Introduction

Phytochemicals or secondary metabolites are chemical compounds formed during the plants normal metabolic processes and plants use them to protect themselves (Ning et al., 2009). The resistance that pathogens build against antibiotics and the oxidative stress caused by free radicals, has sparked interest in the search for new antibacterial and antioxidant compounds also from nature (Berrino et al., 2009; Pervival, 1997; Auroma, 1998; Michael et al., 2006). Natural crude drug extracts isolated from plant species can be prolific resources for such new drugs.

The genus Asparagus comprises approximately 100 species and consists of herbs, shrubs and vines. Asparagus laricinus is a monogeneric family (previously included within the Liliaceae family), belonging to Asparagaceae family (Brummitt, 1992). A. laricinus known as lesitwane in Setswana is reported to have indications for sores, tuberculosis, redwater, uterine infection, general ailments and umbilical cord inflammation (van der Merwe et al., 2001). A. laricinus polyphenol root extract exhibited a dose dependent antimutagenic activity (Mashele et al., 2011). The anti-cancer activity of A. laricinus root extracts was sensitive against three cell lines (Mashele et al., 2010). The leaf and stem of this plant have not yet been investigated for antioxidant and antibacterial activity. Therefore in the present study, A. laricinus stem and leaf were collected to study their antibacterial activities, antioxidant activities and to investigate their active compounds in order to discover resources for new lead structures.

Materials and Methods

Plant: The plant materials were authenticated by scientists at the National Botanical Gardens in Bloemfontein South Africa (MASH002). The collected materials were dried at room temperature and pulverized by mechanical mills and weighed. It was then stored in a cool place until analysis.

Abstract

The aim of this study was to investigate antioxidant activities, antibacterial activities and a phytochemical constituent of Asparagus laricinus stem and leaf extracts. Determination of antibacterial activity of extracts was assessed by agar dilution method and antioxidant properties by 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. The minimum inhibitory concentration (MIC) of the leaf was at a concentration of 0.125 mg/mL against S. saprophyticus and E. cloacae, and at a concentration of 1 mg/mL against S. aureus and B. subtilis. There was no MIC of the stem extract at any concentration. The leaf extract showed effective free radical scavenging activity (72.1%), while stem extract had low activity. Qualitative phytochemical analysis of these plant extracts revealed the presence of tannins, saponins, flavonoids and phlobatannins. The leaf extract further confirmed the presence of glycosides, steroids, terpenoids and carbohydrates. Our results indicate that, A. laricinus leaf extracts have potential antimicrobial and antioxidant activities.

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Microorganisms: Clinical isolates of Staphylococcus aureus (ATCC29213), Staphylococcus saprophyticus (ATCC 15305), Escherichia cloacae (ATCC13047) and Bacillus subtilis (ATCC11774) were used in this study.

Antibacterial activity test (MIC determination): Antibacterial activity was assessed using the agar-dilution method as described elsewhere (Madamombe and Afolayan, 2003). Staphylococcus aureus (ATCC 29213), Staphylococcus saprophyticus (ATCC15305), Escherichia cloacae (ATCC13047) and Bacillus subtilis (ATCC11774) were cultured and maintained on nutrient broth. Different volumes of extracts (51.9; 25.9; 12.9; 6.4; 3.2 µL) were added to nutrient agar respectively, mixed to obtain different concentrations (2; 1; 0.5; 0.25; 0.125 mg/mL), and dishes were allowed to set. Using a sterile swab, microorganisms were streaked on diluted nutrient agar. Dilutions of chloramphenicol served as a positive control while broth without plant extract was used as a negative control. Plates were covered and incubated for 24 hours at 37°C. Bacterial growth was determined by visual looking at the plates and results were recorded as growth or no growth. Since the activity of the antibacterial depends frequently on its material activity was assessed using the agar-dilution method as described elsewhere (Madamombe and Afolayan, 2003).

Scavenging ability towards 2, 2- diphenyl-1-picrylhydrazyl (DPPH) radical: The (DPPH) assay was performed as described by Shirwaikar et al. (2006). 100 µL of various concentrations of each sample was added to 2 mL solution of 0.1 mM DPPH. 100 µL of methanol and 2 mL DPPH served as control. After 60 min of incubation at 25°C in the dark, the absorbance was recorded at 517 nm. The experiment was performed in triplicates. The DPPH radical scavenging activity was calculated according to the following equation:

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\% \text{ DPPH radical scavenging activity} = 1 - \frac{A_{\text{sample}}}{A_{\text{control}}} \times 100
\]

where \(A_{\text{sample}}\) and \(A_{\text{control}}\) are absorbance of sample and control respectively. The \(SC_{50}\) (concentration of sample at which 50% scavenging of DPPH radicals) values were determined. The decrease of absorbance of DPPH solution indicates an increase of the DPPH radical scavenging activity. The antioxidant activity was expressed as the number of equivalents of ascorbic acid.

