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Antioxidant properties, phenolic composition, bioactive compounds and nutritive value of medicinal halophytes commonly used as herbal teas

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ABSTRACT

Halophytes, distributed from coastal regions to inland deserts have traditionally been used for medicinal and nutritional purposes. Living in sub-optimal conditions, these plants synthesize stress associated bioactive molecules, which are still remain largely unexplored. In search of natural antioxidant sources, antioxidant capacity (AC) and total phenolic content (TPC) of 100 medicinal plants (halophytes vs non-halophytes), commonly used as herbal teas, were investigated. Nutrients and phytochemical composition, especially phenolic metabolites in selected medicinal plants with higher AC were also determined. Most of the medicinal plants analysed for the first time showed considerable AC. In general, halophytes displayed higher AC and TPC than non-halophytes. High correlation indicated a major contribution of TPC in AC of these plants. Five medicinal halophytes i.e., *Thespesia populneoides*, *Salvadora persica*, *Ipomoea pes-caprae*, *Suaeda fruticosa*, and *Pluchea lanceolata* displayed significantly higher AC than synthetic antioxidants (BHT and BHA). Presence of bioactive phytochemicals including phenols (42.3–63.9 mg GAE g^{-1}), flavonoids (12.3–37.1 mg QE g^{-1}), tannins (8.7–20 mg TAE g^{-1}), proanthocyanidins (15.8–22.4 mg CE g^{-1}), carotenoids (0.07–0.84 mg g^{-1}), alkaloids (0.64–1.1 mg g^{-1}), and saponins (11.2–28.4 mg DAE g^{-1}) reflected therapeutic benefits of these plants. HPLC analyses showed that the hydrolysed extracts contained chlorogenic acid, gallic acid, catechin, and quercetin as abundant phenolic metabolites which may be responsible for higher AC. These plants were also found to contain suitable amounts of proteins (8.5–17%), carbohydrates (2.6–11.4%), fibre (31.6–41.2%), and minerals (2.1–9.7%) showing their nutritional potential that has already been exploited by rural communities. The present study highlights the potential of medicinal halophytes as a source of natural antioxidants, valuable phytochemicals, and essential nutrients for pharmaceutical, nutraceutical, and chemical industries.

1. Introduction

Reactive oxygen species (ROS), produced during aerobic metabolism, are essential mediators of important functions (Salganik, 2001). However, over-production of ROS results in oxidative damage of macro-molecules. Studies have demonstrated the involvement of ROS in a number of disorders including Alzheimer, atherosclerosis, diabetes, inflammation, and neurodegenerative and cardiovascular diseases. ROS also plays a key role in certain types of cancers and the ageing process. Antioxidants are molecules that neutralize harmful ROS by inhibiting oxidative chain reaction, preventing lipid peroxidation, reducing free radical concentration and chelating metal ions (Zhou and Yu, 2004). It has been recognized that consumption of vegetables and fruits reduce the risk of degenerative diseases, which may be ascribed to their antioxidant compounds (Oueslati et al., 2012). In addition, some commercial antioxidants i.e. butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA), which have been widely used in pharmaceuticals and food industry are found to be toxic (Sasaki et al., 2002). The impact of oxidative stress on human health and increasing safety concerns about synthetic antioxidants, shift the focus of the scientific community to search for new sources of safe and feasible natural antioxidants. Vegetables, cereals, fruits, and mushrooms have been screened worldwide; however, medicinal plants are more potent source of natural antioxidants (Cai et al., 2004; Li et al., 2008, 2013; Albouchi et al., 2013; Baba et al., 2015).

Medicinal plants have long been used to treat infections and other human ailments. Medicinal plants share a common origin with edible plants thus it is difficult to separate medicinal plants from foods. For instance, a number of medicinal plants have been used as vegetables or salads and also for colouring, flavouring or spicing agents (Qasim et al., 2011, 2014). In this capacity, medicinal plants can provide basic nutrients and essential minerals. Studies have demonstrated a suitable composition of protein, carbohydrate, fat, fibre and minerals in some medicinal plants, comparable to or even better than common edible plants (Hussain et al., 2010). Beside nutritional importance, health benefits of medicinal plants are associated with their secondary

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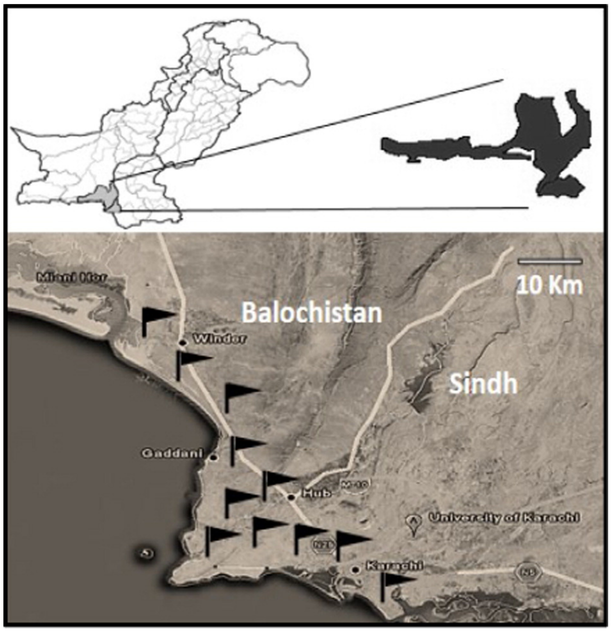

Fig. 1. Map of study area showing site of plant collection from coastal habitats (dark flags).

