Evaluation of in vitro biological properties of Senna occidentalis (L.) Link

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ABSTRACT. Senna species have been widely used by American, African and Indian ethnic groups mainly in the treatment of feebleness, constipation, liver disorders and skin infections. Senna occidentalis (L.) Link is a perennial shrub native to South America and indigenous to tropical regions throughout the world. Current study evaluated the antimicrobial activity of aqueous and hydroalcoholic extracts from S. occidentalis prepared from different parts of the plant. Antimicrobial activity was assessed against standard pharmaceutical microorganisms by spectrophotometry and microdilution technique. Escherichia coli was sensitive only to compounds extracted from seeds which may be proteinaceous. A broader antimicrobial spectrum was demonstrated by the hydroalcoholic extract of seeds, mostly against Pseudomonas aeruginosa. The in vitro toxicity using mouse fibroblasts indicated that the extract might be a biocompatible ingredient for topical formulations, while the hydroalcoholic extract of aerial parts demonstrated to be potentially cytotoxic.

Keywords: Cassia occidentalis, Leguminosae, traditional medicine, antibacterial, antifungal, fibroblasts.

Introduction

Cassia is a large genus of the family Fabaceae Lindl. (Leguminosae), highly relevant in folk medicine. Several species have been used for centuries by American, African, and Indian tribes, principally as a laxative, hepatoprotective, antimalarial or antimicrobial medicine (LOMBARDO et al., 2009). Scientific data have revealed that Cassia spp. comprise a rich source of phenolic derivatives with important biological and pharmacological properties (VIEGAS JÚNIOR et al., 2006).

The species Senna occidentalis (L.) Link (syn.: Cassia occidentalis L.) is a perennial shrub native to South America and indigenous to tropical regions throughout the world frequently considered a weed growing in wastelands. Although the legume releases a volatile substance with a characteristically fetid odor, its seeds are a substitute for coffee beans in some regions in Northeastern Brazil, Central America, Africa and India (CORRÊA, 1926).

Numerous reports have demonstrated that S. occidentalis, which often grows in pastures and among cereal crops, is poisonous to animals that accidentally ingest large amounts of its seeds or food rations contaminated with them (TAKEUTI et al., 2011). According Hueza et al. (2007), even small quantities of seeds in the diet of birds were able to...
cause immunotoxic effects, including depletion of lymphoid cells on the spleen and bursa of Fabricius.

In traditional medicine, Senna spp. have several therapeutic indications. It is commonly employed to heal skin disorders by topical applications, demonstrating a possible role in the treatment of mycoses, parasitic diseases and eczemas (CACERES et al., 1993; OGUNKUNLE; LADEJOBI, 2006). In Brazilian folk medicine, leaves and seeds of S. occidentalis are employed as a topical antifungal agent, especially in the treatment of wounds and mycoses such as ringworms (tinea corporis) and the skin eruption pityriase versicolor (FENNNER et al., 2006).

Since S. occidentalis extract may be used in medical topical preparations, particularly as a natural preservative agent, current study examines the antibacterial and antifungal activities of aqueous and hydroalcoholic extracts prepared from different segments of the plant and checks the toxic effect of their extracts on fibroblasts.

Material and methods

Plant collection

Senna occidentalis was collected from a culture collection maintained at the Instituto Biológico, São Paulo, Brazil. The species was authenticated by Dr. Inês Cordeiro and deposited under the number SP-363817 in the Maria Eneida Fidalgo Herbarium of the Instituto de Botânica, São Paulo, São Paulo State, Brazil. Aerial parts (including flowers, young pods, stems, petioles and predominantly leaves) were dried at 35°C and seeds were dried at room temperature. Aerial parts and seeds were pulverized separately with a grinder and stored at room temperature in closed containers until use.

