source of biologically active isoquinoline alkaloids. The present study aimed to analyze the alkaloid composition of *Berberis vulgaris* based on published phytochemical and pharmacognostic data, with particular emphasis on the major alkaloids and their distribution in different plant organs. A literature-based analytical approach was applied using scientific publications indexed in PubMed and other international scientific databases. The analysis demonstrated that the alkaloid profile of *B. vulgaris* is characterized mainly by protoberberine and related isoquinoline alkaloids. Berberine was identified as the predominant and most extensively studied alkaloid, while berbamine, palmatine, jatrorrhizine, columbamine, magnoflorine, oxyberberine, isocorydine and other alkaloids have also been reported. The concentration and qualitative composition of alkaloids vary considerably depending on the plant organ, geographical origin, species or subspecies, and extraction conditions. Chromatographic methods, particularly high-performance liquid chromatography (HPLC), are considered suitable for the qualitative and quantitative determination of major alkaloids. The obtained literature data confirm that *B. vulgaris* represents a promising plant material for pharmacognostic and phytochemical investigations and may serve as a source of pharmacologically significant isoquinoline alkaloids.

Keywords: *Berberis vulgaris* L.; barberry; alkaloids; berberine; berbamine; palmatine; jatrorrhizine; isoquinoline alkaloids; HPLC; phytochemical analysis.

Аннотация

Барбарис (*Berberis vulgaris* L.) относится к семейству Berberidaceae и является ценным источником биологически активных изохинолиновых алкалоидов. Целью настоящего исследования являлся анализ алкалоидного состава *Berberis vulgaris* на основе опубликованных фитохимических и фармакогностических данных с особым вниманием к основным алкалоидам и их распределению в различных органах растения. Был проведён анализ научной литературы, посвящённой химическому составу и биологически активным веществам *B. Vulgaris*. Установлено, что алкалоидный профиль растения представлен преимущественно протобербериновыми и родственными изохинолиновыми алкалоидами.



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Берберин является основным и наиболее изученным алкалоидом, наряду с которым в растении обнаружены бербамина, пальматин, ятрооризин, колумбамина, магнофлорин, оксистерберин, изокоридин и другие соединения. Количественный и качественный состав алкалоидов зависит от органа растения, географического происхождения, вида или подвида растения, а также условий экстракции. Для идентификации и количественного определения основных алкалоидов перспективным методом является высокоэффективная жидкостная хроматография (ВЭЖХ/HPLC). Анализ литературных данных подтверждает перспективность *B. Vulgaris* как источника фармакологически значимых изохинолиновых алкалоидов.

Ключевые слова: *Berberis vulgaris* L.; барбарис; алкалоиды; берберин; бербамина; пальматин; ятрооризин; изохинолиновые алкалоиды; ВЭЖХ; фитохимический анализ.

Annotatsiya

Zirk (*Berberis vulgaris* L.) Berberidaceae oilasiga mansub dorivor o'simlik bo'lib, biologik faol izoxinolin alkaloidlarining muhim manbalaridan biri hisoblanadi. Ushbu tadqiqotning maqsadi *Berberis vulgaris* o'simligining alkaloid tarkibini ilmiy adabiyotlarda keltirilgan fitokimyoviy va farmakognozik ma'lumotlar asosida tahlil qilish hamda asosiy alkaloidlar va ularning o'simlikning turli organlarida tarqalish xususiyatlarini baholashdan iborat. Tadqiqotda *B. vulgaris*ning kimyoviy tarkibi va biologik faol moddalari bo'yicha chop etilgan ilmiy manbalar tahlil qilindi. Adabiyotlar tahlili natijasida o'simlikning alkaloid profilida asosan protoberberin va boshqa izoxinolin alkaloidlari mavjudligi aniqlandi. Berberin eng asosiy va eng ko'p o'rganilgan alkaloid bo'lib, undan tashqari berbamin, palmatin, jatrorrizin, kolumbamin, magnoflorin, oksisterberin, izokoridin va boshqa alkaloidlar ham aniqlangan. Alkaloidlarning miqdoriy va sifat tarkibi o'simlik organi, geografik kelib chiqishi, tur yoki kenja tur hamda ekstraksiya sharoitlariga bog'liq ravishda farq qilishi mumkin. Asosiy alkaloidlarni aniqlash va miqdoriy baholash uchun yuqori samarali suyuqlik xromatografiyasi (HPLC) samarali usullardan biri hisoblanadi. Olingan adabiy ma'lumotlar *B. vulgaris* o'simligini farmakognozik va fitokimyoviy tadqiqotlar uchun istiqbolli xomashyo hamda farmakologik ahamiyatga ega izoxinolin alkaloidlarining manbai sifatida baholash imkonini beradi.

