Comparative Assessment of Phytochemicals, Antioxidant, and Antimicrobial Potential of Stem Bark and Small Branches of *Buchanania cochinchinensis* (Lour.) MR Almeida for Substitution in Ayurvedic Drugs

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**Abstract**

**Aim:** Present study was intended to investigate the physicochemical parameters, phytochemical constituents, and biochemical studies of the stem bark (STB) and small branches (SBs) of *Buchanania cochinchinensis* (Lour.) MR Almeida.

**Materials and methods:** The parameters were checked in different solvent systems, viz., petroleum ether, acetone, and methanol.

**Results:** Significant antioxidant (10–85%) and antimicrobial (5–20 mm) activities were observed in acetone and methanolic extracts of STB and SB as compared to the controls. In acetone and methanolic extracts, the observed values for total phenol content (TPC) ranged from 10 mg to 93 mg of gallic acid equivalent per gram of extract and the total flavonoid content (TFC) ranged from 30 mg to 87 mg of quercetin equivalent (QE) per gram of extract. Bovine serum albumin (BSA) protein interaction studies of all the extracts were performed and the observed values for binding constant ranged from 22 to 62 × 10⁻⁵ μM⁻¹.

**Conclusion:** Overall, acetone and methanolic extracts of STB and SB of plant have shown significant results in medicinal aspects mentioned above.

**Clinical significance:** These comparative findings of STB and SB of *Buchanania cochinchinensis* (Lour.) MR Almeida provide undeniable systematic facts of its beneficial prospective as an Ayurvedic drug.

**Keywords:** Antimicrobial, Antioxidant, *Buchanania*, Medicinal plants, Natural products, Phytochemicals.

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**Introduction**

Nature and natural products are the major source of medicines especially in the developing countries. These herbal drugs are valuable in diverse treatments. Plants remain an imperative feature in healthcare as the developing and underdeveloped countries mostly rely on plants and natural products for their traditional medicines.¹ The diverse applications of herbal drugs or natural products are due to the presence of a wide class bioactive organic compounds.¹–³ In recent past, important organic compounds have been isolated from the natural product, and these natural products and their derivatives have been introduced in market as active drugs even in allopathic system.²–⁴ Several species of flora belonging to different families have been investigated regarding the presence of any possible beneficial properties for medicinal use.

*Buchanania cochinchinensis* (Lour.) MR Almeida (BC) is commonly known as Chironji belongs to Anacardiaceae family and contains multiple class of phytochemicals such as terpenoids, saponins, and tannins.⁵ Tannins, alkaloids, saponins, reducing sugars, triterpenoids, and flavonoids are the major chemical constituents of BC. The reported phytochemical constituents of BC are linoleic acid, β-amyrin, palmitoleic acid, myricetin 3-rhamnoside-3-rhamnopyranoside, as expectorant, aphrodisiac, purgative, blood purifier, and thirst-quencher.⁸–¹² The fruit kernels of BC are used as ointment in skin diseases and as antioxidants.⁵ ⁶

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Recent studies revealed that BC is an important plant as it helps in wound-healing, gastric ulcer treatment and has antistress, anti-diarrheal, anti-venom, antimicrobial, antioxidant anti-inflammatory, analgesic, and anti-Alzheimer properties. During the course of our study of the biologically active constituents of BC, we examined the chemical constituents of the small branches (SBs) and stem bark (STB) in various extracts. In the current study, we investigated the phytochemical, antioxidant, and antimicrobial properties of the extracts (petroleum ether, acetone, and methanol) of SB and STB obtained from BC.

**MATERIALS AND METHODS**

**Plant Material Collection**
The STB and SB of BC were collected from Gwalior, Madhya Pradesh, India. The STB and SB were dried in shade and their dried powder was stored in airtight jars for further study.

**Preparation of Plant Extracts**
Three solvents, viz., petroleum ether, acetone, and methanol, were used to extract the phytochemicals. To extract the phytochemicals, approximate 25 g of the dried powder (STB or SB) was soaked in the screw tight glass jar for 48 hours. The extracts were filtered and evaporated, and the yield percentages were calculated as:

\[
\text{Percentage of extract yield} = \frac{R}{S} \times 100
\]

where \( R \) = wt. of the dry residues of the extract; \( S \) = wt. of the dry powder of STB or SB i.e., 25 g.

**Physicochemical and Phytochemical Analysis**
Physicochemical parameters, viz., the pH, loss on drying (LOD), ash values, and extractive values were investigated as per the Ayurvedic Pharmacopoeia of India (API) protocols. The qualitative analysis of phytochemicals, viz., phenols, tannins, carbohydrates, saponins, alkaloids, flavonoids, furanoids, quinone, proteins, coumarins, steroids, and triterpenoids was done as per recent studies. Quantitative analysis of phytochemicals was done by using direct mass study.

**Biochemical Assays**
Biochemical assays, viz., the TPC and TFC were analyzed by following the recent protocols. Antioxidant assays, viz., nitric oxide scavenging activity, ferric-reducing power estimation, 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay, ferric-reducing antioxidant power (FRAP) assay, metal-chelating activity assay, scavenging activity of superoxide anion assay, and phosphomolybdenate antioxidant assay of various extracts were performed per our recent reports. Also, bovine serum albumin (BSA) protein-binding ability of various extracts was assessed per our recent reports.

**Determination of Antimicrobial Activities**
Antimicrobial activities were determined on three fungal and three bacterial strains. The antimicrobial studies of various extracts were performed per the recent reports.

