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Composition and properties of the polyphenolic extracts obtained from industrial plum pomaces

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ABSTRACT

The polyphenol composition of purified extracts obtained from plum pomace gathered from production lines of a modern fruit transformation plant was characterized. The extraction of polyphenols from pomaces was performed using water. These water extracts were purified on an Amberlite polymer bed and freeze-dried. The resulting preparations were characterized by high polyphenol contents (up to 50 g/100 g) determined using spectrophotometric method with Folin–Ciocalteu reagent. The selected plum preparations were characterized by high flavanol contents (up to 10 g/100 g) and high antioxidant capacities. Additionally, significant amounts of hydroxycinnamic acids and flavonols were detected in the plum preparations. The bacteriostatic effects of the extracts were observed against *Salmonella*, *Listeria* and *E. coli* O157:H7. Two of the extracts had high bactericidal effects against *Listeria*. This research showed that plum pomaces are a good raw material for the production of highly-concentrated polyphenol preparations with potential biological properties.

1. Introduction

A considerable volume of published research indicates that increased consumption of fruits and their polyphenols is beneficial to human health (Lee, Kang, & Cho, 2007). Stone fruits, including plums, are polyphenol-rich. Plums are grown all over the world. According to FAO (2012), the yearly production of plum over the last 10 years surpassed 9 million tons. Plum fruits are desired products in many markets, including Europe, for their taste, nutritional value and as a raw-material for many products, such as juices, fruit drinks, alcoholic drinks, jams, and dried fruits (Hooshmand & Arjmandi, 2009; Satora & Tuszyński, 2010; Tarhan, 2007; Will & Dietrich, 2006). Plums are characterized by a high concentration of phenolic compounds ranging from 138 mg/100 g to 684 mg/100 g, depending on the cultivar (Cevallos-Casals, Byrne, Okie, & Cisneros-Zevallos, 2006; Chun, Kim, Moon, Kang, & Lee, 2003; Kim, Jeong, & Lee, 2003).

The most important phenolic compounds in plums are hydroxycinnamic acids, mainly four isomers of caffeoylquinic acid, where neochlorogenic acid is predominant. In addition to caffeoylquinic acids, significant amounts of *p*-coumaroylquinic acids are present. In addition to the

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presence of anthocyanins, flavonol glycosides, such as quercetin, flavanols and procyanidins, were detected (Nunes et al., 2008; Slimestad, Vangdal, & Brede, 2009). According to numerous reports, these substances are characterized by beneficial health properties, such as cancer prevention (Kim, Yu, & Lee, 2008; Nandakumar, Singh, & Katiyar, 2008), including breast cancer (Noratto, Porter, Byrne, & Cisneros-Zevallos, 2009). Moreover, they are able to prevent heart diseases, digestive system illnesses and osteoporosis (Franklin et al., 2006; Hooshmand & Arjmandi, 2009). Another interesting issue is the potential technological uses of plums, e.g., the possibility of applying fruits or plum products as meat additives for preventing lipid oxidation (Nunez de Gonzalez et al., 2008, 2009).

Press cake residue (pomace) is a by-product of the industrial transformation of fruit to juice. The amount of pomace depends on the type of transformed fruits and technological conditions (grinding size, enzyme treatment and pressing conditions), and may reach up to 25% of the transformed raw material (Buchert et al., 2005; Fronc & Nawirska, 1994). The potential uses of pomace are composting or use as a fuel (Schaub & Leonard, 1996). The use of pomace as an animal food component (Joshi & Sandhu, 1996), dietary supplements as fiber preparations (Larrauri, 1999), and as anthocyanins extracts (Kapasakalidis, Rastall, & Gordon, 2006; Landbo & Meyer, 2001) are alternative pomace uses. Plum pomace is a less recognized raw material, and there are few literature references on its polyphenol composition and properties.

