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Studies on the dual antioxidant and antibacterial properties of parsley (*Petroselinum crispum*) and cilantro (*Coriandrum sativum*) extracts

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Abstract

Antioxidant and antibacterial activities of freeze-dried and irradiated parsley (*Petroselinum crispum*) and cilantro (*Coriandrum sativum*) leaves and stems were determined on methanol and water extracts. The total phenolic content was quantified with the Folin–Ciocalteau reagent. Several mechanisms of potential antioxidant activity of all extracts, including determining relative free radical-scavenging and ferrous ion-chelating activities, as well as reducing power, were examined. Assessment of the total antioxidant activity of all extracts was done using an iron-induced linoleic acid oxidation model system. Antimicrobial activity towards *Bacillus subtilis* and *Escherichia coli* by different extracts was assessed by determining cell damage. Total phenolic content varied between parsley and cilantro, leaf and stem, as well as methanol and water extracts. Methanol-derived leaf extracts exhibited significantly ($p < 0.05$) greater radical-scavenging activity towards both lipid- and water-soluble radicals, which was attributed to the total phenolic content. Ferrous ion-chelating activity was significantly ($p < 0.05$) greater in the stem methanol extracts, and corresponded to antioxidant activity. Prooxidant activity was a feature of all aqueous extracts and corresponded to the reducing activity of both leaf and stem parts of parsley and cilantro. Bacterial cell damage, resulting in significant ($p < 0.05$) greater growth inhibition of *B. subtilis* and *E. coli*, corresponded to ferrous sequestering activity of methanol-derived stem extracts.

Keywords: Parsley; Cilantro; Leaf; Stem; Phenolics; Antioxidant; Antimicrobial properties

1. Introduction

Culinary herbs have a long history of use as important constituents that can reduce food spoilage and control against the growth of food-borne pathogens. Notwithstanding this, many herbs also contribute to the enhancement of flavour in both foods and beverages. Parsley (*Petroselinum crispum*) and cilantro (*Coriandrum sativum*) are two culinary herbs commonly used to flavour the cuisines of China, Mexico, South America, India and South East Asia. In addition, culinary herbal extracts and essential oils have become increasingly popular as alternative sources of natural preservative agents, largely because herbs are widely cultivated, effective and safe for consumption.

Lipid oxidation is a major cause of food quality deterioration. Many culinary herbs (e.g., rosemary, sage and thyme) have been shown to function as natural antioxidants (Jaswir, Che Man, & Kitts, 2000). Components of fresh parsley leaf scavenge superoxide anion in vitro (Campanella, Bonanni, Favero, & Tomassetti, 2003), and methanol extracts of parsley scavenge hydroxyl radical in addition to protecting against ascorbic acid-induced membrane oxidation (Fejes et al., 2000). Supplementation of diets with fresh parsley leaf can

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increase antioxidant capacity of rat plasma (Hempel et al., 1999) and decrease oxidative stress in humans (Nielsen et al., 1999). Similarly, aqueous and ethanol extracts of fresh cilantro leaf strongly inhibit linoleic acid oxidation in an emulsion (Kaur & Kapoor, 2002), whereas essential oil obtained from fresh cilantro leaf inhibits lipid oxidation in both model emulsion and bulk sunflower oil systems (Stashenko, Puertas, & Martinez, 2002).

Many culinary spices (e.g., garlic, onion, cinnamon, clove, and mustard) have also effectively been used to inhibit microbial spoilage in foods. Fresh and dried parsley inhibit the growth of *Listeria monocytogenes*, *L. innocua*, *Escherichia coli* O157:H7, *E. coli* Bs-1 and *E. carotovora* (Manderfield, Schafer, Davidson, & Zottola, 1997). Furthermore, ethanol-derived extracts of dried parsley can reduced viable populations of both *Lactobacillus plantarum* and *Leuconostoc mesenteroides* in culture media (Kim, Kim, Lee, Lee, & Kim, 1998), and *L. monocytogenes.*, *E. coli* O157:H7 and *Micrococcus luteus* in a model food system (Ulate-Rodriguez, Schafer, Zottola, & Davidson, 1997). Other studies have shown the effectiveness of aqueous and ethanol extracts of fresh cilantro leaf in inhibiting growth of *Bacillus subtilis*, *Staphylococcus aureus*, *E. coli*, *Salmonella typhimurium*, *L. plantarum*, *L. mesenteriodes* and *Pseudomonas fluorescens* (Kim, Kang, & Choi, 2001). The essential oil prepared from fresh cilantro leaf has growth inhibition properties towards numerous Gram-positive and Gram-negative bacteria in both culture media and model food systems (Chao, Young, & Oberg, 2001; Delaquis, Stanich, Girard, & Mazza, 2002; Kizil & Sogut, 2003; Minija & Thoppil, 2001) and can reduce the viable population of these organisms (Elgayyar, Draughon, Golden, & Mount, 2001; Gill, Delaquis, Russo, & Holley, 2002).