**Statistics Analysis**
Studies were executed in triplicates and the results were presented as ± mean. Excel (window 8), analysis of variance, and Tukey’s test were used for statistical analysis. \( p \leq 0.05 \) was considered statistically significant.

**RESULTS AND DISCUSSIONS**

**Physicochemical Parameters**
The observed pH values for SB and STB of BC were 5.63 ± 0.09 and 5.52 ± 0.11, respectively. The pH range was similar in both the SB and STB of BC, indicating the presence of similar kind of phytochemicals in SB and STB. It is well-documented that the pH plays a significant role in the medicinal activities of phytochemicals. Furthermore, the pH values ranging from 4 to 7 exhibited a relatively high antioxidant activity. In line with this, the concerned plant sample, in this context, is supposed to correlate well in terms of its antioxidant activities.

Total ash value determined for the SB and STB of BC was 8.80 ± 0.65% and 8.01 ± 0.33%, respectively. However, the total ash of STB was slightly less than that of SB which means the mineral content of SB is higher than that of STB. The total ash value represents the diagnostic purity index. The observed acid-insoluble ash values for SB and STB were 78.66 ± 2.22% and 81.61 ± 2.44%, respectively.

**Table 1:** Qualitative analysis of phytochemicals present in the various extracts of stem bark and branches of *Buchanania cochinchinensis* (Lour.) MR Almeida (++++, excellent; ++, good; +, present; −, not present)

| Phytochemical      | Petroleum ether | Acetone | Methanol |
|--------------------|-----------------|---------|---------|
|                    | STB              | Branches (SB) | STB     | Branches (SB) | STB     | Branches (SB) |
| Glycosides         | +++              | ++       | +++     | +            | +++     | +             |
| Terpenoids         | ++++             | ++++     | ++++    | +            | ++++    | +++           |
| Proteins           | −                | −        | −       | −            | −       | −             |
| Amino acids        | −                | −        | −       | −            | −       | −             |
| Alkaloids          | −                | −        | +       | −            | +       | −             |
| Carbohydrates      | +                | +        | −       | −            | +       | +             |
| Flavonoids         | −                | −        | +++     | +++          | +       | +             |
| Phenols            | −                | −        | −       | −            | −       | −             |
| Saponins           | −                | −        | −       | −            | −       | −             |
| Steroid            | −                | −        | +       | −            | −       | −             |
| Tannins            | −                | −        | +++     | +++          | +       | +             |

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Similarly, steroids, derived from plants, also have been reported to possess antibacterial and insecticidal properties besides having cardiotoxic effect. Saponins are reported to have antidiabetic and hypocholesterolemic properties, while triterpenoids display antancer and analgesic properties. Secondary metabolites play a potent role in pharmacological industrial sector. Dissimilarities were identified between previous and current studies. The variances might include changes in divergences in the genetic structural, geographic location, and environmental effects of the plants and their extraction method used. In our study, acetone and methanol offer better solvent systems for the extraction of various metabolites from such plants.

Quantitative phytochemical tests were used to ensure the occurrence of phytochemicals in various extracts of STB and SB (Tables 2 to 4). Direct mass analysis of the extracted metabolite was performed and compared with the National Institute of Advanced Industrial Science and Technology, Natural Product library, and National Institute of Standards and Technology.

**Table 2:** Quantitative analysis of phytochemicals present in the petroleum ether extracts of stem bark and small branch of *Buchanania cochinchinensis* (Lour.) MR Almeida

| Mass (m/z) | Name of compound |
|-----------|------------------|
| 102       | N-Methoxy-N-methylacetamide |
| 113       | 4-Imidazolecarboxylic acid |
| 124       | 2-Pyrazinecarboxylic acid |
| 141       | 4-Hydroxy-3,6-dimethylpyran-2-one |
| 144       | Methyl 3-Hydroxyisoxazole-5-carboxylate |
| 152       | 8-Azaguanine |
| 157       | 4-Hydroxy-3,5,6-trimethylpyran-2-one |
| 167       | m-Phenylenediboronic acid |
| 186       | 7-Hydroxy-6-methoxychromen-2-one |
| 198       | 3-Acetyl-5-sec-butyl-4-hydroxy-1,5-dihydro-2H-pyrrol-2-one |
| 220       | Diethyl bis (hydroxymethyl) malonate |
| 227       | 7,8-Dihydroxy-6-methoxychromen-2-one |
| 253       | Methyl 5-bromo-5-deoxy-β-D-idofuranosiduronic acid gamma-lactone |
| 256       | p-Nitrophenylphosphorodichloridate |
| 263       | Diheptyl disulfide |
| 274       | N-[2-(1H-Indol-3-yl)ethyl] acetamide |
| 279       | 6-Acetyl-1-bromo-2-methoxynaphthalene |
| 282       | 9-Octadecanamide |
| 337       | Ibogamine-18-carboxylic acid, 3,4-dehydro-, methyl ester |
| 356       | 8-Hydroxy-8-(3-octoxiran-2-yl) octanoic acid |
| 375       | 2-Chloro-10-(3-(4-methyl-1-piperazinyl)propyl)phenothiazine dimaleate |
| 485       | 2(3H)-Furanone, 4-[2-{16-O-[[2E]-3-(3,4-dihydroxyphenyl)-1-oxo-2-propen-1-yl]-β-D-glucopyranosyl]oxy]-1-methylethyl[dihydro-4-hydroxy |
| 537       | 5-Cholestene-3β,4β-diol 3-mono[ p-anisate) |
| 569       | 10-Methyl-6-(3-furyl)-15,18-dihydroxy-1,5,16-trimethyl-8,14-dioxo-7,11-dioxahexacyclonadec-19-yl](hydroxy)acetate |

The observed water-soluble ash values for SB and STB were 0.76 ± 0.08% and 0.78 ± 0.04%, respectively. The observed LOD for SB and STB was 0.302 ± 0.06% and 0.292 ± 0.05%, respectively.

