WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

"To Review the Traditional Uses, Phytochemistry, and Pharmacological Activities of *Berberis aristata* DC. and Highlight Its Therapeutic Potential"

Saksham Thakur[1]* , Ms. Isha Sharma[2] , Mr. Nishant Sharma[3] , Mr. Bhupendra Singh[4]

Abhilashi University

ABSTRACT :

Berberis aristata DC. is a medicinal shrub valued in traditional Indian healthcare and commonly referred to as Daruharidra. Its traditional applications have made it an important subject for botanical and pharmacological research.. It is an erect, spiny shrub with hard, yellowish wood. It is primarily found in the sub-Himalayan areas and the Nilgiri Hills in southern India. The plant has branched, woody stems, sharp spines, clustered green leaves, yellow flowers, and small berry-like fruits that turn red to dark purple when ripe. The roots and stem bark are important medicinal parts and are known for their characteristic yellow color, which is mainly associated with berberine, an important isoquinoline alkaloid.

Researchers have studied B. aristata and its chemical compounds to understand how they may affect different functions of the body.. Preclinical studies have investigated its antidiabetic, antihyperlipidemic, antimicrobial, antioxidant, anti-inflammatory, cardioprotective, neuroprotective, and anticancer activities.

The antimicrobial properties of B. aristata are of particular interest because microorganisms can contribute to the development or worsening of skin conditions. Its reported antioxidant and anti-inflammatory properties have also encouraged research into its possible use in topical and dermatological formulations.

INTRODUCTION

Berberis aristata DC. is a medicinal plant belonging to the Berberidaceae family and is traditionally used in Ayurveda. Commonly known as Indian barberry or Daruharidra, it is recognized for its diverse chemical constituents, particularly berberine, a major alkaloid found in the plant. Other reported phytochemicals include flavonoids, tannins, and phenolic compounds. These constituents have attracted scientific interest in the potential antimicrobial properties .



TAXONOMICAL CLASSIFICATION

The taxonomic classification of Berberis aristata is given below. [1, 22]

Kingdom	**Plantae**
Division	Magnoliophyta

Class	Magnoliopsida
Order	Ranunculales
Family	Berberidacea
Genus	Berberis
Species	Berberis aristata DC

BOTANICAL IDENTITY

Berberis aristata DC. is an erect, perennial, spiny shrub that usually grows to a height of 2–3 metres. Its stems are nearly cylindrical, approximately 0.2–2 cm in diameter, and covered with bark. The simple leaves are obovate to elliptic and grow in clusters at the nodes. They have serrated margins with small, spine-like teeth and a leathery texture. The roots are thick, woody, yellowish-brown, and somewhat furrowed, with thin, brittle bark. The fruits are oblong or oval berries that become bright red or purplish when ripe. [1, 21]

GEOGRAPHICAL DISTRIBUTION

Berberis aristata is naturally distributed in the mountainous regions of the Indian subcontinent, particularly along the Himalayan belt. Its ripe berries are edible and have been described as sweet, acidic, and slightly bitter. The plant is found in parts of Assam, Bihar, the Himalayas, and the Nilgiri Hills, generally at elevations of about 1,000–3,000 m. In northern India, it occurs in areas including Himachal Pradesh, Uttarakhand, and Jammu and Kashmir. It is also found in the neighboring regions of Nepal, particularly in the central and western parts of the country. [1, 7]

RELEVANCE IN THE PHARMACEUTICAL INDUSTRY

Berberis aristata is relevant to the pharmaceutical, nutraceutical, and cosmetic industries because it contains bioactive compounds, particularly alkaloids such as berberine. These compounds have been studied for antimicrobial, anti-inflammatory, and antidiabetic effects. The plant has also attracted interest for cosmetic applications because of its reported antioxidant and antimicrobial properties, which may be relevant to skin-care research. [1, 7]

ETHNOBOTANY

Berberis aristata is a Himalayan medicinal shrub belonging to the family Berberidaceae It is a hardy, thorny plant with a yellowish appearance, and its distribution differs across regions. It grows in several parts of the Indian subcontinent, particularly in the Himalayan region.