Preparation of extracts

The hydroalcoholic extract of the aerial parts (HAAP) was obtained with ethanol 75% (v v⁻¹) by slow percolation at room temperature, following the Farmacopeia Brasileira (2010). The ethanol extract was evaporated at 40°C in a rotary evaporator and lyophilized. The seeds’ hydroalcoholic extract (HAS) was obtained under the same conditions described above. Seeds were then macerated with 10% (w v⁻¹) phosphate buffer (0.2 M; pH 7.3) for 12 h at 4°C by stirring to obtain the aqueous extract of seeds (AS). Starting from the AS, protein fractionation based on polarity characteristics was performed. The macromolecules showed interesting biological properties in previous studies (LOMBARDO et al., 2004). AS was centrifuged at 10,000 rpm for 30 min. at 4°C. The supernatant was subjected to protein fractionating by precipitation with ammonium sulfate at 25, 50 and 75% saturation (DEUTSCHER, 1990). The protein fractions (F25, F50 and F75) were dialyzed against deionized water and lyophilized.

Phytochemical analysis

Anthraquinones and flavonoids in ethanol extracts (HAAP and HAS) were evaluated by thin layer chromatography (TLC) using silica plates 20 x 15 cm (Merck™ silica gel 60), ethyl acetate: methanol: water (10:1.35:1) as mobile phase and 1,8-hydroxyanthraquinone and quercetin as references. Plates were analyzed under UV light (365 nm) and sprayed with KOH 0.1N or Natural Products reagent (NP) number 28 (WAGNER; BLADT, 1996). The protein content of the aqueous extract of seeds (AS) and its fractions (F25, F50 and F75) was determined by the Lowry method, using bovine serum albumin (BSA) as reference. The Lowry method consists of a colorimetric reaction in which occurs the binding of copper (II) ions with the peptide nitrogens, followed by the reduction of the Folin Ciocalteu reagent by tyrosine, tryptophan and polar amino acids, under alkaline conditions. The chromogenic groups formed have an intense blue color with absorption at 660 nm (WATERBORG, 2009).

Antimicrobial activity

Sample preparation

The ethanol extracts were solubilized in DMSO/MeOH (1:1) at 60 mg mL⁻¹ (w v⁻¹). The aqueous extract and its fractions were solubilized in phosphate buffer at 20 mg mL⁻¹ (w v⁻¹).

Microbial strains

Antimicrobial activity was performed against Staphylococcus aureus (ATCC 6538), Escherichia coli (ATCC 8739), Pseudomonas aeruginosa (ATCC 9027), Candida albicans (ATCC 10231), and Aspergillus brasiliensis (ATCC 16404), formerly Aspergillus niger (A. brasiliensis Varga et al. deposited as A. niger van Tieghem, anamorph). These organisms were obtained from the Laboratório de Materiais de Referência, Instituto Nacional de Controle de Qualidade em Saúde (INCOQS), Rio de Janeiro, Brazil. Bacteria were cultured on Tryptone Soy Agar (TSA, Difco™) for 24h at 37°C. C. albicans and A. brasiliensis were cultured on Sabouraud Dextrose Agar (SDA, Difco™) for 48 h and 5 days respectively, at 25°C. The microbial growth was recovered in a physiological saline solution by adding polysorbate 80 at 0.05% (w v⁻¹) and glass beads to re-suspend A. brasiliensis. The number of
Colony-Forming Units (CFU mL⁻¹) of each microbial suspension was determined by pour plate count, following according to United States Pharmacopoeia (2012). Standardized suspensions at a concentration of 5 × 10⁴ CFU mL⁻¹ were prepared with Müller Hinton broth (Himedia™) for bacteria and Sabouraud Dextrose Broth (SDB, Difco™) for fungi. Cell viability of each inoculum was verified by pour plate count.

**In vitro antimicrobial assay**

Antibacterial and antifungal activities were determined by spectrophotometry, microdilution protocol, sterile 96-well microplates and ELISA reader (OSTROSKY et al., 2011). Each well was filled to a final volume of 200 μL. Quadruplicates of the extract (10–20 μL) were incubated with 180–190 μL of bacterial or fungal inoculum. Samples were tested at concentrations (mg mL⁻¹): 0.05, 0.10, 0.20, 0.30 and 0.40. Solutions of chloramphenicol, amycacin, or nystatin at 1 mg mL⁻¹ were used as positive antibiotic-containing controls (0.01 mg well⁻¹). Sample diluents without micro-organisms were included as negative controls. Wells in each microtiter dish were included to monitor microbial growth (no extracts) and broth sterility (no microorganism). Microplates were incubated for 24h at 37°C (bacteria) or for 48h at 25°C (fungi). Growth of bacteria and C. albicans was determined by measuring turbidity values at 630 nm. Growth of A. brasiliensis was qualitatively evaluated by visually inspecting and subculturing plating.

