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Evaluation of phytochemicals, antioxidant capacity, and antidiabetic activity of novel smoothies from selected *Prunus* fruits

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ABSTRACT

The aim of this study was to screen the *Prunus* smoothies for their polyphenols profile and determine the correlation between the polyphenols, and antioxidant capacity, α-glucosidase, and α-amylase inhibitory effect. A total of 22 polyphenolic compounds were assessed in the *Prunus*-smoothies (LC–MS QTof), which the content (UPLC–PDA–FL) in sour cherry juice was 726 mg/100 g, while in purees it was 429 mg (peaches), 606 mg (apricots), and 697 mg (plums) in 100 g. Therefore, the smoothies were significantly different, and the main factor determining the chemical composition of final products was quantitative addition of each semi-products (sour cherry juice, peaches puree, apricots puree, or plums puree). The obtained results showed that the anthocyanins and flavonols have the greatest impact on the antioxidant capacity and anti-α-glucosidase activity, while the flavan-3-ols may be responsible for α-amylase inhibition.

The study showed that the *Prunus* smoothies may be important natural sources of polyphenolic antioxidants with a high potential for controlling early stages of postprandial hyperglycaemia.

1. Introduction

Increasingly diabetes is claimed to be an epidemic of the 21st century. According to current data of the World Health Organization (WHO), ca. 250 millions of patients are suffering from this disease globally, 2 millions of whom are Polish people. Prognoses are even more terrifying, as within the next 25 years the number of diabetic patients is estimated to double. The development of diabetes is accompanied by many changes occurring in the human body that are associated, among other things, with increased oxidative stress, a large increase in blood concentration of glucose, metabolic disorders, or the appearance of disease symptoms both in large (macroangiopathies) and small (microangiopathies) blood vessels (Peng et al., 2011). In over 80% of cases, the development of diabetes is due to environmental factors. Therefore, one of the key elements in the prevention of diabetes is a well-balanced diet, and thus maintenance of the proper body mass. It seems advisable, therefore, to significantly increase the proportion of dietary fruits and vegetables, because they contain many components, including polyphenols, vitamins, minerals, and pectins, which not only stimulate insulin secretion and successfully reduce the blood level of glucose, but also inhibit carbohydrate absorption in the small intestine (Rafighi, Shiva, Arab, & Yusuf, 2013; Yavuz et al., 2012).

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Fruits may be used, as whole or as raw material, to prepare specified new products with health-promoting properties. Therefore, in recent years there has been an intensive development of the fruit and vegetable industry, with attempts to design new, attractive products, compatible with the latest trends of healthy nutrition. In this way, the consumer has permanent access to fruit and vegetable products, despite their seasonality and thus can eat healthy food all year around (Andres, Villanueva, & Tenorio, 2016). Consumers especially liked liquid and semi-liquid product and the ready to drink products. Therefore, one can observe increased interest in these beverages. One such product is smoothies, blended beverages with typical semi-liquid, smooth consistency. Smoothies might be considered as typical examples of the so-called superfoods, which are defined as a natural food regarded as especially beneficial, because of its nutrient profile or its health-protecting qualities, which are created by fruit components (Medina, 2011). In the production of such products different types of fruit may be used, but *Prunus* fruits appear to be of particular interest.

The *Prunus* fruits include the plum, peach, apricot, nectarine, and sour and sweet cherries. All of them are stone fruits, commonly cultivated around the world. Their pulps are suitable for direct consumption, but also provide excellent processing material. Each of them has its own unique flavour, so they are commonly used for the production of jams, marmalades, purees or dried fruit. These fruits are also characterized by also an interesting chemical composition, i.e. high content of polyphenols, vitamins, minerals, and pectin. Therefore their consumption protects not only against diabetes itself and its consequences, but also against inflammatory states, neoplasms, obesity or cardiovascular diseases (Michalska, Wojdyło, Lech, Łysiak, & Figiel, 2016; Tomas-Barberan et al., 2001; Wojdyło, Nowicka, Laskowski, & Oszmiański, 2014).