B. aristata is used in traditional Indian medicine and has been used for various complaints, including skin conditions and metabolic disorders. It has also been used traditionally for skin problems in Nepal and nearby regions. Some traditional polyherbal preparations containing B. aristata are used for conditions such as bleeding piles. [22, 1]

CORRELATION BETWEEN TRADITIONAL AND MODERN PHARMACOLOGY

Berberis aristata has a history of traditional use for several health complaints, including skin problems, digestive disorders and fever. Modern research has examined some of these uses through laboratory and preclinical investigations.

Studies of its extracts and constituents have explored antimicrobial, anti-inflammatory, antioxidant and glucose-regulating activities. Berberine is an important compound in this research, although the effects of isolated berberine may differ from those of the whole plant extract.

Traditional applications provide useful directions for further investigation, but they do not independently establish clinical effectiveness. Controlled studies are necessary to determine which preparations may be beneficial and safe for specific uses [22, 1].

PHYTOCHEMISTRY OF BERBERIS ARISTATA

The chemical composition of *Berberis aristata* includes several classes of plant constituents. Isoquinoline alkaloids, particularly berberine, have received considerable attention in phytochemical research. Other compounds reported or investigated in the plant include additional alkaloids, phenolic compounds, flavonoids and tannins.

The quantity and distribution of these constituents may vary according to the plant part, geographical origin and extraction procedure. Therefore,

identifying the chemical composition of a particular preparation is important when interpreting its reported biological activities [22, 1].

1. ALKALOIDS

Alkaloids are among the most important bioactive constituents of Berberis aristata. The plant contains several isoquinoline-derived alkaloids, including [22, 19]

- Berberine Berbamine
- Palmatine Jatrorrhizine
- Oxyberberine
- Oxyacanthine
- Aromoline
- Karachine
- Epiberberine
- Columbamine
- Taxilamine .
- Tetrahydropalmatine
- Dihydropalmatine

2. BERBERINE

Berberine is a yellow-coloured isoquinoline alkaloid associated with the roots and stem bark of *Berberis aristata*. It is among the plant's most extensively investigated constituents because of its diverse biological activities.

Research has examined berberine in relation to microbial growth, glucose regulation, inflammatory processes, oxidative stress and lipid metabolism. However, results obtained with purified berberine should not automatically be applied to every extract or preparation of *B. aristata*. The composition and concentration of the tested material must also be considered [7, 11, 1].

3 .FLAVONOIDS

Flavonoids are plant-derived compounds found in many species, and they may also occur in Berberis aristata. They are commonly associated with antioxidant activity and may contribute to the biological properties of plants. Their presence and concentration can vary depending on the plant part and extraction method.

Examples such as quercetin, kaempferol, rutin, and their glycosides have been discussed in studies of various Berberis species..Flavonoids are known for their antioxidant properties and ability to neutralize free radicals. Some flavonoids have also been studied for their anti-inflammatory, liver-protective, and other biological effects. [22]

4. PHENOLIC COMPOUNDS

Phenolic compounds are constituents of plants that may contribute to the antioxidant activity of Berberis aristata. They have been investigated in different plant parts, including flowers and other tissues.

Caffeic acid, chlorogenic acid, quercetin, rutin, and other phenolic constituents have been identified in phytochemical studies.

