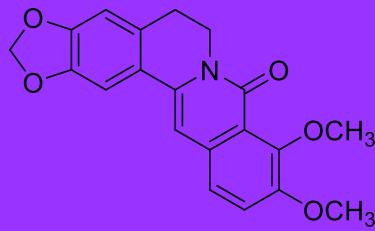


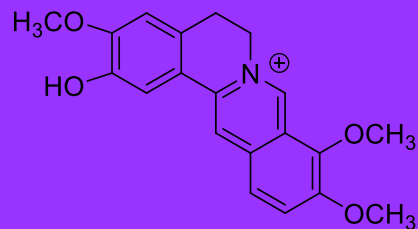
Berberine (1)



8- Oxo-berberine (2)



Dehydrocheilanthifoline (3)



Columbamine (4)

BJP

Bangladesh Journal of Pharmacology

Research Article

Anti-diabetic and antimicrobial activities of fractions and compounds isolated from *Berberis brevissima* Jafri and *Berberis parkeriana* Schneid

Anti-diabetic and antimicrobial activities of fractions and compounds isolated from *Berberis brevissima* Jafri and *Berberis parkeriana* Schneid

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Article Info

Received: 21 February 2013
Accepted: 16 July 2013
Available Online: 1 August 2013
DOI: 10.3329/bjp.v8i3.13888

Cite this article:

Ali S, Igoli J, Clements C, Semaan D, Alamzeb M, Mamoon-Ur-Rashid, Shah SQ, Ferro VA, Gray AI, Khan MR. Anti-diabetic and antimicrobial activities of fractions and compounds isolated from *Berberis brevissima* Jafri and *Berberis parkeriana* Schneid. Bangladesh J Pharmacol. 2013; 8: 336-42.

Abstract

Methanol extracts of the roots of *Berberis brevissima* and *Berberis parkeriana* were examined for anti-diabetic and antimicrobial activities. Six compounds i.e berberine, 8-oxo-berberine, dehydrocheilanthifoline, columbamine, jatrorrhizine and glutamic acid were isolated from the active fractions of these species for the first time. The anti-diabetic activity was determined against protein tyrosine phosphatase 1B (PTP 1B), a negative insulin regulator while the antimicrobial activity was performed against four bacterial strains: *Mycobacterium marinum* ATCC BAA535, sporadic methicillin resistant *Staphylococcus aureus* (SMRSA), endemic methicillin resistant *Staphylococcus aureus* (EMRSA) and *Escherichia coli* ATCC.8739 at different concentrations. Amongst the isolated compounds 8-oxo-berberine was found to be the most active antidiabetic (29% of the positive control) while jatrorrhizine was the most active and selective antimicrobial against SMRSA and EMRSA (-1.2% of the DMSO (D) control).

Introduction

According to the International Diabetes Federation about 366 million people around the world had diabetes in 2011 and the number was predicted to double by the year 2030 (IDF, 2013). The high risk of diabetes and health-related complications has led to research for active anti-diabetic compounds from plants (Maqsood et al., 2009).

Berberidaceae is a well-known family for a number of medicinal uses and is incorporated in the British and the Indian pharmacopeias (Meliani et al., 2011; British Pharmacopeia, 2011). Antibacterial, anticancer, anticoagulant, antifatigue, antipyretic, hypoglycemic and hypotensive activities have been reported for the crude

solvent extracts and isolated compounds of various *Berberis* species (Freile et al., 2003). Root extracts of *Berberis aristata* form a bitter tonic used as a laxative and antiseptic (Singh et al., 2007). Some *Berberis* species are reported to have anticancer activity in human epidermal cells (Nkengfack et al., 2001). An ethanolic extract of the roots of *Berberis lycium* has been reported to possess anti-diabetic activity (Uniyal and Tewari, 1991). *Berberis* spp. possess berberine as a major constituent along with other principle isoquinoline alkaloids e.g. berbamine, jatrorrhizine and palmatine (Freile et al., 2003).