Kalit so'zlar: *Berberis vulgaris* L.; zirk; alkaloidlar; berberin; berbamin; palmatin; jatrorrizin; izoxinolin alkaloidlari; HPLC; fitokimyoviy tahlil.

Introduction

Medicinal plants have historically served as important sources of biologically active natural compounds. Among the numerous groups of secondary metabolites, alkaloids occupy a particularly important position because of their structural diversity and wide range of pharmacological activities. The genus *Berberis* L., belonging to the family Berberidaceae, is one of the plant genera known for its high content of isoquinoline alkaloids [1,2].

Berberis vulgaris L., commonly known as European barberry, is a thorny shrub distributed in different regions of Europe and Asia. Different parts of the plant, including roots, root bark, stems, leaves and fruits, have been used in traditional medicine. Phytochemical investigations have demonstrated the presence of alkaloids, phenolic compounds, tannins, sterols, triterpenes and other secondary metabolites [1,3].

Among the constituents of *B. vulgaris*, berberine has received particular scientific attention. It is a quaternary protoberberine isoquinoline alkaloid characterized by a yellow color and has been isolated from several species of the genus *Berberis*. Other important alkaloids reported from *B. vulgaris* include berbamine, palmatine, jatrorrhizine, columbamine, magnoflorine, oxyberberine and isocorydine [1,4].

Previous phytochemical studies have shown that alkaloids are distributed unevenly throughout the plant. They are particularly concentrated in the roots and stems, especially in the cortical tissues [2]. A comparative HPLC study of *Berberis* plant materials demonstrated that berbamine,



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jatrorrhizine, berberine and palmatine can be simultaneously determined in extracts of roots, root bark, stems and stem bark, while their contents vary according to plant species, geographical origin and plant part [5].

Therefore, systematic investigation of the alkaloid composition of *B. vulgaris* is relevant for pharmacognostic standardization, quality control of medicinal plant materials and further pharmaceutical research.

The aim of this study was to analyze the known alkaloid composition of *Berberis vulgaris* L., identify the major alkaloids reported in different plant organs, and evaluate suitable analytical approaches for their qualitative and quantitative determination.

Materials and Methods

The present work was conducted as a literature-based phytochemical analysis of the alkaloid composition of *Berberis vulgaris* L. Scientific publications concerning the phytochemistry, pharmacognosy and chemical analysis of *Berberis* species were reviewed.

Particular attention was given to publications describing:

1. identification of alkaloids in *B. vulgaris*;
2. distribution of alkaloids in different plant organs;
3. chromatographic determination of individual alkaloids;
4. quantitative differences associated with plant origin and plant material;
5. major pharmacologically relevant isoquinoline alkaloids.

Scientific information was collected from PubMed-indexed publications and open-access scientific literature. Reviews and original analytical studies concerning *Berberis vulgaris*, *Berberis* species and their alkaloid composition were considered.

The principal search terms included: "*Berberis vulgaris*", "barberry", "alkaloids", "berberine", "berbamine", "palmatine", "jatrorrhizine", "isoquinoline alkaloids", and "HPLC".

Various chromatographic and spectroscopic methods have been applied to the investigation of *Berberis* alkaloids. Among them, HPLC is particularly useful because it enables simultaneous qualitative and quantitative determination of several structurally related alkaloids.

One published HPLC method was developed for the determination of berbamine, jatrorrhizine, berberine and palmatine in methanolic extracts of root bark, roots, stem bark and stems. The reported calibration characteristics demonstrated good linearity for all four analytes [5].

For future experimental investigation of *B. vulgaris*, plant material should be collected separately according to plant organ. After drying and grinding, an appropriate extraction procedure can be used, followed by chromatographic analysis against authenticated reference standards of the target alkaloids.

Results

The literature analysis demonstrated that *B. vulgaris* contains a diverse group of isoquinoline alkaloids. Berberine is considered the principal alkaloid, while berbamine and palmatine are also among the major compounds reported from the plant [1,3].

A broader phytochemical review reported several alkaloids from *B. vulgaris*, including berberamine, palmatine, berberine, oxyberberine, columbamine, isocorydine, lambertine and magnoflorine. The bisbenzylisoquinoline alkaloid oxycanthine has also been reported [1].

The principal alkaloids identified in *B. vulgaris* according to published data are summarized below.