Phenolic compounds may possess antioxidant potential and scavenge free radicals. Some have also been investigated for their anti-inflammatory effects and protection against oxidative stress. Their biological activity depends on the individual compounds and available experimental evidence. [22]

5. TERPENOIDS

Terpenoids are another group of secondary metabolites reported in Berberis aristata. Although alkaloids are considered the principal phytochemical constituents of this plant, certain terpenoid compounds have also been identified. [22, 1]

Identified compounds: Lupeol has been reported to be a bioactive constituent associated with B. aristata. Terpenoids have been studied for their possible antioxidant, anti-inflammatory, and other pharmacological effects. [22]

6. LIGNANS

Lignans are naturally occurring plant compounds formed from phenylpropanoid units. They have attracted scientific interest because of their varied biological activities. However, they are not as well established as major constituents of Berberis aristata, as its isoquinoline alkaloids. The occurrence of specific lignans in B. aristata should be supported by a species-specific source before this statement is treated as established.

Lignans from various plant sources have been studied for their antioxidant, anti-inflammatory, and liver-protective properties, among others.

7. TANNINS

Tannins are naturally occurring polyphenolic compounds that have been identified in phytochemical investigations of Berberis aristata. Their presence and concentration may vary among different plant parts, including the roots, stem bark, and leaves, depending on the extraction method and the analytical conditions. [22, 20]

Major compounds: Tannins may include hydrolyzable and condensed tannin groups. However, the individual tannin compounds specifically identified in B. aristata should be confirmed through species-specific phytochemical studies. [20]

Tannins are associated with antioxidant and astringent properties and have been investigated for antimicrobial and anti-inflammatory effects. Their biological effects depend on their chemical structure, concentration, and experimental conditions. [20]

8. SAPONINS

Saponins are naturally occurring glycosidic compounds that have been identified in phytochemical screening studies of Berberis aristata. Their presence may vary among different plant parts, including the roots, stem bark, and leaves, depending on the extraction method and the analytical conditionsMajor compounds: Saponins are generally classified into triterpenoid and steroidal saponins. However, specific saponin compounds in B. aristata require further confirmation through detailed phytochemical investigations.

Saponins have been studied for their possible antimicrobial, antioxidant, and anti-inflammatory properties. Some compounds in this group have shown other biological effects in experimental research. [20]

9. FATTY ACIDS

Fatty acids are organic compounds that contribute to the lipid content of plants. The fatty acid profile of Berberis aristata may vary with the plant part, geographical origin, and extraction method. Further research is required to establish the complete fatty acid composition of this species

Palmitic acid, stearic acid, oleic acid, and linoleic acid are common plant fatty acids. Their presence in B. aristata should be verified using species-specific studies, such as gas chromatography–mass spectrometry

Fatty acids are important for cell membranes, energy storage, and lipid metabolism. Some unsaturated fatty acids have also been studied for their potential anti-inflammatory and antioxidant effects. [20]

PHARMACOLOGICAL ACTIVITIES

1. Antimicrobial and Antifungal Activity

Studies have examined B. aristata extracts against certain microorganisms to see whether their effects in the laboratory support the plant's traditional use for treating infections. Root-bark extracts have shown inhibitory effects against some gram-positive and gram-negative bacteria in laboratory studies. [15, 1]

Laboratory studies have also investigated the antifungal potential of B. aristata. Root-bark extracts have shown activity against Candida albicans, and a comparative study of Indian Berberis species reported the activity of B. aristata root extracts against Aspergillus terreus and Aspergillus flavus. These findings support further investigation of selected fungal organisms but do not establish clinical effectiveness. [15, 22]

2. Anti-inflammatory, Analgesic, and Antipyretic Activity

Berberis aristata has been investigated for its possible anti-inflammatory, analgesic, and antipyretic activities. Its major alkaloid, berberine, has shown anti-inflammatory effects in experimental studies, including effects on substances involved in inflammation. Studies on Berberis extracts and their alkaloids have also explored possible pain-relieving and fever-reducing effects. [1, 7]

3. Antioxidant Activity

Berberis aristata extracts have demonstrated antioxidant activity in previous studies. Root and stem extracts contain compounds such as berberine and other phenolic constituents that may contribute to this effect. Some studies report that B. aristata extracts can scavenge free radicals and may help reduce oxidative stress [22, 1]

4. Antidiabetic Activity

The possible role of berberine in glucose regulation has been investigated in experimental studies and clinical research. These investigations have examined its effects on blood glucose levels and metabolic processes associated with diabetes.