In **Biochemical Assays**

**In vitro Antioxidant Activity**

Under DPPH assay, the observed value for control (ascorbic acid) was 91.30 ± 2.78%. Under the same experimental conditions, the observed LOD for SB and STB was 0.302 ± 0.06% and 0.292 ± 0.05%, respectively.

The observed water-soluble ash values for SB and STB were 0.76 ± 0.08% and 0.78 ± 0.04%, respectively. The observed LOD for SB and STB in petroleum ether were 0.66% and 0.49%, respectively. In acetone, these were 2.08% and 4.37%, respectively. The observed extractive values for SB and STB in methanol were 79.98% and 18.34%, respectively. As compared to petroleum ether extract, excellent yield was observed with solvents acetone and methanol (methanol >> acetone). It highlights the presence of polar compounds in the plant.
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Table 3: Quantitative analysis of phytochemicals present in the acetone extracts of STB and SB of *Buchanania cochinchinensis* (Lour.) MR Almeida

| Mass    | m/z²   | Name of compound                                                                 |
|---------|--------|-----------------------------------------------------------------------------------|
| 656     | 356, 198, 152, 91 | p-Octylphenyl 2-chloro-4-(p-heptylbenzoyloxy)benzoate                            |
| 680     | 566, 356, 157, 141 | 5-Cholestone-3β,4β-diol bis(p-chlorobenzoate)                                     |
| 736     | 225, 124, 87, 53   | Trihexadecyl borate                                                               |
| Petroleum ether extract of STB   |
| 102     | 75, 57, 45        | N-Methoxy-N-methylacetamide                                                       |
| 131     | 89, 47, 43        | N-Methoxydiacetamide                                                              |
| 134     | 102, 89, 71, 59   | 3-Methyl-1,3,5-pentanetriol                                                        |
| 144     | 131, 102          | Methyl 3-hydroxyisoxazole-5-carboxylate                                           |
| 155     | 44, 43, 42        | 6-Amino-2,4,5(3H)-pyrimidinetrione 5-oxide                                        |
| 157     | 150, 125, 113, 102| 4-Hydroxy-3,5,6-trimethylpyran-2-one                                               |
| 164     | 131, 103, 85, 74  | 2-Deoxy-D-galactose                                                              |
| 220     | 127, 141, 113, 98, 27 | Diethyl bis(hydroxymethyl)malonate                                             |
| 227     | 193, 186, 152, 131| 7,8-Dihydroxy-6-methoxychromen-2-one                                               |
| 242     | 169, 155, 151, 141, 127, 113 | 1-Bromo-2-methylhexadecane                                                      |
| 256     | 253, 124, 75, 63  | p-Nitrophenylphosphoridichloridate                                                |
| 267     | 220, 192, 166, 102| 2-(2-(5-Nitro-2-furyl)vinyl)quinoxaline                                           |
| 274     | 253, 225, 198, 157, 124 | N-[2-(1H-indol-3-yl)ethyl]acetamide                                           |
| 295     | 220, 198, 166, 103| Ethyl(5-methoxy-2-nitrobenzoyl)pyruvate                                         |
| 305     | 257, 228, 198, 76 | N-(2-Iodobenzoyl)glycine                                                          |
| 314     | 267, 258, 152, 134| 5,7-Dihydroxy-2-(p-methoxyphenyl)-6,8-dimethyl-4-chromanone                      |
| 318     | 295, 220, 164     | 2-Benzyl-1-methyl-5-nonylpyrrolidin-3-ol                                          |
| 371     | 267, 102, 91, 77  | N-Benzyl-N-(1-benzoyl-1-methylpropyl)benzamide                                    |
| 373     | 305, 273, 228     | 1,3,6,8-Tetrahydroxy-2-(1-hydroxyhexyl)anthracene-9,10-dione                     |
| 383     | 255, 174, 144     | Methyl tetracosanoate                                                             |
| 433     | 231, 157, 134, 102| Ethyl 3,5-dicyano-2,4-bis(p-methoxyphenyl)-6-oxo-3-piperidinecarboxylate          |
| 447     | 273, 150          | 3,4,5-Trihydroxy-6-[5-hydroxy-2-(4-hydroxyphenyl)-4-oxochromen-7-yl]oxyoxane-2-carboxylic acid |
| 485     | 167, 144, 131    | 2(3H)-Furanone, 4-[[6-O-[[2E]-3-(3,4-dihydroxyphenyl)-1-oxo-2-propen-1-yl]-β-Dglucopyranosyl]oxy]-1-methylethyl[dihydro-4-hydroxy |
| 502     | 383, 157, 114, 102| N(2)-Tosyl-L-glutamic acid bis(p-vinylanilide)                                    |
| 562     | 243, 164, 141, 43 | Methyl 2,3,4-Tri-O-acetyl-6-O-triphenylmethyl-β-D-galactopyranoside               |
| 625     | 383, 341, 267, 152| Glycerol 1,2-diarteate                                                            |
| 680     | 566, 356, 157, 141| 5-Cholestone-3-β,4β-diol bis(p-chlorobenzoate)                                    |
| 736     | 225, 124, 87, 53  | Trihexadecyl borate                                                               |
| 757     | 599, 438, 383, 178, 164 | 2,2′-Bis(dibromomethyl)-1,1′-bianthaquinone                                     |
| 887     | 267, 152, 134, 55 | 1,2,3-Propanetriyl tris(trans-9-octadecenoate)                                   |