Phytochemical screening of the plant extract: A small portion of the dry extract was used for the phytochemical tests for compounds which include tannins, flavonoids, alkaloids, saponins, and steroids in accordance with the methods with little modifications (Trease and Evans, 1989; Harborne, 1998). The MIC is the lowest concentration of the agent that completely inhibits visible growth, disregarding a single colony or a thin haze within the area of the inoculated spot. A. laricinus stem and leaf extracts were tested with agar-dilution assay. The stem extract of A. laricinus showed absence of susceptibility when compared with chloramphenicol (positive control) therefore all organisms grew at different extract concentration. Results showed (Table I) that only leaf extracts possess antibacterial activities with MIC of 0.125 mg/mL against S. saprophyticus and E. cloacae and 1 mg/mL against S. aureus and B. subtilis. This part of the plant can be further investigated for toxicity and may be used to develop new antibacterial medical drugs against S. aureus, S. saprophyticus, E. cloacae and B. subtilis at >1 mg/mL concentration.

Results

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The DPPH radical scavenging activity of A. laricinus stem and leaf extracts was done in comparison with that of ascorbic acid (Table II). Ascorbic acid showed a high activity with SC<50 from a concentration of 1.25 mg/mL. The radical scavenging activity of the aqueous extract of Asparagus laricinus leaf on DPPH showed high activity with SC<50 <2.5 mg/mL. The antioxidant activity of leaf extract was significantly higher than stem extract (p<0.05), and the antioxidant activity of ascorbic acid was higher than leaf and stem extracts. Values of leaf extracts were statistically similar to ascorbic acid at 2.5 mg/mL. Total phenolic content of asparagus leaf (0.572 ± 0.063 mg/GAE) showed the strong correlation with the determined antioxidant activity.
The qualitative phytochemical screening of the leaf extract revealed the presence of tannins, saponins, flavonoids, phlobatannins, glycosides, steroids, terpenoids and carbohydrates while that of the stem extract showed the presence of tannins, saponins, flavonoids and phlobatannins.

Phytochemical analysis of *A. laricinus* leaf and stem extracts demonstrated in Table III revealed the presence of tannins, saponins, flavonoids and phlobatannins. The leaf extract further confirmed the presence of glycosides, steroids, terpenoids and carbohydrates.

The total phenol content of *A. laricinus* leaf and stem extracts which were analysed at 1 mg/mL against gallic acid. Leaf extract showed more polyphenols than stem extract. The gallic acid equivalents of the estimated phenolic concentrations ranged from 0.277 ± 0.010 to 0.572 ± 0.063 mg/GAE.

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**Table I: Antibacterial activity of *Asparagus laricinus* leaf and stem**

| Bacterial species | Minimum Inhibition Concentrations (0.125 mg/mL to 2 mg/mL) | Chloramphenicol (positive control) | Water (negative control) |
|-------------------|-----------------------------------------------------------|-----------------------------------|-------------------------|
|                   | Stem | Leaf |                                 |                          |                        |
| *S. aureus*       | -    | 1 mg/mL | 0.125 mg/mL                      | -                       |
| *S. saprophyticus*| -    | 0.125 mg/mL | 0.125 mg/mL                      | -                       |
| *E. cloacae*      | -    | 0.125 mg/mL | 0.125 mg/mL                      | -                       |
| *B. subtilis*     | -    | 1 mg/mL      | 0.125 mg/mL                      | -                       |

(-) Bacteria grew

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**Table II: DPPH scavenging activity of ascorbic acid, *Asparagus laricinus* leaf and stem**

| Concentration (mg/mL) | Leaf | Stem | Ascorbic acid |
|-----------------------|------|------|---------------|
|                       | % Scavenging | Δ Absorbance @517 | % Scavenging | Δ Absorbance @517 | % Scavenging | Δ Absorbance @517 |
| 2.500                 | 72.1 | 0.209 ± 0.028 | 6.3 | 1.407 ± 0.004 | 95.3 | 0.024 ± 0.002 |
| 1.250                 | 42.3 | 0.433 ± 0.002 | 2.2 | 1.468 ± 0.016 | 89.5 | 0.053 ± 0.003 |
| 0.625                 | 16.9 | 0.623 ± 0.001 | 1.6 | 1.500 ± 0.013 | 23.1 | 0.389 ± 0.009 |
| 0.313                 | 3.9 | 0.721 ± 0.007 | 0.13 | 1.499 ± 0.014 | -12.5 | 0.569 ± 0.011 |
| 0.078                 | -7.6 | 0.807 ± 0.006 | -0.9 | 1.516 ± 0.016 | -29.8 | 0.657 ± 0.004 |

Results are represented as mean ± standard deviation, n=3

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**Table III: Phytochemical screening of *Asparagus laricinus* leaf and stem**

| Test          | Leaf | Stem | + | ++ |
|---------------|------|------|---|----|
| Glycosides    | -    | ++   |   |    |
| Steroids      | -    | ++   |   |    |
| Alkaloids     | -    | -    |   |    |
| Flavonoids    | +    | ++   |   |    |
| Saponins      | +++  | ++   |   |    |
| Tannis        | ++   | ++   |   |    |
| Phlobatannins | +    | +    |   |    |
| Terpenoids    | -    | +    |   |    |
| Carbohydrates |       |      |   |    |
| Reducing sugars | - | ++ |   |    |
| Non-reducing sugars | - | - |   |    |