Research has explored several potential mechanisms, including changes in glucose metabolism, insulin-related pathways and lipid regulation. The extent of the evidence differs between experimental models and clinical studies, and findings involving isolated berberine may not represent the effects of all *B. aristata* preparations.

Further research is required to establish the effects, safety and appropriate use of standardised preparations. Evidence from studies of berberine or other *Berberis* species should be distinguished from evidence obtained specifically from *B. aristata* [10, 6, 1].

5. Antidiarrheal Activity

Studies have explored the effects of B. aristata bark extracts in experimental models of diarrhoea. The findings offer some initial support for its traditional use in managing certain digestive problems. Joshi et al. (2011) examined aqueous and ethanolic bark extracts using laboratory antimicrobial tests and animal models of diarrhoea. Their findings indicated that both extracts reduced the number of diarrhoeal episodes and delayed their onset in the experimental model. The researchers also observed a reduction in intestinal transit during a separate test. Berberine was identified as an important constituent of the extracts. [26]

6. Wound-Healing Potential

Berberis aristata has a history of traditional use in certain skin conditions and wounds. Research has investigated its phytochemical constituents and antimicrobial properties, which provide a basis for further study of its possible applications in topical herbal preparations. Berberine and other plant constituents may also be relevant to research on inflammatory processes. However, antimicrobial or anti-inflammatory activity alone does not establish that the plant can accelerate wound healing in humans. Further studies are needed to evaluate the safety and effectiveness of specific topical preparations [22, 1].

7. Antipyretic Activity

The antipyretic potential of *Berberis aristata* has been described in pharmacological reviews in connection with its traditional use in fever-related conditions. Antipyretic activity refers to the ability of a substance to reduce an elevated body temperature. The plant contains berberine and other phytochemicals that have been investigated for different biological effects, including their influence on inflammatory processes. However, the direct evidence supporting the fever-reducing activity of specific *B. aristata* preparations is less clearly established than some of the findings reported for its antimicrobial and antidiarrhoeal effects. [22, 1]

Toxicity & Safety

1. Acute Oral Toxicity Studies

Acute oral toxicity testing is used to examine the harmful effects that may occur following a single oral dose or limited period of exposure. The results apply to the substance, dose and experimental conditions tested. Joshi et al. (2011) investigated the toxicity of aqueous and ethanolic bark extracts of *Berberis aristata* using Swiss albino mice. The study reported an estimated oral LD_{50} value greater than 5000 mg/kg body weight for both extracts. This finding indicated relatively low acute oral toxicity under the specific experimental conditions used in the study.

The results provide useful preliminary information about the safety of the tested bark extracts. However, these findings should not be interpreted as proof that every preparation of *B. aristata* is safe at high doses. Different extracts may contain different concentrations of active constituents, and an acute toxicity study cannot fully predict the effects of repeated or prolonged consumption. [26, 1]

2. In Vitro Cytotoxicity and Cellular Effects

In vitro studies are conducted using cells under laboratory conditions to investigate whether a substance affects cell survival or produces cellular damage. Research on *B. aristata* extracts has examined their effects on different cell types to obtain preliminary information about their biological activity and safety.

A study published in 2024 investigated commercial bark extracts of *B. aristata* and evaluated their effects on intestinal, hepatic, gastric and renal cell models. The tested extracts showed limited cytotoxicity within the experimental conditions. The study also examined the behaviour of important alkaloids, including berberine and jatrorrhizine, in relation to their bioaccessibility and potential interactions with drug-metabolising systems.