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### Mass and Name of Compound

| Mass | m/z | Name of compound |
|------|-----|------------------|
| 219  | 127, 141, 113, 98, 27 | Diethyl bis(hydroxymethyl)malonate |
| 245  | 242, 169, 155, 141, 127, 113 | 1-Bromo-2-methylhexadecane |
| 256  | 213, 185, 171, 157, 113 | Hexadecanoic acid |
| 264  | 262, 166, 53, 43 | Diheptyl disulfide |
| 274  | 253, 225, 198, 157, 124 | N-[2-((1H-Indol-3-yl)ethyl]acetamide |
| 279  | 263, 220, 193, 113 | 6-Acetyl-1-bromo-2-methoxynaphthalene |
| 281  | 141, 128, 113 | 9-Octadecanamide |
| 304  | 245, 243, 185, 141, 102 | n-Hexanoyl-L-leucineanilide |
| 311  | 181, 152, 136, 83 | (3,4-Dimethoxyphenethylaminomethyl)methylmalonic acid |
| 319  | 243, 157, 143, 43 | 1,2,3,5-Tetra-O-acetylated 3-Galactopyranosyl-β-D-ribofuranose |
| 327  | 340, 169, 144, 113 | 5-(3-Chloro-4-hydroxyphenyl)isoxazole-3-quinolinol |
| 363  | 319, 169, 152, 113, 102 | 1-Acetyl-2-morpholin-5,5-diphenyl-2-imidazolin-4-one |
| 373  | 372, 272, 246, 141, 113 | 2-Chloro-10-(3-(4-methyl-1-piperazinyl)propyl)phenothiazine dimaleate |
| 396  | 396, 363, 184, 155, 103 | 1-Acetyl-2-morpholin-5,5-diphenyl-2-imidazolin-4-one |
| 443  | 281, 267, 185, 113 | L-Ascorbic acid 6-stearate |
| 469  | 304, 256, 178, 157, 136, 103 | Glycyrhretinic acid |
| 572  | 199, 103, 77 | 1-(3-Benzamido-5-o-benzoyl-2-benzoylthio-2,3-dideoxy-β-D-ribofuranosyl)-2,4(1H,3H)-pyrimidinedione |
| 610  | 304, 256, 178, 157, 136 | Hesperedin |
| 672  | 219, 199, 178, 157, 141 | 4-((1E)-3-((2-((3-Bromo-2-methylimidazo(1,2-a)pyridin-8-yl)oxy)methyl)-2,4-dichlorophenyl)methylamino)-2-oxoethyl)amino)-3-oxo-1-propenyl-N,N-dimethylbenzamide monomethanesulfonate |
| 680  | 566, 356, 157, 141 | 5-Cholestene-3β,4β-diol bis(p-chlorobenzoate) |
| 822  | 373, 311, 219, 155 | [3,4-Dihydroxy-6-[5-hydroxy-2-(4-hydroxyphenyl)-4-oxo-7-[3,4,5-trihydroxy-6-(hydroxymethyl)oxyan-2-yl]oxychromen-3-yl]oxy-5-[(2S,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxyoxan-2-yl]methyl acetate |
| 896  | 610, 373, 264, 136 | Pentopyranoside, (3β,5ξ,9ξ,16β,18ξ,22β)-22-(benzoyloxy)-16,28-dihydroxyolean-12-en-3-yl-3-O-hexopyranosyl |

### Acetone extract of STB

| Mass | m/z | Name of compound |
|------|-----|------------------|
| 102  | 75, 57, 45 | N-Methoxy-N-methylacetamide |
| 113  | 112, 94, 68, 44 | 4-Imidazolecarboxylic acid |
| 121  | 80, 53, 44 | 2-Pyrazinecarboxylic acid |
| 134  | 102, 89, 71, 59 | 3-Methyl-1,3,5-pentanetriol |
| 137  | 136, 102, 89, 71, 59 | 3-Methyl-1,3,5-pentanetriol |
| 141  | 138, 124, 105 | 4-Hydroxy-3,6-dimethylpyran-2-one |
| 150  | 103, 91, 77 | 4-(3-Hydroxybutyl)phenol |
| 154  | 44, 43, 42 | 6-Amino-2,4,5(3H)-pyrimidinetrione 5-oxime |
| 157  | 150, 125, 113, 102 | 4-Hydroxy-3,5,6-trimethylpyran-2-one |
| 164  | 131, 103, 85, 74 | 2-Deoxy-D-galactose |
| 178  | 177, 144, 141, 113, 102 | 5-Amino-4,6-dichloro-2-methylpyrimidine |
| 185  | 157, 155, 126, 102 | 2,3-Naphthalenedialdehyde |
| 199  | 152, 124 | 3-Acetyl-5-sec-butyl-4-hydroxy-1,5-dihydro-2H-pyrrol-2-one |
| 219  | 127, 141, 113, 98, 27 | Diethyl bis(hydroxymethyl)malonate |
| 227  | 193, 186, 152, 131 | 7,8-Dihydroxy-6-methoxychromen-2-one |
| 236  | 236, 219, 178, 141, 121 | 6,7,8-Trmethoxychromen-2-one |
| 243  | 169, 155, 151, 141, 127, 113 | 1-Bromo-2-methylhexadecane |
| 250  | 236, 199, 141, 134, 102 | 2-Amino-3-[4-hydroxy-3-(3-methylbut-2-enyl)phenyl]propanoic acid |
| 253  | 236, 219, 199, 141 | 5,6,7-Trmethoxychromen-2-one |
| 255  | 253, 124, 75, 63 | p-Nitrophenylphosphorodichloridate |
| 273  | 253, 225, 198, 157, 124 | N-[2-((1H-Indol-3-yl)ethyl]acetamide |
| 288  | 185, 129, 115 | Tetradecanoic acid |
Table 4: Quantitative analysis of phytochemicals present in the methanolic extracts of STB and SB of *Buchanania cochinchinensis* (Lour.) MR Almeida