Plant derived phytochemical preparations with dual functionalities in preventing lipid oxidation and microbial spoilage have tremendous potential for extending shelf-life of food products with minimal use of synthetic preservative agents. Flavouring agents, food-grade phosphates and lactates have long been known to possess dual functions in foods (Jay & Rivers, 1984; Raccach, 1984). In addition, Raccach (1984) highlighted the antimicrobial activity of synthetic phenolic antioxidants such as butylated hydroxylanisole (BHA), butylated hydroxytoluene (BHT), monotertiary butylhydroquinone (TBHQ) and propyl gallate (PG). Garrote, Cruz, Moure, Dominguez, and Parajo (2004) described the antimicrobial activity of natural phenolic antioxidants, such as caffeic acid, *p*-coumaric acid, chlorogenic acid and ferulic acid. Other workers have investigated the dual functions of plant extracts which maintain food quality and safety [e.g., plant extracts from potato peel (Rodriguez de Sotillo, Hadley, & Wolf-Hall, 1998), sage (Yildirim et al., 2000), anise seed (Gulcin, Oktay, Kirecci, & Kufrevioglu, 2003), black cumin (Shah & Ray, 2003), edible plants of *Rumex crispus* L. (Yildirim, Mavi, & Kara, 2001), *Polygonum cognatum* (Yildirim, Mavi, & Kara, 2003), *Thymus eigii* (Tepe, Daferera, Sokmen, Polissiou, & Sokmen, 2004a), *Thymus pectinatus* (Vardar-Unlu et al., 2003), *Salvia cryptantha* and *Salvia multicaulis* (Tepe et al., 2004b), and *Satureja hortensis* L. (Gulcin et al., 2003)]. Essential oils from cinnamon, basil, lemon, lemongrass, marjoram, or rosemary (Baratta et al., 1998), shallot, scallion (Yin, Hsu, & Chang, 2003), and lemon balm (Mimica-Dukic, Bozin, Sokovic, & Simin, 2004) have also been shown to have both antioxidant and antimicrobial activities.

More information is needed on the dual antioxidant and antimicrobial activities of phytochemical extracts derived from common culinary herbs, such as parsley and cilantro, and the influence of plant part and extraction methods used to recover bioactive phytochemicals (Ahn, Lee, & Yeom, 2000; Kaur & Kapoor, 2002; Kim et al., 2001; Melo, Mancini, Guerra, & Maciel, 2003). The objectives of this study were to identify and characterize antioxidant and antibacterial activity in both parsley and cilantro leaves and stems extracted by methanol and water solvents.

2. Materials and methods

All reagent grade chemicals and HPLC grade solvents were purchased from Sigma Aldrich (St. Louis, MO) and Fisher Scientific (Toronto, ON). Only distilled deionized water was used. Bacterial cultures of *B. subtilis* (ATCC 10774) and *E. coli* (ATCC 25922) were obtained from American Type Culture Collection (Manassas, VA). Fresh parsley (*P. crispum*) and cilantro (*C. sativum*) were purchased from a local market (Vancouver, BC).

2.1. Sample preparation

Fresh parsley and cilantro were thoroughly washed and air-dried. Senescence leaves were removed, and the leaf and stem of each herb were separated. Whole leaf and stem of the herbs were freeze-dried, vacuum-packaged and irradiated at 10 kGy with an electron beam generated from a linear electron accelerator (Iotron Technologies; Port Coquitlam, BC). Freeze-dried and irradiated leaf and stem of parsley and cilantro were stored at ambient temperature prior to experimentation.

2.2. Herbal extracts

2.2.1. Methanol extract

The leaf and stems of each herb were coarsely ground in a coffee grinder and then extracted with absolute methanol, in a 1:10 (w/v) ratio of herb to solvent, for