**Cytotoxic activity**

**Sample preparation**

The ethanol extracts were solubilized in DMSO/MeOH (1:1) at 300 mg mL⁻¹ (w v⁻¹), sterilized by filtration (0.45 μm) and then diluted in D-10 medium (DMEM - Dulbecco’s modified Eagle’s medium Gibco™, supplemented with 10% fetal bovine serum, 1% penicillin-streptomycin, and glutamineat 4 mM). Samples were tested at concentrations (mg mL⁻¹): 0.005, 0.090, 0.190, 0.375, 0.750, 1.500, 3.000 and 6.000.

**Cells**

Cytotoxicity was evaluated against Balb/C NIH-3T3 fibroblasts, using sterile 96-well microplates and ELISA reader (FUNARI et al., 2007). After cell cultivation, each well was filled with 120 μL of D-10 medium containing approximately 8 × 10⁴ cells mL⁻¹ and plates were incubated for 24h at 37°C in a humidified atmosphere and 5% CO₂. The medium was removed and cells were treated with 100 μL of samples.

**In vitro toxicity assay**

Cell viability was assessed with MTS assay which consists of a colorimetric reduction of tetrazolium salt (MTS) to formazan by metabolically active cells. Cells remained in contact with the extracts for 24 and 48h at 37°C in a humidified atmosphere and 5% CO₂. The wells were then washed, filled with 100 μL of D-10, 20 μL of the Promega™ solution MTS/PMS (phenazine methosulfate) and incubated for 2h. The absorbance was measured at 490 nm and the toxicity of the extracts on fibroblasts was evaluated by comparing it with that of untreated cells.

**Results and discussion**

The hydroalcoholic extract of the aerial parts (HAAP) yield was approximately two-fold higher than the hydroalcoholic extract of seeds (HAS). Anthraquinones were not detected by TLC in the aerial parts. According to Rai and Shok (1983), anthraquinones contents in S. occidentalis seeds are much greater than in leaves and roots. Aerial parts and seeds both contained flavonoids (Table 1). The abundance of flavonoids in S. occidentalis leaves was demonstrated by Purwar et al. (2003).

**Table 1.** Extraction yield and phytochemical characterization of *Senna occidentalis* hydroalcoholic extracts.

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Yield*</th>
<th>Anthraquinone</th>
<th>Flavonoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAAP</td>
<td>0.23</td>
<td>(−)</td>
<td>(+)</td>
</tr>
<tr>
<td>HAS</td>
<td>0.12</td>
<td>(+)</td>
<td>(+)</td>
</tr>
</tbody>
</table>

HAS (hydroalcoholic extract of aerial parts); HAAP (hydro-alcoholic extract of seeds).

*Aerial parts included 0.65 g of flowers, 2.65 g of young pods, 8.56 g of stems, and 133.38 g of leaves and petioles; 156 g of seeds; *Values are expressed in g extract g⁻¹ plant part; (+) Presence; (−) Absence.

Source: Author’s data.

Plants of the legume family are a rich source of dietary protein. In addition to the nutritional aspects, lectins and proteins function in the plant’s defense and may have antimicrobial properties (LOMBARDO et al., 2004). Since proteins and peptides were extracted from *S. occidentalis* seeds after the hydroalcoholic extraction, sugars and pigments were eliminated. Table 2 shows protein concentration and protein yield of the aqueous extracts of seeds (AS) and fractions (F25, F50 and F75). The results revealed a predominance of proteins and peptides from *S. occidentalis* seeds with hydrophilic characteristics, i.e., very polar molecules which require a high degree of salt saturation for the removal of water during precipitation. Therefore, F75 had the highest protein concentration.
In current assay, antimicrobial activities were evaluated by the microdilution technique, a sensitive and reproducible method that enables the analysis of a large number and small amounts of samples. Results demonstrated that *S. occidentalis* extracts have antimicrobial activity against bacterial and fungal pathogens (Table 3).