| Mass (m/z) | Name of compound                                                                 |
|-----------|----------------------------------------------------------------------------------|
| 291       | 2-(4,5-Dihydroxy-2-methylphenyl)-6-hydroxy-4-methoxybenzoic acid                 |
| 299       | 2-(3-Hexyl-4-methyl-2,5-dioxopyrrol-1-yl)-3-hydroxybutanoic acid                 |
| 315       | 5,7-Dihydroxy-2-(p-methoxyphenyl)-6,8-dimethyl-4-chromanone                       |
| 321       | 2-Benzy1-1-methyl-5-nonylpyrrolin-3-ol                                            |
| 325       | (35,62)-3-Methyl-6-[[2-(2-methylbut-3-en-2-yl)-1H-indol-3-yl][methylidene] Piperazine-2,5-dione |
| 371       | 1,3,6,8-tetrahydroxy-2-(1-hydroxyhexyl)anthracene-9,10-dione                     |
| 391       | β-D-Galactopyranosepentacetate                                                   |
| 401       | (5-Benzyloxy-1,2,6-trihydroxycyclohex-3-en-1-yl)methyl benzoate                  |
| 419       | 6-Benzyl-2-(p-methoxyphenyl)-5-phenyl-5,6-dihydro-2H-1,2-thiazine,1,1-dioxide    |
| 537       | 5-Cholestan-3β,4β-diol 3-mono(p-anisate)                                         |
| 578       | 3-[5-(3,5-Dihydroxydecanoyloxy)-3-hydroxydecanoyloxy-5-hydroxydecanoyl acid     |
| 484       | 2(3H)-Furanone, 4-[[6-O-[[2E]-3-(3,4-dihydroxyphenyl)-1-oxo-2-propen-1-yl]-β-D-glucopyranosyl]oxy]-1-methyl(ethyl)dihydro-4-hydroxy |
| 597       | (25)-7-[[25,3R,4S,5R,6R]-4,5-Dihydroxy-6-(hydroxymethyl)-3-[[25,3R,4S,5R,6S]-3,4,5-tri hydroxy-6-methyloxan-2-yl]oxyoxan-2-yl]oxy-2-(3,4-dihydroxyphenyl)-5-hydroxy-2,3-dihydrochromen-4-one |
| 612       | Hesperidin                                                                      |
| 993       | Pentopyranoside, (3β,5ξ,9ξ,16β,18ξ,22β)-22-(benzyloxy)-16,28-dihydroxyolean-12- en-3-yl 3-O-hexopyranosyl |

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| Mass | m/z | Name of compound |
|------|-----|------------------|
| 443  | 281, 267, 185, 113 | L-Ascorbic acid 6-stearate |
| 479  | 173, 143, 91 | 2,7-Dibenzyll-1,8-diphenyl-2,7-octanediol |
| 576  | 199, 103, 77 | 1-(3-Benzamido-5-o-benzoyl-2-benzoylthio-2,3-dideoxy-β-D-ribofuranosyl)-2,4(1H,3H)-pyrimidinedione |
| 640  | 304, 256, 178, 157, 136 | Hesperidin |
| 686  | 338, 320, 113, 97 | Cis,cis-N,N'-methylenebis(13-docosenamide) |
| 712  | 360, 279, 214, 149, 102 | 1-Hydroxy-2-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)-9H-xanthene-3,6,7-triy triacetate |
| 757  | 338, 178, 149, 133 | 3-Hydroxy-1-[3-hydroxy-1-oxo-1(2,3,4,5,6-pentahydroxyhexoxy)decan-5-yl]oxy-1-oxodecan-5-yl 3,5-dihydroxydecanoate |