These findings are encouraging for further research into preparations containing *B. aristata*. Nevertheless, cell-based experiments cannot reproduce all the processes that occur in the human body. Therefore, results obtained in laboratory cell models should be considered preliminary and should not be treated as direct evidence of safety in humans. [2]

Important factors to consider:

- The concentration of the extract may influence its effect on cells.
- Different plant preparations may vary in their chemical composition.
- Laboratory findings may differ from effects observed after absorption and metabolism in the body.
- Additional animal and human studies are required to establish a more complete safety profile.

3. Liver and Kidney Safety

The liver and kidneys play important roles in the processing and removal of substances from the body. Therefore, evaluating their safety is an essential part of studying medicinal plants and their extracts.

Research on *B. aristata* bark extracts has included laboratory investigations using liver and kidney cell models. The limited cytotoxicity observed in the tested extracts provides preliminary information about their effects under the conditions studied. However, such findings do not establish that prolonged use of the plant cannot affect these organs.

The safety of a preparation may depend on its chemical composition, concentration, dose and duration of exposure. Further investigations involving appropriate biochemical measurements, organ examinations and longer exposure periods would help clarify its effects on liver and kidney function. [2]

4. Safety of Berberine and Other Active Constituents

Berberine is one of the principal bioactive alkaloids found in *B. aristata* and is widely investigated for its pharmacological properties. However, the biological effects of an isolated compound may differ from those of a complete plant extract because the extract contains several constituents in varying proportions.

Research on berberine and other alkaloids from *Berberis* species has identified potential safety concerns related to dosage, duration of exposure and individual physiological conditions. Gastrointestinal disturbances have been reported in research involving berberine-containing preparations. These findings highlight the importance of evaluating the quantity consumed and the characteristics of the preparation. [18, 1]

5. Gastrointestinal Effects

The gastrointestinal tract may be affected by medicinal substances, particularly when they are consumed in concentrated forms or at unsuitable doses. Research involving berberine-containing preparations has reported gastrointestinal disturbances in some circumstances.

Possible symptoms associated with berberine-containing products include nausea, abdominal discomfort, diarrhoea and constipation. However, the occurrence and severity of these effects may vary with the product, amount consumed and individual response. These symptoms should not be assumed to occur in every person using *B. aristata*. [11, 1].

6. Pregnancy, Infancy and Drug Interactions

The use of berberine-containing preparations requires particular caution in vulnerable groups. Research concerning berberine has raised safety concerns during pregnancy and the neonatal period. Therefore, medicinal preparations containing concentrated amounts of berberine should not be considered automatically safe for pregnant women, breastfeeding women or infants.

Another important consideration is the possibility of interactions with medicines. Berberine and related alkaloids have been investigated for their effects on drug transport and metabolism. Such interactions may influence the way certain medicines are handled by the body. The extent of these effects can depend on the preparation, dose and medicine involved.

People taking prescription medicines should consult a qualified healthcare professional before using concentrated *B. aristata* extracts or berberine-containing supplements. These precautions are especially important because evidence concerning isolated berberine does not always establish the same effects for the whole plant. [1, 11, 8]

7. Factors Affecting the Safety of *Berberis aristata*

The safety of *B. aristata* preparations may be influenced by several factors. These factors should be considered when developing herbal products for medicinal or pharmaceutical use.

Major factors include:

- *Plant part used:* Roots, root bark and stem bark may differ in their chemical composition and alkaloid content. [2, 1]
- *Extraction method:* Water, alcohol and other extraction solvents may produce extracts with different chemical profiles. [2]
- *Concentration of active compounds:* The amount of berberine and other alkaloids can vary between preparations. [2, 1]
- *Dose and duration:* A single exposure and repeated long-term use may produce different effects. [1]

CONCLUSION

Overall, B. aristata is an important medicinal plant because of its traditional uses and the biological activities observed in studies of its extracts and chemical compounds. However, further research is needed to better understand its effectiveness, safety, and proper medicinal uses. It is mainly found in the Himalayan region and has an important place in traditional medicine. The roots and stem bark are commonly used for medicinal purposes because they contain several bioactive compounds, especially berberine.