* = present, - = absent

Discussion

Free radicals are highly reactive oxygen species produced through oxidative process within the mammalian body. In normal conditions, the human body possesses many defense mechanisms against oxidative stress, including antioxidant enzymes and non-enzymatic compounds but also under some circumstances including exposure to some environmental pollutants, e.g. cigarette smoke, pesticides, smog, UV radiation, etc. The natural antioxidant mammalian mechanism become insufficient and then the excess of free radicals can damage both the structure and function of a cell membrane in a chain reaction leading to many degenerative diseases (*Atta-ur-Rahman and Choudhary, 2001*). Many antioxidant based drug formulations are used for the prevention and treatment of complex diseases like atherosclerosis, stroke, diabetes, Alzheimer’s disease and cancer (*Mosquera et al., 2007*). Recently, interest has increased considerably...
Free radicals are important mediators that provoke inflammatory processes and are neutralized by antioxidants which exerts anti-inflammatory effect (Filomena et al., 2008). Free radical scavenging molecules such as flavonoids, tannins, alkaloids, quinones, amines, vitamins, and other metabolites possess anti-inflammatory, anti-carcinogenic, antibacterial and antiviral activities (Salata et al., 2002). The aqueous extracts of *A. laricinus* stem and leaf were investigated for their antioxidant properties using rapid and stable in vitro methods. Evaluation of the antioxidant activity of *A. laricinus* was done in comparison with that of ascorbic acid in Table II. Ascobic acid showed a high activity with $SC_{50}$ from a concentration of 1.25 mg/mL. The radical scavenging activity of the aqueous extract of *A. laricinus* leaf on DPPH showed high activity with $SC_{50} < 2.5$ mg/mL. The *A. laricinus* stem extracts did not show any scavenging activity even at the concentration of 2.5 mg/mL when compared to ascobic acid.

The data presented in Table I shows that only *A. laricinus* leaf totally inhibited growth of all microorganisms tested against at a concentration of 1 mg/mL. *A. laricinus* leaf extract had high antibacterial activity against *E. cloacae* and *S. saprophyticus* with the minimum inhibition concentration of <0.125 mg/mL. The stem extracts of *A. laricinus* did not inhibit the growth of any organism even at the high concentration of 2 mg/mL as compared to the growth inhibition by chloramphenicol which was used as a positive control. In these screenings, the Gram-positive bacteria were found to be more susceptible to plant extracts than the Gram-negative ones (Kelmanson et al., 2000; Massika and Afolayane 2002; Fennell et al., 2004). Indeed, Gram-positive bacteria have only an outer peptidoglycan layer which is not an effective barrier (Scherrer and Gerhardt, 1971). The Gram-negative bacteria have an outer phospholipid membrane that makes the cell wall impermeable to lipophilic solutes, while the porins constitute a selective barrier to hydrophilic solutes with an exclusion limit of about 600Da (Nikaido and Vaara, 1985). Thus this might be the reason why the Gram-positive bacteria were more inhibited by *A. laricinus* leave extracts.

Phytochemicals or secondary metabolites are chemical compounds formed during the plants normal metabolic processes and plants use them to protect themselves (Alison et al., 2001; Ning et al., 2009). Plants with antioxidants properties are used for minimizing the severity of the inflammation related diseases and a health-promoting effect of antioxidants from plants is thought to arise from their protective effects by counteracting ROS (Wong et al., 2006).

The flavonoids in these plants extracts may contribute to their effects as antibacterial and antioxidant agents. Flavonoids have anion radicals and inhibit membrane-bound enzymes (Li et al., 2003), this may explain the mechanisms of antioxidative action of *A. laricinus* leaf extract. The leaf extract was also positive for steroids which are very important compounds especially due to their relationship with compounds such as sex hormone. Both plant extracts were revealed to contain saponins, which are known to produce inhibitory effect on inflammation (Just et al., 1998) and this tend to justify the use of *A. laricinus* in traditional medicine. Tannins are found in almost every plant part: bark, wood, leaf, fruits, and roots and can be toxic to filamentous fungi, yeasts, and bacteria (Scalbert, 1991). Alkaloids were not detected in this study plant and studies on *Asparagus* species showed no evidence of alkaloids in the Asparagaceae family.

Phenols are known to be synthesized by plants in response to microbial infection (Dixon et al., 1983) it should not be surprising that they have been found in *vitro* to be effective antimicrobial substances against a wide array of microorganisms. The mechanism behind phenolic toxicity to microorganism includes enzyme inhibition by the oxidized compounds, possibly through reaction with sulphydryl groups or through more nonspecific interactions with the proteins (Mason and Wasserman, 1987). Their presence correlates with the antibacterial and antioxidant activities of the leaf extract. These observations support the usefulness of this plant in folklore remedies in the treatment of stress-related ailments.

In conclusion, the leaf extracts of the *A. laricinus* exhibited a significant free radical scavenging effect of DPPH in a concentration dependent manner and antibacterial activity at the minimum inhibition concentration of <1 mg/mL.

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