**Methanolic extract of STB**

| Mass | m/z | Name of compound |
|------|-----|------------------|
| 102  | 75, 57, 45 | N-Methoxy-N-methylacetamide |
| 113  | 112, 94, 68, 44 | 4-Imidazolecarboxylic acid |
| 125  | 124, 80, 53, 44 | 2-Pyrinecarboxylic acid |
| 131  | 113, 84, 53, 43 | 3-Guanidinopropionic acid |
| 137  | 136, 102, 89, 71, 59 | 3-Methyl-1,3,5-pentanetriol |
| 142  | 138, 124, 105 | 4-Hydroxy-3,6-dimethylpyran-2-one |
| 144  | 131, 102 | Methyl 3-hydroxyisoxazole-5-carboxylate |
| 157  | 150, 125, 113, 102 | 4-Hydroxy-3,5,6-trimethylpyran-2-one |
| 164  | 131, 103, 85, 74 | 2-Deoxy-D-galactose |
| 171  | 170, 153, 125, 103 | Gallic acid |
| 178  | 177, 144, 141, 113, 102 | 5-Amino-4,6-dichloro-2-methylpyrimidine |
| 192  | 127, 141, 113, 98, 27 | Diethyl bis(hydroxymethyl)malonate |
| 227  | 193, 186, 152, 131 | 7,8-Dihydroxy-6-methoxychromen-2-one |
| 236  | 236, 219, 178, 141, 121 | 6,7,8-Trimethoxychromen-2-one |
| 243  | 169, 155, 151, 141, 127, 113 | 1-Bromo-2-methylhexadecane |
| 256  | 253, 124, 75, 63 | p-Nitrophenyl phosphorodichloridate |
| 269  | 220, 192, 166, 102 | 2-(2-(5-Nitro-2-furyl)vinyl)quinoline |
| 280  | 180, 128, 114, 112 | 9-Octadecenamide |
| 283  | 184, 148, 137, 124, 114, 111 | 12-Hydroxy-9-octadecenoic acid |
| 299  | 253, 236, 134 | 2-(3-Hexyl-4-methyl-2,5-dioxopyrrol-1-yl)-3-hydroxybutanoic acid |
| 313  | 267, 258, 152, 134 | 5,7-Dihydroxy-2-(p-methoxyphenyl)-6,8-dimethyl-4-chromanone |
| 321  | 295, 220, 164 | 2-Benzyl-1-methyl-5-nonylpyrolidin-3-ol |
| 341  | 340, 169, 144, 113 | 5-(3-Chloro-4-thiocyanatophenylazo)-8-quino linol |
| 366  | 363, 319, 169 152, 113, 102 | 1-Acetyl-2-morpholin-5,5-diphenyl-2-imidazolin-4-one |
| 375  | 305, 273, 228 | 1,3,6,8-Tetrahydroxy-2-(1-hydroxyhexyl)anthracene-9,10-dione |
| 391  | 243, 199, 157, 141, 103 | β-D-Galactopyranosepentaacetate |
| 437  | 391, 236, 171, 166, 144, 131 | Dimethyl 5′,6′-bis(methylthio)-p-terphenyl-2′,3′-dicarboxylate |
| 443  | 281, 267, 185, 113 | L-Ascorbic acid 6-stearate |
| 462  | 420, 303, 283, 256, 236 | (1α,2α,3α)-1,2,3,5,8-Pentahydroxy-6-methoxy-3-methyl-1,2,3,4-tetrahydroanthraquinone 1,2,8-triacetate |
| 477  | 304, 256, 178, 157, 136, 103 | Glycyrhrinetinic acid |
| 487  | 485, 167, 144, 131 | 2(3H)-Furanone, 4-[2-{6-O-(3E)-3-(3,4-dihydroxyphenyl)-1-oxo-2-propen-1-yl]-β-D-glucopyranosyl(oxy)-1-methyl(ethyl)dihydro-4-hydroxy |
| 536  | 356, 274, 152, 135, 124 | 5-Cholestene-3β,4β-diol 3-monoo-p-anisate |
| 662  | 373, 178, 134, 102 | 3-[5-(3,5-Dihydroxydecanoxyloxy)-3-hydroxydecanoxyloxy-5-hydroxydecanoic acid |

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observed values for various extracts, viz., petroleum ether, acetone, and methanol extracts of SB and STB were 9.04 ± 0.91%, 8.22 ± 0.88%, 90.83 ± 3.02%, 88.83 ± 3.77%, 90.48 ± 2.55%, and 89.18 ± 2.91% respectively. In present study, polar solvent extracts, i.e., acetone and methanol extracts of SB and STB of BC under study demonstrated almost similar antioxidant properties to that of ascorbic acid (Fig. 1A). Clearly, the DPPH properties are similar in both STB and SB.

Under metal-chelating assay, EDTA was used as a control and the observed value for the assay was 89.17 ± 2.84%. Under similar experimental conditions, the observed value for petroleum ether,
The acetone and methanol extracts of SB and STB were evaluated for their antioxidant activities. The DPPH radical scavenging activity of the extracts was measured, and the values were as follows: acetone and methanol extracts of SB and STB were 73.61 ± 2.14%, 88.05 ± 3.65%, 81.93 ± 2.89%, 82.23 ± 3.12%, 84.24 ± 2.54%, and 93.62 ± 3.53%, respectively (Fig. 1B). Clearly, the STB demonstrated a higher activity as compared to that of SB in petroleum ether and methanolic extract (Fig. 1B).

In other antioxidant assay, i.e., FRAP, the observed values for control (ferrous sulfate) were 82.73 ± 2.42%; and under the same conditions, the value for acetone and methanol extracts of SB and STB was 52.34 ± 1.93%, 61.71 ± 2.19%, 45.29 ± 2.21%, and 57.01 ± 2.11%, respectively (Fig. 1C). It was noticed that...
petroleum ether extracts of SB and STB have no FRAP antioxidant activities but polar solvents showed significant activities under the FRAP assay.