Berberine, has shown significant antibacterial and antifungal activities against *Staphylococcus aureus* and *Candida* spp (Aydemir and Biloglu, 2003). The root



extracts of *B. aristata*, *B. asiatica* and *B. lycium* have also been reported to show good antifungal activity against *Aspergillus flavus* and *A. terreus* (WHO, 2009).

Keeping in view the activities of the genus *Berberis*, we have selected *B. brevissima* Jafri and *Berberis parkeriana* Schneid to investigate their anti-diabetic and antimicrobial activities. In the current study, we have isolated six compounds and are reporting the activities of their fractions and the isolated compounds.

Materials and Methods

General

Compounds were isolated from fractions of crude extracts using Silica gel 60 (0.063-0.200 mm, Merck, Germany) for column chromatography (CC) and silica gel 60 PF₂₅₄ for preparative thin layer chromatography (TLC). Characterization of compounds was achieved using NMR instruments (Bruker AVANCE 500 and 400 MHz, Germany) using DMSO-d₆ as solvent. The mass spectra (EIMS) were recorded on a JEOL MSRoute through direct insertion probe. All the chemicals used were from Sigma International.

Plant material

B. brevissima Jafri and *B. parkeriana* roots (3 kg each) were collected from the north west of Pakistan, July 2009. The voucher specimens (No. Bot/10701 and 8719 respectively) were deposited in the herbarium of the Botany Department, University of Peshawar.

Extraction and isolation

The scheme described in Figure 1 was used for the extraction and fractionation of the plant material.

Fraction A (BRA and PRA)

These fractions were recrystallized to give berberine (**1**) (2 g), mp 208-209°C (lit 208-210°C) (Suau et al., 1998).

Fraction C (BRC and PRC)

The BRC fraction was subjected to CC using silica gel (210 g) and eluted with CHCl₃-MeOH with increasing polarity. The subfractions obtained were further subjected to preparative chromatography (PC) using CHCl₃-MeOH-NH₃ (80:20: 0.5 and 75:25:0.5) to give 8-oxo-berberine (**2**) (9.1 mg) and dehydrocheilanthifoline (**3**) (7.9 mg) respectively. Fraction PRC was subjected to CC on silica gel (200 g) eluted with CHCl₃-MeOH (20:80) followed by PC using CHCl₃-MeOH-NH₃ (10:90:0.5 and 75:25:0.5) to give columbamine (**4**) (11.8 mg) and dehydrocheilanthifoline (**3**) (5.3 mg).

Fraction D (BRD and PRD)

The BRD fraction (15.0 mg) was subjected to CC on silica gel (210 g) and eluted with CHCl₃-MeOH with increasing polarity. The four fractions obtained were

further separated on PC which afforded jatrorrhizine (**5**) (9.7 mg) and glutamic acid (**6**) (5.8 mg). Similarly the fraction PRD (15.0 mg) was subjected to CC on silica gel (210 g) and eluted with CHCl₃-MeOH, which gave jatrorrhizine (**5**) (2.3 mg).

Anti-diabetic assay

Buffer preparation

The buffer was composed of: 2.975 g of HEPES (H3375) (25 mM), 1.461 g of sodium chloride (S9625) (50 mM), 0.32 g of dithiothreitol (D5545) (2 mM), 0.365 g of ethylene diamine tetra acetic acid (E1644) (EDTA, 2.5 mM) and 5 mg of bovine serum albumin (A2153) (BSA 0.01 mg/mL) were dissolved in 500 mL of distilled water and the pH was adjusted to 7.2. All chemicals were purchased from Sigma Aldrich, UK.

Sample preparation

The concentration of stock solutions for all the samples was 10 mg/mL. Samples were screened at 100 µg/mL by taking 2 µL of each sample and adding it to 98 µL buffer.