Therefore, it seems necessary to disseminate knowledge on the benefits of consumption of fruits consumption, and their products in the population and to continue scientific research on the feasibility of exploiting their health potential in the effective eradication of civilization diseases in the future. So, the objective of this study was to screen the *Prunus* smoothies for their polyphenols profile and determine the correlation of the polyphenol content to antioxidant capacity, and the α-glucosidase, and α-amylase inhibitory effect.

2. Materials and methods

2.1. Chemicals

The acetic acid, Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), 2,2′-azinobis-(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS), 2,2′-azobis (2-amidino-propane) dihydrochloride (AAPH), fluorescein disodium (FL), potassium persulfate, TPTZ (2,4,6-tripyridyl-1,3,5-triazine), $FeCl_3$, phloroglucinol, 3,5-dinitrosalicylic acid, potassium sodium tartrate tetrahydrate, sodium phosphate monobasic, starch from potato, α-amylase from porcine pancreas (type VI-8), dipotassium hydrogen orthophosphate dihydrogen, *p*-nitrophenyl-α-D-glucopyranoside, α-glucosidase from *Saccharomyces cerevisiae* (type I), fructose, sorbitol, glucose, sucrose and methanol were purchased from Sigma-Aldrich (Steinheim, Germany). Quercetin and keampferol-3-*O*-glucoside, cyanidin-3-*O*-rutinoside, -3-*O*-glucoside, -3-*O*-sophoroside, peonidin-3-*O*-rutinoside, *p*-coumaric acid, (+)-catechin, and (–)-epicatechin, procyanidin B1 and B2 were purchased from Extrasynthese (Lyon Nord, France). Chlorogenic, neochlorogenic and cryptochlorogenic acids were supplied by TRANS MIT GmbH (Giessen, Germany). Acetonitrile for ultra-pressure liquid chromatography (UPLC, gradient grade) and ascorbic acid were from Merck (Darmstadt, Germany). UPLC grade water, prepared by HLP SMART 1000s system (Hydrolab, Gdańsk, Poland), was additionally filtrated through a 0.20 µm membrane filter (Millex Samplicity® Filters Membrane) immediately before use.

2.2. Plant material

Fruit of sour cherry (*Prunus cerasus* L.) cv. 'Łutówka', peach (*Prunus persica* (L.) Batsch) cv. 'Hardow Beauty', apricot (*Prunus armeniaca* L.) cv. 'Miodowa', and plum fruit (*Prunus* L.) cv. 'Promis' harvested at the Research Station for Cultivar Testing in Zybiszów about 10 km from Wrocław (Poland).

2.3. Smoothie production

The *Prunus*-fruit smoothies production process included 3 main technology steps:

(i) *Sour cherry juice production*. The sour cherries were ground in a Thermomix, and then the pulps were pressed on a hydraulic press (pilot plant laminar press; 15 tons of pressure) to obtain juice.
(ii) *Processing of plums, peaches, and apricots puree*. The pitted plum, peach, and apricot fruit were ground and heated at 80 °C in a Thermomix device (Vorwerk, Wuppertal, Germany) and mashed in a blender (Symbio, Zelmer, Rzeszów, Poland) to obtain puree. After that puree was cooled and used to produce smoothies.
(iii) *Mixing semi-finished products*. Sour cherry juice and puree samples were mixed in the appropriate proportions (w/w): 80/20, 50/50 and 20/80, respectively. Then, the products were heated to 100 °C and put into glass jars, pasteurized (10 min at 90 °C), and cooled to 20 °C.

Finally, thirteen different products were obtained, as is presented in Table 1, which were analysed immediately after processing.

2.4. Identification and quantification of polyphenols by LC-PDA-MS method

The solvent for identification (LC/MS QTof) and quantitative (UPLC-PDA-FL) analysis of polyphenols (anthocyanin, flavan-3-ol, flavonol, and phenolic acid) were performed as described previously by Wojdyło et al. (2014). The results were expressed as mg per 100 g of product.

2.5. Analysis of polymeric procyanidins by phloroglucinolysis method

The analysis of polymeric procyanidins by phloroglucinol method was performed according to the protocol described