The plant contains different phytochemicals, including alkaloids, flavonoids, phenolic compounds, tannins and other constituents. Among these, berberine is one of the most important compounds and has been studied for its various biological activities. Research has reported potential antimicrobial, antidiabetic, antioxidant, anti-inflammatory and antidiarrhoeal effects of the plant and its constituents.

The traditional uses of *B. aristata* are related to several of the activities investigated in modern research. Its phytochemical properties have also created

interest in its possible use in pharmaceutical and herbal preparations. However, further studies are needed to confirm its effectiveness and safety in humans.

Toxicity studies have provided some preliminary information about the safety of particular extracts, but more research is required to understand the effects of long-term use. Proper quality control, standardisation and selection of suitable concentrations are important for developing reliable herbal products.

Overall, *Berberis aristata* is a valuable medicinal plant with traditional importance and promising pharmacological potential. Further research may help improve our understanding of its medicinal properties and support its use in the development of safe and effective herbal formulations.

REFERENCE

1. Marchelak A, Gieleta M, Krasocka W, Magiera A. *Berberis aristata* DC. (Indian barberry): Current insight into botanical, phytochemical, and pharmacological aspects, pharmacokinetics, safety of use and modern therapeutic applications. Fitoterapia. 2025;183:106539.
2. Rigillo G, et al. Comprehensive Analysis of *Berberis aristata* DC. Bark Extracts: In Vitro and In Silico Evaluation of Bioaccessibility and Safety. Nutrients. 2024;16(17):2953.
3. Hashmi SF, Saleem H, Khurshid U, et al. Genus *Berberis*: A Comprehensive and Updated Review on Ethnobotanical Uses, Phytochemistry and Pharmacological Activities. Chemistry & Biodiversity. 2024;21(10):e202400911.
4. Goswami R, Arya D, Siddiqui R, Chand P. Unveiling the Medicinal Potential of *Berberis aristata*: A Traditional Native Plant of Uttarakhand. Journal of Phytopharmacology. 2024;13(3):268–274.
5. Li Z, Wang Y, Xu Q, et al. Berberine and health outcomes: An umbrella review. Phytotherapy Research. 2023;37(5):2051–2066.
6. Xie W, Su F, Wang G, et al. Glucose-lowering effect of berberine on type 2 diabetes: A systematic review and meta-analysis. Frontiers in Pharmacology. 2022;13:1015045.
7. Malhotra B, Kulkarni GT, Dhiman N, Joshi DD, Chander S, Kharkwal A, et al. Recent advances on *Berberis aristata* emphasizing berberine alkaloid including phytochemistry, pharmacology and drug delivery system. Journal of Herbal Medicine. 2021;27:100433.
8. Ai X, Yu P, Luo L, Liu J, Li S, Lai X, Luan F, Meng XM. Berberine: A review of its pharmacokinetics properties and therapeutic potentials in diverse vascular diseases. Frontiers in Pharmacology. 2021;12:762654.
9. Zhang Y, et al. Efficacy and safety of berberine alone for several metabolic disorders: A systematic review and meta-analysis of randomized clinical trials. Frontiers in Pharmacology. 2021;12:653887.
10. Belwal T, Bisht A, Devkota HP, Ullah H, Khan H, Pandey A, Bhatt ID, Echeverría J. Phytopharmacology and clinical updates of *Berberis* species against diabetes and other metabolic diseases. Frontiers in Pharmacology. 2020;11:41.
11. Och A, Podgórski R, Nowak R. Biological activity of berberine—A summary update. Toxins. 2020;12(11):713.
12. Song D, Hao J, Fan D. Biological properties and clinical applications of berberine. Frontiers of Medicine. 2020;14(5):564–582.
13. Kong WJ, Vernieri C, Foiani M, Jiang JD. Berberine in the treatment of metabolism-related chronic diseases: A drug cloud effect to target multifactorial disorders. Pharmacology & Therapeutics. 2020;209:107496.
14. Gao Y, Wang F, Song Y, Liu H. The status of and trends in the pharmacology of berberine: A bibliometric review (1985–2018). Chinese Medicine. 2020;15:7.
15. Sood H, Kumar Y, Gupta VK, Arora DS. Scientific validation of the antimicrobial and antiproliferative potential of *Berberis aristata* DC root bark, its phytoconstituents and their biosafety. AMB Express. 2019;9:143.
16. Salehi B, Selamoglu Z, Sener B, Kilic M, Jugran AK, de Tommasi N, et al. *Berberis* plants—Drifting from farm to food applications, phytotherapy, and phytopharmacology. Foods. 2019;8(10):522.
17. Neag MA, Mocan A, Echeverría J, Pop RM, Bocsan CI, Crișan G, Buzoianu AD. Berberine: Botanical occurrence, traditional uses, extraction methods, and relevance in cardiovascular, metabolic, hepatic, and renal disorders. Frontiers in Pharmacology. 2018;9:557.
18. Imenshahidi M, Hosseinzadeh H. Toxicology effects of *Berberis vulgaris* (barberry) and its active constituent, berberine: A review. Iranian Journal of Basic Medical Sciences. 2017;20(5):516–529.
19. Ahamad J, Naquvi KJ, Ali M, Mir SR. New isoquinoline alkaloids from the stem bark of *Berberis aristata*. Indian Journal of Chemistry—Section B: Organic and Medicinal Chemistry. 2014;53B(10):1237–1241.
20. Mokhber-Dezfuli N, Saeidnia S, Gohari AR, Kurepaz-Mahmoodabadi M. Phytochemistry and pharmacology of *Berberis* species. Pharmacognosy Reviews. 2014;8(15):8–15.
21. Rathi B, Sahu J, Koul S, Kosha RL. Detailed pharmacognostical studies on *Berberis aristata* DC plant. Ancient Science of Life.