Enzyme preparation

The enzyme Protein Tyrosine Phosphatase 1B (PTP 1B, purchased from Invitrogen, Life Technologies, UK) was prepared by adding 100 µL to 25 mL of the buffer, then aliquoted into 250 µL lots (sufficient for 1 plate) which were then stored at -80°C until used.

Substrate preparation

6,8-Difluoro-4-methylumbelliferylphosphate (DiFMUP) (Invitrogen D6567, Molecular Probes, Life Technologies, UK) was used as the substrate, which was dissolved in DMSO. Seven µL of the stock (10 mM) was added to 1.75 mL of buffer and stored at -20°C until used.

Inhibitor preparation

Bis(4-trifluoromethylsulfonamido-phenyl)-1,4-diisopropylbenzene (TFMS, Calbiochem 540211, 10 mg, Millipore, UK) inhibitor was dissolved in DMSO (10 mg in 1.64 mL) and then a displacement curve was drawn for the TFMS (concentration range 0.0003-3 µM).

Assay

In a 96-well plate (Costar®, Sigma Aldrich, UK), 10 µL of standard (TFMS) or samples were added to the plate, then 20 µL of PTP1B enzyme was added to each well and incubated for 30 min at 37°C in 5%CO₂ in air. After incubation, 10 µL of the substrate was added to the wells followed by incubation for 10 min. The plate was read at 355 nm/460 nm wavelengths using Wallac Victor².

Antimicrobial assay

The extracts and compounds were tested against *Mycobacterium marinum* ATTC.BAA535 an indicator