The percentage of antioxidant activity for ascorbic acid (control) was 33.23 ± 1.44 and for petroleum ether, acetone, and methanol extracts of SB and STB was 2.66 ± 0.037, 2.41 ± 0.12, 20.31 ± 1.07, 28.92 ± 1.28, 15.48 ± 1.31, 27.43 ± 1.83, respectively. Clearly, the antioxidant properties of acetone and methanol extracts are almost similar to that of ascorbic acid (Fig. 1D). Low activities were observed for petroleum ether extracts (2.4–2.7% only). The STB's acetone and methanolic extracts have low activities (15.40–20.30% only) as compared to the control.

The percentage of radical scavenging activity (antioxidant superoxide) against NO, for ascorbic acid (control) was 64.98 ± 2.38 and for petroleum ether, acetone, and methanol extracts of SB and STB was 26.81 ± 1.11, 25.65 ± 1.19, 40.26 ± 1.96, 61.41 ± 2.58, 55.75 ± 2.12, and 45.99 ± 2.22, respectively. Clearly, acetone and methanol extracts have better antioxidant properties compared to that of petroleum ether, but all less than that of ascorbic acid (Fig. 1E). Here petroleum ether and methanolic extracts of SB demonstrated more superoxide radical scavenging activity compared to that of STB.

Table 5: Total phenolic and flavonoid contents of various extracts of SB and STB of Buchanania cochinchinensis (Lour.) MR Almeida. Code: A = STB, B = SB. Solvents: petroleum ether (1), acetone (2), and methanol (3). Values are expressed as mean ± SD (n = 3).

Table 6: Quantitative analysis of rate constants of the various extracts of STB and SB of Buchanania cochinchinensis (Lour.) MR Almeida observed in bovine serum albumin study.

Table 7: Antibacterial activities of various extracts of Buchanania cochinchinensis (Lour.) MR Almeida of SB and STB. Code: A = SB, B = STB. Solvents: petroleum ether (1), acetone (2), and methanol (3). Values are expressed as mean ± SD (n = 3).
extracts. Acetone extracts of STB showed more activity compared to that of SB extracts.

The percentage of radical scavenging activity (antioxidant superoxide) against NO, for ascorbic acid (control) was observed 29.21 ± 1.58 and for petroleum ether, acetone, and methanol extracts of SB and STB was 21.65 ± 1.12, 21.76 ± 1.22, 16.34 ± 1.61, 14.59 ± 1.45, 18.61 ± 1.08, and 20.51 ± 1.24, respectively. Clearly, petroleum ether and methanolic extracts have better antioxidant property compared to that of acetone extracts of SB and STB as compared with ascorbic acid; it highlights STB and SB as useful drugs (Fig. 1F). Here we noticed that both STB and SB have almost the same activities.

For phosphomolybdenum antioxidant assay, the percentage of antioxidant activity for ascorbic acid (without treatment) was 85.31 ± 2.11 and for petroleum ether, acetone, and methanol extracts of SB and STB was 1.63 ± 0.19, 0.69 ± 0.05, 31.26 ± 1.94, 37.66 ± 2.12, 25.73 ± 1.55, and 32.21 ± 2.29, respectively. Evidently, petroleum ether extracts have poor antioxidant property than acetone and methanol extracts of SB and STB, as compared with ascorbic acid. Here SB extracts have fewer activities than STB extracts.

**Total Flavonoid and Phenol Contents**

The outcomes of the total phenolics were estimated in equivalents of gallic acid and the total flavonoids in QEs (Table 5). Like the antioxidant properties, the polar solvents, i.e., acetone and methanolic extracts demonstrated higher phenolic and flavonoid content, indicating the linear relationship between these two values. In acetone and methanol extracts, the observed values for total phenolic content ranged from 10 to 93 mg of gallic acid and TFC ranged from 30 to 87 mg of quercetin (Table 5).

**Anti-inflammatory and Protein-binding Assay**

Denaturation of proteins causes inflammation. In this study, all extracts showed good inhibition (95–98%) against BSA protein. In the second experiment of BSA protein, the behavior of extracts and acetylsalicylic acid were determined by combining it with the BSA protein. The BSA protein binds to acetylsalicylic acid and various extracts of SB and STB were performed. The mean values of protein-binding constants are observed to be 2.31 ± 0.05 × 10⁻⁵ μM⁻¹ for acetylsalicylic acid (ASA) and 61.5 ± 2.45 × 10⁻⁵ μM⁻¹, 39.5 ± 1.11 × 10⁻⁵ μM⁻¹, 22.4 ± 1.01 × 10⁻⁵ μM⁻¹, 31.3 ± 1.16 × 10⁻⁵ μM⁻¹, 32.7 ± 1.14 × 10⁻⁵ μM⁻¹ and 33.3 ± 1.15 × 10⁻⁵ μM⁻¹ for various extracts (Fig. 2 and Table 6).

This study confirms the weak interaction of BSA complex with extracts which is used as drug delivery systems in the present world.

**Antimicrobial Activities**

**Antibacterial Activity**

Tables 7 and 8 exhibited the antimicrobial activities, and various extracts showed mild effects against the selected bacterial and fungal strains. Like the antioxidant assays and TPC and TFC, polar solvents, i.e., acetone and methanolic extracts showed good inhibition against the selected strains. Table 7 exhibited that acetone and methanol extracts are more effective as compared to the petroleum ether for bacterial strains under study. Acetone extracts have reportedly and significantly repressed the growth of all the strains studied, whereas the methanolic extract could significantly inhibit the growth of Streptococcus mutans, Staphylococcus aureus, and Pseudomonas aeruginosa. Table 8 exhibited the antifungal results of selected strains. It was noticed that all the extracted compounds inhibit the growth of Aspergillus parasiticus. But petroleum ether and acetone extracts were found to be inactive against Candida albicans and Aspergillus niger. Methanolic extracts were found to be positive against C. albicans and A. niger as well as A. parasiticus.