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No.	Alkaloid	Chemical group	Reported plant organs
1	Berberine	Protoberberine isoquinoline alkaloid	Root, stem, fruit
2	Berbamine	Bisbenzylisoquinoline alkaloid	Root, stem bark, fruit
3	Palmatine	Protoberberine alkaloid	Root, stem bark, fruit
4	Jatrorrhizine	Protoberberine alkaloid	Root and other organs
5	Columbamine	Protoberberine alkaloid	Root, stem bark
6	Magnoflorine	Aporphine-type alkaloid	Root and other organs
7	Oxyberberine	Berberine-related alkaloid	Root
8	Isocorydine	Isoquinoline alkaloid	Root and other organs
9	Oxycanthine	Bisbenzylisoquinoline alkaloid	Plant tissues
10	Acanthine	Isoquinoline alkaloid	Root, stem bark, leaves and sprouts

The occurrence of these compounds in different organs is not uniform. Literature data indicate that the root and root bark generally represent particularly rich sources of alkaloids [2,6].

The distribution of alkaloids in *B. vulgaris* is closely associated with plant anatomy. Alkaloids of the genus *Berberis* have been reported predominantly in cortical tissues of roots and stems [2].

The root bark has attracted particular attention because of its relatively high alkaloid content. Published phytochemical studies have identified berberine, palmatine, berbamine and several other alkaloids in the root bark of *B. vulgaris* [6].

Berberine has also been detected in stems and fruits, although the concentration may differ substantially from that found in roots. Such differences indicate that the selection of plant material is an important factor in phytochemical standardization.

HPLC represents one of the most appropriate analytical approaches for studying the alkaloid composition of *Berberis* species. A published study successfully developed an HPLC method for simultaneous determination of berbamine, jatrorrhizine, berberine and palmatine [5].

The reported calibration curves demonstrated high linearity, with correlation coefficients exceeding 0.999 for the investigated alkaloids [5]. The study also demonstrated substantial differences in alkaloid content depending on geographical origin, plant species and plant organ.

These findings indicate that quantitative determination should be conducted using validated analytical methods rather than relying only on qualitative phytochemical screening.

Discussion

The results of the literature analysis confirm that the alkaloid fraction represents one of the most chemically significant groups of secondary metabolites in *Berberis vulgaris*. The predominance of isoquinoline alkaloids is consistent with previous investigations of the genus *Berberis* [1,2].

Berberine is the most characteristic alkaloid associated with *B. vulgaris*. It belongs to the protoberberine group of isoquinoline alkaloids and has been extensively investigated because of its broad range of biological activities. Reviews of *B. vulgaris* have emphasized berberine as one of the major active constituents of the plant [4,7].

However, evaluation of the alkaloid composition should not be limited exclusively to berberine. Berbamine, palmatine, jatrorrhizine and columbamine may also contribute significantly to the chemical and biological properties of the plant. In addition, several less abundant alkaloids have been isolated from *B. vulgaris*, demonstrating considerable chemical diversity [1,6].

The differences in alkaloid composition between plant organs are particularly important from the perspective of medicinal plant standardization. Roots and root bark are frequently characterized by higher concentrations of alkaloids, whereas fruits have a different phytochemical profile.



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Consequently, the plant part used for extraction should always be clearly specified during pharmacognostic and analytical studies.

Another important factor is geographical variability. HPLC analysis of *Berberis* materials demonstrated significant differences in the amounts of berbamine, jatrorrhizine, berberine and palmatine between samples originating from different regions and plant parts [5]. This observation suggests that environmental conditions, genotype, developmental stage and post-harvest processing may influence the alkaloid profile.

For an experimental study of locally collected *B. vulgaris*, it would therefore be appropriate to analyze roots, root bark, stems, leaves and fruits separately. HPLC or HPLC-DAD could be used for determination of the major marker alkaloids, while LC-MS/MS may provide additional confirmation of compound identity.

From a quality-control perspective, berberine can be considered a primary chemical marker, while a multi-component chromatographic fingerprint including berberine, palmatine, berbamine and jatrorrhizine would provide more comprehensive characterization of the plant material.

Conclusion

The literature-based investigation demonstrated that *Berberis vulgaris* L. contains a chemically diverse group of isoquinoline alkaloids. Berberine represents the principal and most extensively investigated alkaloid, while berbamine, palmatine, jatrorrhizine, columbamine, magnoflorine, oxyberberine and isocorydine are among the other reported constituents.

Alkaloids are distributed unevenly throughout the plant, with roots and root bark generally representing particularly important sources. The qualitative and quantitative alkaloid composition is influenced by plant organ, geographical origin, species or subspecies and extraction conditions.

HPLC is an appropriate method for the simultaneous determination of major alkaloids, particularly berberine, berbamine, palmatine and jatrorrhizine. Further experimental research using authenticated *B. vulgaris* samples, validated chromatographic methods and reference standards is recommended to establish the quantitative alkaloid profile of locally cultivated or naturally occurring plant material.

The obtained findings indicate that *Berberis vulgaris* L. is a promising source of biologically active isoquinoline alkaloids and deserves further investigation for pharmacognostic standardization and pharmaceutical applications.

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