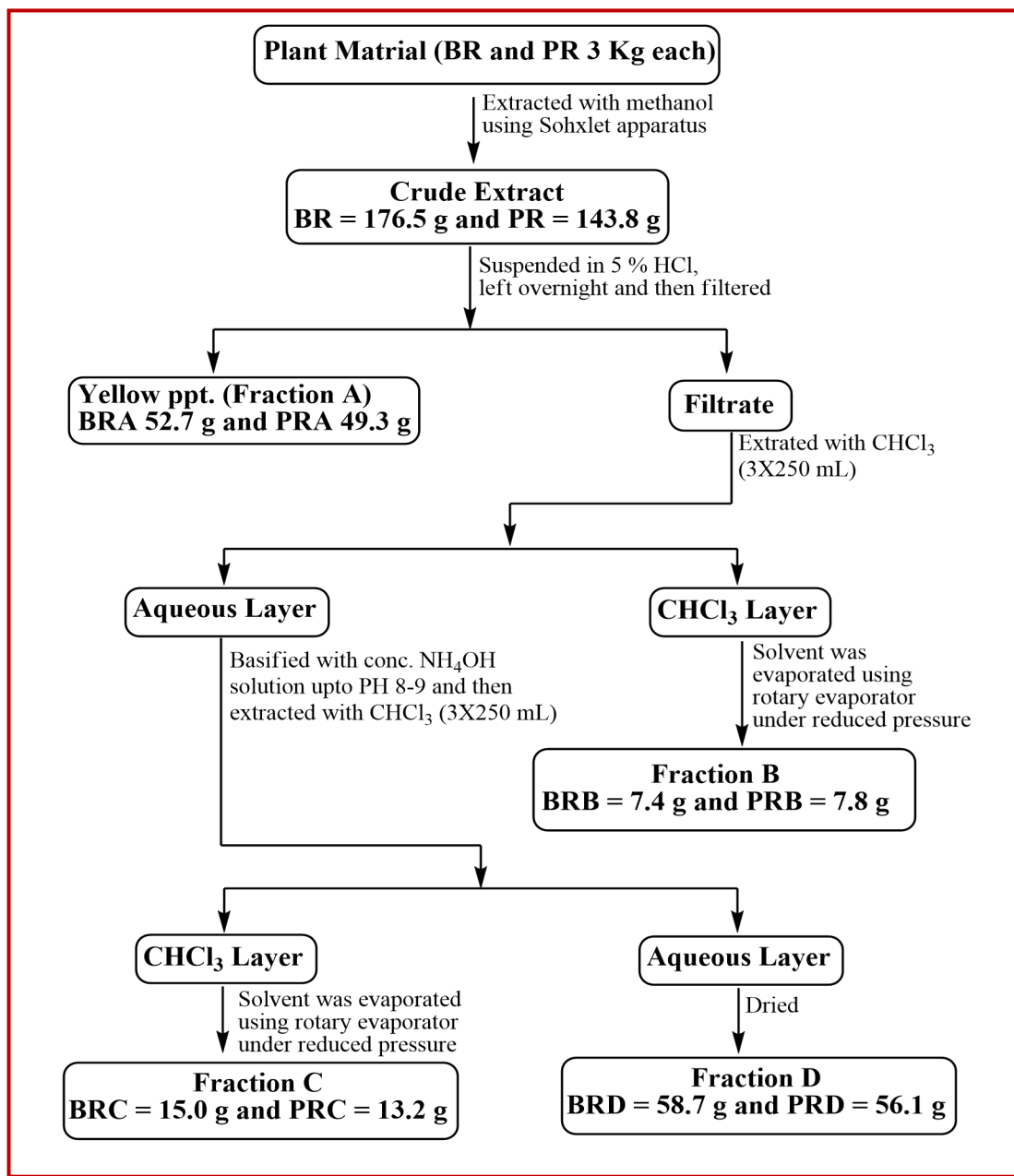


Figure 1: Fractionation scheme for *Berberis brevissima* and *Berberis parkeriana*

BR = *B. brevissima* roots, PR = *B. parkeriana* roots, BRA = *B. brevissima* roots fraction A, PRA = *B. parkeriana* roots fraction A, BRB = *B. brevissima* roots fraction B, PRB = *B. parkeriana* roots fraction B, BRC = *B. brevissima* roots fraction C, PRC = *B. parkeriana* roots fraction C, BRD = *B. brevissima* roots fraction D, PRD = *B. parkeriana* roots fraction D

species for potential activity against *Mycobacterium tuberculosis*; 2 antibiotic resistant clinical isolates of *Staphylococcus aureus*: SMRSA 106 and EMRSA 16 and *Escherichia coli* ATTC.8739. The activity of the fractions and compounds was assessed using a well established Alamar blue⁹⁶™ well microplate assays. Concentrations of 100, 200 and 500 µg/mL of the extracts and pure compounds were assessed.

Ten mg/mL of sample was dissolved in DMSO to prepare the stock solution and then diluted to a concen-

tration of 1 mg/mL using cation adjusted Muller Hinton Broth (MHB). Samples with final test concentrations of 100, 200 and 500 µg/mL were prepared from the stock solutions of test samples.

The plate was arranged with DMSO as a negative control in column 1, samples in columns 2-11 and a positive control (Gentamicin) in column 12. The microbes used were diluted up to 3×10^4 microbes/mL. The bacterial suspensions were adjusted to the same optical density as a 0.5 McFarland standard, then diluted 1 in