Several works have demonstrated the antimicrobial activity of flavonoids extracted from bergamot (Mandalari et al., 2007), *Garcinia* spp. (Negi, Jayaprakasha, & Jena, 2008), pome fruits including apples, pears, quinces (Alberto, Canavosio, & Manca de Nadra, 2006; Fattouch et al., 2007, 2008), and grapes (Baydar, Özkan, & Sağdiç, 2004), among others. Polyphenols extracted from plants and fruits could be an alternative to chemical disinfectants and preservatives as consumers demand for more natural and fresh foods with fewer synthetic additives but increased safety and longer shelf life (Negi et al., 2008). Currently, chlorine in the form of sodium hypochlorite is commonly used as a disinfectant in agro-food industries, which is also used to wash fresh and fresh-cut fruits and vegetables. Nevertheless, concerns about its limited efficacy and the toxicity of chlorination by-products formed in the presence of organic matters have prompted the search for alternative, safer, more effective and environmentally friendly sanitation agents. Concerning microbial preservatives, traditional antimicrobials, such as acetic, benzoic, lactic, propionic and sorbic acids, nitrites, sulphites, have been used for many years to control the growth of microorganisms in food (Sofos, Beuchat, Davidson, & Johnson, 1998).

The aim of the work was to obtain concentrated polyphenol preparations from industrial plum pomaces using a low-pressure chromatography method with solvents applicable in food production. The resulting preparations were qualitatively and quantitatively characterized, and their antioxidant activities measured. Moreover, with the aim of replacing chemical disinfectants in agro-food industry processes, the bactericidal effects of the polyphenol extracts were determined against the foodborne pathogens *Salmonella*, *Listeria* and *E. coli* O157:H7.

2. Material and methods

2.1. Chemicals

Ultrapure water (Millipore System, GmbH, Vienna, Austria) and HPLC gradient-grade methanol (J.T. Baker, Deventer, Holland) were used to prepare all of the solutions. HPLC gradient-grade acetonitrile and formic acid were purchased from J.T. Baker (Deventer, Holland). Cyanidin-3-*O*-glucoside, cyanidin-3-*O*-rutinoside, peonidin-3-*O*-glucoside, quercetin-3-*O*-rutinoside, quercetin-3-*O*-galactoside, quercetin-3-*O*-glucoside, kaempferol-3-*O*-rutinoside, kaempferol-3-*O*-glucoside, isorhamnetin-3-*O*-rutinoside, isorhamnetin-3-*O*-glucoside, quercetin, kaempferol, isorhamnetin from Extrasynthese (Genay, France) and (+)-catechin, (–)-epicatechin, chlorogenic acid from Sigma-Aldrich Chemie GmBH (Steinheim, Germany) were used as standards for MS spectral comparisons. Trolox (6-hydroxy-2,5,7,8-tetramethychroman-2-carboxylic acid) and DPPH (2,2-diphenyl-1-picrylhydrazyl) radicals to determine antioxidant activities were purchased from Sigma-Aldrich Chemie GmbH (Steinheim, Germany).

2.2. Plant material

Stoned pomaces of plums were the material for the research. The pomaces were collected in September 2009 from Alpex (Łęczeszyce, Poland), a modern fruit processing company. Ten tons of plums of various dark blue cultivars (Najbolia, Dabrowicka, Promis) were used to produce juice on a belt press. Detailed data on the technological conditions of the plum pressing are not given because they are confidential to the company. A representative sample of the obtained pomace was submitted for analysis in a laboratory.

One kilogram of the pomace was freeze-dried and 3 kg of fresh pomace was extracted with water to obtain raw polyphenol extracts and post-extraction pomace after drying. The raw extracts were then purified on a polymer bed (Amberlite XAD-7HP) resulting in three types of purified extracts, which differed in polyphenol contents.

For the determination of the phenolics in the starting material, 50 g of a representative sample of fresh plum pomace was ground with liquid nitrogen in an IKA A11 (IKA-Analytical Mill, Staufen, Germany) laboratory mill. The analytical sample (2 g) was then extracted, as described in our previous work (Sójka & Król, 2009).

2.3. Preparation of plum extracts

Fresh plum pomaces (3 kg) were subjected to water extraction in three steps at temperatures of 70–75 °C for 30 min. In the first step, the weight ratio of fresh pomace to water was 1:4 (w/v), while in second and third extraction steps, the volume of the water was equal to the volume of the extracts from the previous extraction step. The first and second extracts were collected by soaking on filtration cloth, while the third extract was pressed on a laboratory hand screw press (homemade, Lodz University of Technology, Poland) after soaking the pomace. All three extracts were combined and filtered on cellulose sheet Hobrafilt S40 N – 5 μm nominal retention, 3.6-mm thickness