To understand the antibacterial potential against various gram-positive and gram-negative bacteria, several extracts including ether, ethyl acetate, aqueous, and methanol extracts of plants tested in previously documented studies were reviewed. Methanolic extracts displayed significant activity against Bacillus subtilis (8 ± 0.4 mm), Bacillus cereus (12 ± 0.8 mm), P. aeruginosa (9 ± 0.5 mm), Proteus vulgaris (7 ± 0.4 mm), Salmonella sp. (12 ± 1.5 mm), Trichoderma viride (10 ± 0.9 mm), Penicillium sp. (8 ± 0.3 mm), and A. niger (6 ± 0.9 mm). Furthermore, no activity of methanolic extract of bark of Buchanania cochinchinensis (Lour.) against S. aureus and Escherichia coli was found.²⁻⁶

Plant-derived natural products having poor antimicrobial and antifungal activities are reported to represent synergism against microbial pathogens when combined with various chemotherapeutic compounds.

**Conclusion**

In conclusion, the findings of STB and SB of BC provide undeniable systematic facts of its beneficial prospective as an Ayurvedic drug. The major outcomes of the current study are the following:

- Under physicochemical parameters, significant difference was found between the extractive values of SB and STB under various solvents. A nonsignificant difference was found for pH and ash values.
Under phytochemical studies, in acetone and methanolic extracts, the observed values for TPC ranged from 10 to 93 mg of GAE/g of extract and TFC it ranged from 30 to 87 mg of QE/g of extract.

Under biochemical assay, in antioxidant assays, as compared to control(s), acetone and methanol extracts of SB and STB were more potent compared to petroleum ether extracts of SB and STB.

Overall, based upon the physicochemical, photochemical, and biochemical studies, polar solvents (acetone and methanol) are the best solvent system to extract the maximum phytochemical constituents with significant biochemical activities. Hence, the present study provides a scientific evidence to substitute stem bark and small branches in place of roots, which can protect the plant from destruction.

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हिंदी सारांश

आयुर्वैदिक औषधियों के प्रतिलिपि दर्शन हेतु बुधनानिया कोवियाइंगेलिसिस (लौर.) एम.आर. अलमीडा के तने की छाल और छोटी शाखाओं की फाइटोकेमिकल, एंटीऑक्सीडेंट और एंटीमाइक्रोबियल क्षमता का 
तुलनात्मक मूल्यांकन

उद्देश्य: वर्तमान अध्ययन का आश्रय बुधनानिया कोवियाइंगेलिसिस (लौर.) एम.आर. अलमीडा के तने की छाल (एसटीबी) 
और छोटी शाखाओं (एसबी) के भौतिकरासायनिक मापदंडों, फाइटोकेमिकल घटकों और जैवरासायनिक अध्ययनों की 
जांच करना।

सामग्री और विधियां: विभिन्न धुलनशील द्रव्यों यथा पेट्रोलियम ईंधन, एसीटैन और मिथेनोल आदि में मापदंडों की जांच 
की गई।

परिणाम: लियेंट्र स्की अपेक्षा पादप के एसटीबी और एसबी के एसीटैन और मिथेनोलिक निष्कास में महत्वपूर्ण 
एंटीऑक्सीडेंट (10-85%) और एंटीमाइक्रोबियल (5-20 एमएम) गतिविधियों देखी गई। एसीटैन और मिथेनोलिक 
निष्कास में, कुल फिनोल कंटेंट (टीपीसी) निष्कास के प्रति ग्राम थैलिक अम्ल एक्सिलेज की मात्रा 10 मि.ग्र. से 93 मि. 
ग्र. है और कुल फलोलिक फॉर्म कंटेंट (टीएफसी) निष्कास के प्रति ग्राम के क्वेरेरिन एक्सिलेज (क्यूड) की मात्रा 30 मि. 
ग्र. से 87 मि.ग्र. है। सभी निष्कासों का बोधित सिरम एल्बमिन (बीएए) प्रोटीन इंटरकेशन अध्ययन किया गया और 
बाइडिंग कोस्टेंट के लिए ओब्जर्व वेल्यूज 22 से 62*10^{-5} µM^{-1} है।

निष्कास: कुल मिलाकर, पादप के एसटीबी और एसबी के एसीटैन और मिथेनोलिक निष्कास में उपयुक्त औषधीय 
पहलुओं पर महत्वपूर्ण परिणाम देखे गए हैं।

नेतृत्विक महत्व: बुधनानिया कोवियाइंगेलिसिस (लौर.) एम.आर. अलमीडा के एसटीबी और एसबी के तुलनात्मक परिणाम 
से आयुर्वैदिक औषधि के रूप में इसके लाभकारी पहलुओं के अकार्य व्यवस्थित तर्क को उजागर करता है।

मुख्य शब्द: एंटीमाइक्रोबियल, एंटीऑक्सीडेंट, बुधनानिया, औषधीय पादप, प्राकृतिक उत्पाद, फाइटोकेमिकल।