2013;32(4):234–240.

22. Potdar D, Hirwani RR, Dhulap S. Phyto-chemical and pharmacological applications of *Berberis aristata*. Fitoterapia. 2012;83(5):817–830.

23. Dong H, Wang N, Zhao L, Lu F. Berberine in the treatment of type 2 diabetes mellitus: A systematic review and meta-analysis. Evidence-Based Complementary and Alternative Medicine. 2012;2012:591654.

24. Tillhon M, Guaman Ortiz LM, Lombardi P, Scovassi AI. Berberine: New perspectives for old remedies. Biochemical Pharmacology. 2012;84(10):1260–1271.

25. Sharma K, Bairwa R, Chauhan N, Shrivastava B, Saini NK. *Berberis aristata*: A review. International Journal of Research in Ayurveda and Pharmacy. 2011;2(2):383–388.

26. Joshi PV, Shirkhedkar AA, Prakash K, Maheshwari VL. Antidiarrheal activity, chemical and toxicity profile of *Berberis aristata*. Pharmaceutical Biology. 2011;49(1):94–100.

27. Andola HC, Rawal RS, Rawat MSM, Bhatt ID, Purohit VK. Analysis of berberine content using HPTLC fingerprinting of root and bark of three Himalayan *Berberis* species. Asian Journal of Biotechnology. 2010;2(4):239–245.

28. Yin J, Xing H, Ye J. Efficacy of berberine in patients with type 2 diabetes mellitus. Metabolism. 2008;57(5):712–717.

29. Zhang Y, Li X, Zou D, et al. Treatment of type 2 diabetes and dyslipidemia with the natural plant alkaloid berberine. Journal of Clinical Endocrinology & Metabolism. 2008;93(7):2559–2565.

30. Rout KK, Pradhan S, Mishra SK. Estimation of berberine in Ayurvedic formulations containing *Berberis aristata*. Journal of AOAC International. 2008;91(5):1149–1153.