metabolites (Ksouri et al., 2007, 2008, 2012; Falleh et al., 2013). Medicinal plants contained a variety of secondary metabolites (e.g. phenols, flavonoids, tannins, proanthocyanidins, carotenoids, alkaloids, saponins, etc.) with a broad range of biological and pharmacological properties. Herbal remedies, usually prepared in the form of decoctions, infusions, and tonics, are commonly known as herbal teas (Qasim et al., 2011, 2014). The therapeutic effects of medicinal plants and herbal teas are associated with their antioxidant potentials (Cai et al., 2004; Li et al., 2013). Phenolic compounds were found as major contributors towards antioxidant capacity (AC) of these plants (Li et al., 2008). Interestingly, the synthesis and accumulation of polyphenols and other antioxidant metabolites are enhanced when the plant undergoes biotic/abiotic stress e.g. salinity (Navarro et al., 2006; Meot-Duros et al., 2008). Therefore it is important to characterize salt stressed plants (halophytes) for their antioxidant (Meot-Duros et al., 2008; Lee et al., 2011) and other health related effects (Trabelsi et al., 2010; Oueslati et al., 2012). Some reports are available showing halophytes as sources of polyphenolic antioxidants and other secondary metabolites of high medicinal value (e.g. Ksouri et al., 2007, 2012; Mariem et al., 2014; Stankovic et al., 2015), little is known about the phytochemical constituents and biological potential of these plants. Considering the growing demand for natural products, there is a need to search new candidates among halophytes that can serve as a safe, sustainable and eco-friendly source of natural antioxidants and other bioactive compounds.

A number of coastal plants which has been used in the form of herbal tea against a range of disease conditions was reported earlier (Qasim et al., 2010, 2011, 2014). These plants thrive in harsh environments, especially hyper saline conditions which demand various adaptive mechanisms, for example redox homeostasis. Plants maintain equilibrium between ROS generation and energy consumption in enzymatic and non-enzymatic antioxidant defence to prevent cells from oxidative damage (Noctor and Foyer, 1998; Apel and Hirt, 2004). Therefore, halophytes are expected to produce bioactive compounds with high AC and hence could be better candidates for focus. The present study aimed to determine the AC and polyphenolic content of 100 medicinal plants from coastal areas of Pakistan. Nutrient, bioactive compound and phenolic metabolite contents were also determined in selected species (i.e., *Thespesia populneoides*, *Salvadora persica*, *Ipomoea pes-caprae*, *Suaeda fruticosa*, and *Pluchea lanceolata*) showing high AC. A relationship between AC and salt resistance of medicinal plants was also determined.

2. Materials and methods

2.1. Sample collection and preparation

Medicinal plants were collected from coastal areas of Sindh and Balochistan province of Pakistan (Fig. 1). The study area represents an arid to semi-arid climate with low annual rainfall (<250 mm) and high temperature (~30 °C; Fig. 2). Jafri (1966) and Ali and Qaiser (1995–2015) were used for initial identification of plants, which were further confirmed by Dr. Jahan Alam (Senior Taxonomist), Centre for Plant Conservation (CPC), University of Karachi. Voucher specimens were also deposited in the CPC for later access. At least five replicated samples per plant species were collected and dried under shade. Leaves of medicinal plants were separated and ground to fine powder using a ball mill (Retsch MM-400). Ground material (1.0 g) was extracted in 20 mL of 80% methanol using a shaking water bath (GFL-1092) at 40 °C for 3 h. After extraction, samples were centrifuged at 4000 rpm and the supernatant was recovered for further analyses (Abideen et al., 2015; Qasim et al., 2016).

2.2. List of chemicals used

2,2′-azino-bis3-ethylbenzothiazoline-6-sulphonic acid (ABTS) radical cation (PubChem CID: 90658258); Butylated hydroxytoluene (BHT; PubChem CID: 31404); Butylated hydroxyanisole (BHA; PubChem CID: 8456); Caffeic acid (PubChem CID: 689043), Catechin (PubChem CID: 107957), Chlorogenic acid (PubChem CID: 1794427), Coumarin (PubChem CID: Coumarin), 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) free radical (PubChem CID: 2735032); Ferulic acid (PubChem

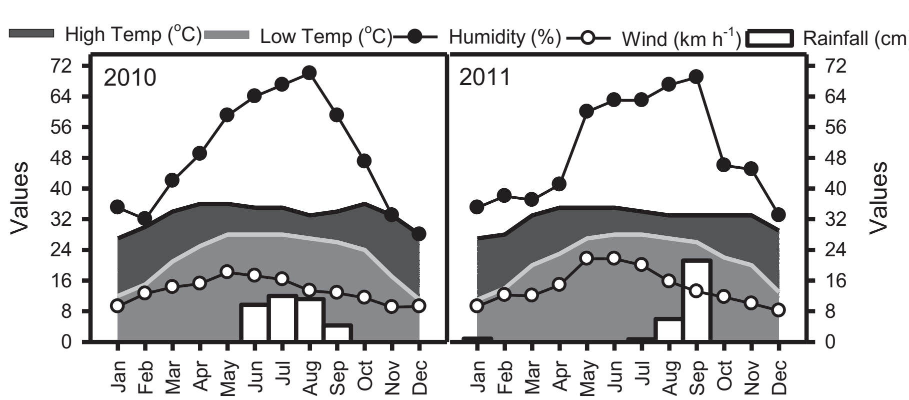

Fig. 2. Two years (2010 and 2011) data of study area comprising mean annual temperature, rainfall, wind velocity and humidity (Pakistan meteorological department).

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