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# Sensory attributes and changes of physicochemical properties during storage of smoothies prepared from selected fruit

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ABSTRACT

This study investigated the changes during storage of smoothies obtained by mixing sour cherry puree with apple, pear, quince and flowering quince juices. Phenolic compounds, antioxidant activity (ORAC, ABTS, FRAP) and physical parameters (viscosity and colour) of 17 different products (12 smoothies and 5 semi-products) before and after storage during 6 months at 4 °C and 30 °C were studied. In addition, sensory attributes (colour, consistency, aroma and taste) were analysed. The content of polyphenols determined by UPLC-PDA-FL ranged from 517.75 mg of sour cherry/flowering quince smoothie to 333.36 mg/100 g of sour cherry/pear smoothie. After 6 months of storage, protective effects of flowering quince juice and quince juice addition on the polyphenol content, especially on polymeric procyanidins, were observed, and these were positively correlated with antioxidant activity. Apart from the high content of polyphenols and antioxidant activity, the obtained smoothies were attractive to consumers, especially those with addition of apple and quince juices.



## 1. Introduction

The relationship between nutritional as well as non-nutritional food components and human health has initiated a trend of healthy eating and changes in the food industry (Barrett & Lloyd, 2012; Layman, 2014). The consumer started to choose products that are appropriate in terms not only of sensory properties (taste, smell, appearance), but also of nutritional attributes (content of polyphenols, vitamins, minerals) (Falguera, Aliguer, & Falguera, 2012). In response, the food industry began to design new products – healthy, safe, and attractive in sensory terms – in order to fulfil customer needs (Andres, Villanueva, & Tenorio, 2016). Reflecting this trend, recently there was observed increased interest in ready-to-drink beverages. One of them is smoothies, blended beverages containing fruit, fruit juice, yoghurt, milk or honey. They have a typical semi-liquid, smooth consistency and are prepared by mixing, in appropriate proportions, different ingredients (Cagno, Minervini, Rizzello, Angelis, & Gobbetti, 2011; Keenan et al., 2012; Teleszko & Wojdyło, 2014). Smoothies can be considered as typical examples of the so-called superfoods, which are defined as natural foods regarded as especially beneficial because of their nutrient profile or health-protecting qualities, which are created by fruit components (Medina, 2011). Scientific reports have confirmed an advantageous association between the consumption of fruit and prevention and treatment of obesity, diabetes and cardiovascular disease (Valenzuela, Sanhueza, & Nieto, 2003). Fruit are characterized by a high content of polyphenols and antioxidant activity: chokeberry, flowering quince, sour cherry, quince protect against cell damage by free radicals (Kujawska, Ignatowicz, Ewertowska, Oszmiański, & Jodynis-Liebert, 2011; Tarko et al., 2014; Wojdyło, Nowicka, Laskowski, & Oszmiański, 2014b; Wojdyło, Oszmiański, & Bielicki, 2013). Furthermore, they stimulate insulin secretion and reduce blood pressure, serum cholesterol and triglycerides. The consumption of pectin-rich fruit, such as pears and apples, evokes a low glycaemic response, which determines the ability of the carbohydrates to the raise of blood glucose in the human body (Barrett & Lloyd, 2012; Layman, 2014; Medina, 2011; Valenzuela et al., 2003).

However, from the point of view of the consumers and also the producers, physicochemical and pro-health properties of the final product immediately after processing are just as important as its stability during storage. There is a risk that traditional thermal

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preservation and external factors during storage may lead to loss of nutritionally beneficial components, and consequently a decrease of the final attractiveness (Keenan et al., 2012; Nunes et al., 2016).

Therefore, the aim of this study was to determine the physicochemical properties (viscosity, colour, polyphenol contents, antioxidant activity) and sensory attributes of smoothie products after processing and also after a 6-month storage period at 4 °C and 30 °C. The smoothies were obtained by mixing sour cherry puree and different fruit juices (apple, pear, quince, flowering quince) in appropriate proportions (20/80, 50/50 and 80/20) to obtain twelve varieties of smoothies.

## 2. Materials and methods

### 2.1. Chemicals

Quercetin and keampferol-3-*O*-glucoside, cyanidin-3-*O*-rutinoside, -3-*O*-glucoside, -3-*O*-sophoroside, peonidin-3-*O*-rutinoside, pelargonidin-3-*O*-glucoside, *p*-coumaric acid, (+)-catechin, and (−)-epicatechin, procyanidin B2 and C1 were purchased from Extrasynthese (Lyon Nord, France). Chlorogenic acid and neochlorogenic acid were supplied by TRANS MIT GmbH (Giessen, Germany). 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, acetic acid, TPTZ (2,4,6-tripyridyl-1,3,5-triazine), $FeCl_3$, phloroglucinol, and methanol were purchased from Sigma–Aldrich (Steinheim, Germany). Acetonitrile for ultra—phase liquid chromatography (UPLC, gradien grade) and ascorbic acid were from Merck (Darmstadt, Germany).