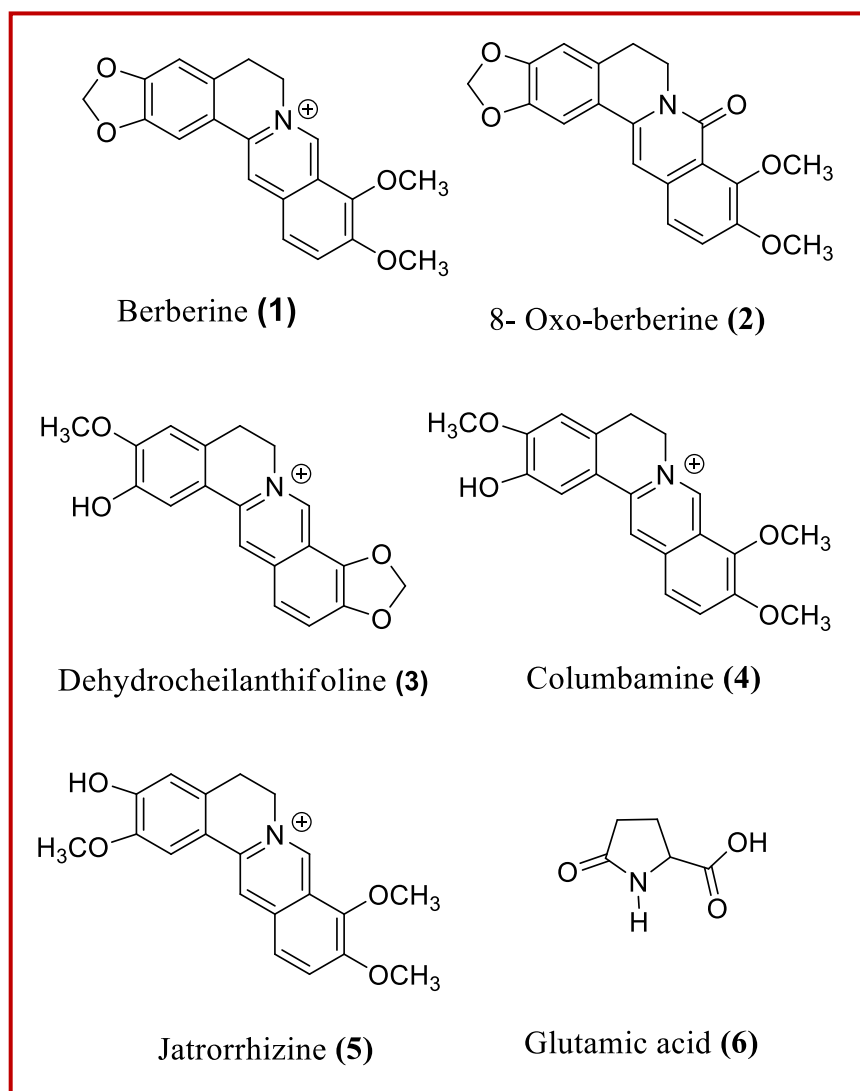


Figure 2: Structures of compounds 1-6 isolated from the fractions of *B. brevissima* and *B. parkeriana*

10 for *M. marinum* and 1 in 100 for EMRSA, SMRSA and *E. coli*. A 100 μ L suspension of the diluted microbes was added to all wells of the 96 well microtitre plate with the exception of well 1 the sterility control. Alamar blue was added to all wells of the MRSA, EMRSA and *E. coli* plates to give a final concentration of 10% (v/v) and a total well volume of 200 μ L. The microplates were sealed with parafilm and incubated at 37°C for 24 hours.

Thereafter the levels of fluorescence were detected using a Perkin Elmer Victor 2 microplate reader in fluorescence mode (excitation 560 nm, emission 590 nm). The *M. marinum* plates were incubated at 31°C for 5 days prior to addition of alamar blue to give a final concentration of 10% (v/v). After a further 2 hours incubation the fluorescence was determined as previously described. The percentage of the DMSO control values were recorded as % D control.

Results and Discussion

A total of six compounds were isolated for the first time from the different fractions of *B. brevissima* and *B. parkeriana*. The structures of the compounds were established using spectroscopic techniques (UV, FT-IR, ^1H NMR, ^{13}C NMR, COSY, HMBC, HSQC, NOESY and mass spectrometry). Comparison with data reported in the literature confirmed the compounds to be berberine (1) (Hsieh et al., 2004), 8-oxo-berberine (2) (Fajardo et al., 1982), dehydrocheilanthifoline (3) (Cooper et al., 1972), columbamine (4) (Hsieh et al., 2004), jatrorrhizine (5) (Hsieh et al., 2004) and glutamic acid (6) (Tanaka et al., 2007). Structures 1-6 are given in Figure 2.