Although none of the extracts showed any activity against *C. albicans*, the hydroalcoholic extracts moderately inhibited *A. brasiliensis*. The HAS (0.3 mg mL$^{-1}$) inhibited the growth of *S. aureus* (47%), *E. coli* (35%) and *P. aeruginosa* (78%). HAAP (0.3 mg mL$^{-1}$) showed activity against *S. aureus* (52%) and *P. aeruginosa* (59%), but *E. coli* was not inhibited by this extract. AS (0.1 mg mL$^{-1}$) inhibited the growth of *S. aureus* (42%) and *E. coli* (32%) but had no effect on *P. aeruginosa*. An inhibition less than 20% was considered an irrelevant activity.

### Table 3. Antimicrobial activity of *Senna occidentalis*.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Concentration (mg mL$^{-1}$) $^a$</th>
<th><em>S. aureus</em> $^b$</th>
<th><em>E. coli</em> $^b$</th>
<th><em>P. aeruginosa</em> $^b$</th>
<th><em>C. albicans</em> $^b$</th>
<th><em>A. brasiliensis</em> $^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS</td>
<td>0.1</td>
<td>42</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>(−)</td>
</tr>
<tr>
<td>F25</td>
<td>0.1</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>(−)</td>
</tr>
<tr>
<td>F50</td>
<td>0.1</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>(−)</td>
</tr>
<tr>
<td>F75</td>
<td>0.1</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>&lt;20</td>
<td>(−)</td>
</tr>
<tr>
<td>HAS</td>
<td>0.3</td>
<td>47</td>
<td>35</td>
<td>78</td>
<td>&lt;20</td>
<td>(−/+)</td>
</tr>
<tr>
<td>HAAP</td>
<td>0.3</td>
<td>52</td>
<td>&lt;20</td>
<td>59</td>
<td>&lt;20</td>
<td>(&lt;−/−)</td>
</tr>
</tbody>
</table>

$^a$Inoculum concentration of 10$^6$ CFU/well. $^b$The highest concentrations with the best activity (mg mL$^{-1}$): Optical density reduction (%); (+) no visual inhibition; (−/−) moderate visual inhibition; AS (Aqueous extract of seeds); F25 (Fraction 25); F50 (Fraction 50); F75 (Fraction 75); HAS (Hydroalcoholic extract of seeds); HAAP (Hydroalcoholic extract of aerial parts).

Source: Author’s data.

The above findings show that multiple antimicrobial compounds with diverse activity or mechanism of action are present in the seeds and foliar parts of *S. occidentalis*. Interestingly, the protein fraction F75 (0.1 mg mL$^{-1}$) showed a moderate but specific activity against *E. coli*, suggesting that this fraction is responsible for the anti-*E. coli* activity of the aqueous extract of seeds (AS). This result indicated that *E. coli* was sensitive to bioactive compounds from *S. occidentalis* seeds (AS and HAS) and some of them may be proteinaceous.

The hydroalcoholic extracts were selected to examine *in vitro* toxicity due to their best antimicrobial performance, discussed previously. While HAS promoted a satisfactory dose-dependent decrease in cellular viability at 24 and 48h, which was < 50% until the concentration of 0.38 mg mL$^{-1}$, all concentrations of HAAP were toxic to fibroblasts cells within 24h (Figure 1). On the other hand, the high cytotoxic potential of HAAP revealed an interesting activity to be explored, similar to the anticancer substances derived from natural products (SHARMA et al., 2000; CALDERÓN et al., 2006).

### Conclusion

The antimicrobial screening of *Senna occidentalis* plant parts showed that the hydroalcoholic extract of the seeds displayed a broad spectrum of activity, with pronounced inhibition to *Pseudomonas aeruginosa*. At the same time, the *in vitro* toxicity profile of this extract indicated that it might be safe for topical use up to the effective concentration. Results suggest that further analysis of *S. occidentalis* bioactive constituents and its effectiveness in pharmaceutical formulations should be undertaken, particularly when the importance of this species as an antimicrobial for ethnic groups is taken into account.

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