### 2.2. Materials

Fruit of sour cherry (*Prunus cerasus* L.) cv. 'Łutówka', apple (*Malus domestica* Borkh.) cv. 'Champion' and pear fruit (*Pyrus* L.) cv. 'Faworytka' harvested at the Research Station for Cultivar Testing in Zybiszów near Wrocław (Poland). While the quince fruit (*Cydonia oblonga* Mill.) cv. 'Lescovac' and flowering quince (*Chaenomeles japonica* L.) cv. 'Witaminnyj' harvest at the Research Institute of Horticulture in Skierniewice (Poland).

### 2.3. Production of smoothies

The production process included 3 main technological stages: (i) sour cherry puree production; (ii) processing of juices; (iii) mixing both semi-products in appropriate proportions.

(i) Pitted sour cherries 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.
(ii) The apple, pear, quince and flowering quince fruit were ground in a Thermomix appliance with 10 mL of ascorbic acid solution (10%) per 1 kg of fruit (to prevent enzymatic browning of the fruit), and then the pulps were pressed on a hydraulic press (pilot plant laminar press; 15 tons of pressure) to obtain juices.
(iii) Sour cherry puree and juices samples, immediately after obtaining, were mixed in the proportions 80/20, 50/50 and 20/80, respectively. Then, the products were heated to 100 °C and put into glass jars, pasteurised (10 min at 90 °C), and cooled to 20 °C.

Finally, seventeen different products were obtained: five semi-products (100% sour cherry puree (SCP); 100% apple juice (AJ); 100% pear juice (PJ); 100% quince juice (QJ) and 100% flowering quince juice (FQJ) and twelve smoothies. Each sample was prepared in two replicates. The purees were subjected to analyses directly immediately after processing and after 6 months of storage at 4 °C and 30 °C (temperatures (cold and warm) were selected as the most suitable to indicate the changes during storage of obtained smoothies).

### 2.4. Consumer evaluation

The sensory properties of obtained smoothies, puree and juices were evaluated using a 9-degree hedonic scale with boundary indications: 'I do not like it very much' [1] – 'I like it very much' [9]. The assessment included the following quality attributes: colour, consistency, aroma and taste. It was conducted by a group of 12 trained panellists (4 men and 8 women in the age group 22–45). Coded samples were provided to the panellists for the evaluation at 20 °C in uniform 50-mL plastic containers.

### 2.5. Colour measurement

Colour properties (L*,a*, b*) of obtained products were determined by reflectance measurement with a Colour Quest XE Hunter Lab colorimeter. The samples were filled in a 1-cm cell, and L*, a*, b* values were determined using Illuminant D65 and 10° observer angle. Samples were measured against a white ceramic reference plate (L* = 93.92; a* = 1.03; b* = 0.52). Total change in colour of juices (ΔE*) (Šumić, Tepić, Vidović, Jokić, & Malbaša, 2013) and also hue angle ($h^{0}$*) and chroma difference (ΔC*) (Wojdyło, Teleszko, & Oszmiański, 2014a) were calculated. The data were mean of three measurements.

### 2.6. Viscosity measurement

Viscosity of the smoothies, puree and juices were measured with a rotation viscometer Brookfield DV-II + Pro (Brookfield Engineering Laboratories, Middleboro, Massachusetts, USA). Analysis was carried out at 20 °C.

### 2.7. Determination of phenolic compounds by UPLC-PDA-FL method

The extract of polyphenols for analysis was prepared as described previously by Wojdyło et al. (2013). The extracts of sample for quantitative (UPLC-PDA-FL) analysis of polyphenols (anthocyanin, flavan-3-ol, flavonol, phenolic acid and dihydrochalcone) were performed as described previously by Wojdyło et al. (2014b). An analysis of polymeric procyanidins by phloroglucinol method was performed according to the protocol described previously by Kennedy and Jones (2001). All measurements were repeated three times. The results were expressed as mg/100 g or 100 ml of product.

### 2.8. Determination of antioxidant activity

A sample for the analysis of polyphenols was prepared as described previously by Wojdyło et al. (2014b). The $ABTS^{\circ+}$, ORAC, and FRAP assay were determined as previously described by Re et al. (1999); Ou, Huang, Hampsch-Woodill, Flanagan, and Deemer (2002); and Benzie and Strain (1996), respectively. Determinations by ABTS and FRAP methods were performed using a UV-2401 PC spectrophotometer (Shimadzu, Kyoto, Japan). ORAC assay was performed using a RF-5301 PC spectrofluorometer (Shimadzu, Kyoto, Japan). Results were expressed as mmol TE/100 g