Anti-diabetic activities of fractions obtained from *B. brevissima* and *B. parkeriana*

The fractions obtained were tested against PTP 1B (a

Table I

Antimicrobial activities of fractions from *B. brevissima* and *B. parkeriana*

Fractions	<i>M. marinum</i> % of D control 100 µg/mL	SMRSA % of D control 200 µg/mL	EMRSA % of D control 200 µg/mL	<i>E. coli</i> % of D control 500 µg/mL
BRB	33.5	61.7	88.6	62.0
BRC	2.5	0.2	0.2	45.9
BRD	2.4	82.6	81.6	64.9
PRB	48.0	56.0	92.3	62.9
PRC	12.7	-1.1	-1.1	43.3
PRD	17.6	1.8	-0.9	68.3

BRB = *B. brevissima* roots fraction B, BRC = *B. brevissima* roots fraction C, BRD = *B. brevissima* roots fraction D, PRB = *B. parkeriana* roots fraction B, PRC = *B. parkeriana* roots fraction C, PRD = *B. parkeriana* roots fraction D

Table II

Antimicrobial activities of compounds isolated from *B. brevissima* and *B. parkeriana*

Compounds	<i>M. marinum</i> % of D control 100 µg/mL	SMRSA % of D control 200 µg/mL	EMRSA % of D control 200 µg/mL	<i>E. coli</i> % of D control 500 µg/mL
Berberine (1)	47.4	1.1	0.5	57.8
8-Oxo-berberine (2)	1.6	18.9	32.6	56.3
Dehydrocheilanthifoline (3)	26.4	0.1	-0.8	44.1
Columbamine (4)	45.9	-0.6	-0.9	51.7
Jatrorrhizine (5)	18.8	-1.2	-1.2	39.4
Glutamic acid (6)	0.9	35.7	47.8	49.3

negative insulin regulator). Samples that showed 40% of the control (i.e. 60% inhibition) were considered to be potentially active. Preliminary screening showed that fraction B (BRB = 66% and PRB = 59%) and D (BRD = 48% and PRD = 51%) were inactive against PTP 1B. The BRC fraction showed 32% activity of the control while PRC showed 37% of the control (100%).

Anti-diabetic activities of pure compounds isolated from the two *Berberis* spp.

These compounds were tested for anti-diabetic activity against PTP 1B. Amongst the compounds 8-oxo-berberine (2) was significantly active and showed 29% of the control. The other isolated compounds i.e berberine (1) (35%), dehydrocheilanthifoline (3) (38%), columbamine (4) (33%) and jatrorrhizine (5) (36%) also showed good activity. Glutamic acid (6) (78%) was inactive.

Antimicrobial activity of *B. brevissima* and *B. parkeriana* fractions

The fractions of the two species were also tested against four microbial strains i.e *M. marinum*, MRSA, EMRSA and *E. coli*. Various concentrations were used against different strains. The concentration tested against *M. marinum* was 100 µg/mL, SMRSA and EMRSA was 200 µg/mL and *E. coli* was 500 µg/mL. Fraction A consisted

of mainly berberine (1), a well-known isoquinoline alkaloid, therefore we did not test it against these strains. In preliminary screening, the fractions whose % D control was less than 5 were considered to be active. Fraction B (BRB and PRB) was not active against all the used strains. The BRC fraction showed good activity (2.4% of D control) against *M. marinum*, SMRSA (0.2% of D control) and EMRSA (0.2 of %D control) while against *E. coli* it was inactive (45.9% of D control). The PRC fraction showed selectivity as well as good activity against SMRSA (-1.1% of D control) and EMRSA (-1.1% of D control) while it showed no activity against the other two strains. The BRD fraction was more selective in activity and was only active against *M. marinum* (2.4% of D control). The PRD fraction was also active against SMRSA (1.8% of D control), EMRSA (-0.9% of D control) and *M. marinum* (17.6% of D control) while it was not active against *E. coli* (68.3% of D control). None of the fraction showed activity against *E. coli* (Table I).

Antimicrobial activity of pure compounds isolated from the tested fractions of *B. brevissima* and *B. parkeriana*

The isolated compounds were also tested against the four strains of bacteria which were tested against the fractions. Berberine (1) showed good selectivity and activity against SMRSA and EMRSA (1.1 and 0.5% of D

control). The isoquinoline alkaloid, 8-oxo-berberine (2) showed high selectivity and good activity (1.6% of D control) against *M. marinum* and was inactive against the other bacterial strains. Dehydrocheilanthifoline (3), columbamine (4) and jatrorrhizine (5) were active against SMRSA (0.1, -0.6 and -1.2% of D control respectively) and EMRSA (-0.8, -0.9 and -1.2% of D control respectively) while against *M. marinum* and *E. coli* these compounds were inactive. Like 8-oxo-berberine, glutamic acid established good activity and high selectivity against *M. marinum* but was inactive against the other tested strains (Table II).

In the past, diabetes was treated orally with medicinal plants or their crude extracts based on folk medicine (Kumar et al., 2010). More than 150 plant extracts have been used to treat *diabetes mellitus* (Eddouks et al., 2005; Choie et al., 1991), but there is still a need to identify insulin substitutes from medicinal plants. In the present study, the effect of various fractions (BRB, BRC, BRD, PRB, PRC and PRD) and their isolated compounds were examined against PTP 1B. The anti-diabetic study showed that fraction C (BRC and PRC) is very active against PTP 1B. Fraction C (BRC and PRC) and D (BRD and PRD) were further analyzed to isolate active constituents. Out of the six isolated compounds, 8-oxo-berberine (2) showed good activity against PTP 1B. Other isolated alkaloids were also good in activity since the literature has shown that many alkaloids have anti-diabetic activities (Maqsood et al., 2009), while glutamic acid (6) was inactive.

The crude methanolic extract of *B. aristata* DC, has shown significant hypoglycemic activity in streptozotocin-induced diabetic rats (Upwar et al., 2011). Animals treated with a *Berberis* root extract and berberine have also shown considerable decrease in blood glucose levels as well as glycosylated hemoglobin levels in diabetic animals (Gulfraz et al., 2008). Berberine enhances the intracellular calcium which increases degranulation and release of insulin from β -cells (Xu et al., 1997).

A major therapeutic intervention in modern medicine, used in surgery, chemotherapy and other diseases, involves antibiotics (Braga et al., 2005). However resistance to antibiotics of many harmful bacteria is developing daily (Schito, 2006). The need for better drugs to combat the problem of resistance can not be over emphasized (Wagh and Vidhale, 2010). In the present study, we have tested *B. brevissima* and *B. parkeriana* fractions and the six isolated compounds against four strains of bacteria. Among the tested fractions; fraction C (BRC and PRC) and D (BRD and PRD) showed good activity against three strains while all of the fractions were inactive against *E. coli* ATTC.8739. The two fractions were further studied for their active constituents responsible for their antimicrobial activity. The isolated compounds showed good selectivity and activity against

st three bacterial strains while they were all inactive against *E. coli*.

A literature survey showed that although *Berberis* species are medicinally important, their antibacterial activities are limited (Dutta and Panse, 1962). *B. aristata* extracts have significant antibacterial and antifungal potential against clinical and other reference strains (Shahid et al., 2009), while the isoquinoline alkaloids have significant in vitro antimicrobial activities (Zhang et al., 2012).

Conclusion

The present study suggests that *B. brevissima* and *B. parkeriana* have potential activity for treating diabetes and could be useful against some antibiotic resistant microbes.

Financial Support

Self-funded

Conflict of Interest

Authors declare no conflict of interest

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