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ENRICHMENT OF FRUIT LEATHERS WITH BERRY PRESS CAKE POWDER INCREASE PRODUCT FUNCTIONALITY

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Abstract

Fruit leathers are tasty, chewy, dehydrated fruit products which are eaten as snack or dessert. Dried berry press cake powders could be a promising ingredient for enhancing nutritional value of such products. The aim of this work was to enrich apple and black currant fruit leather with dried blackcurrant and raspberry press cake powders, and to evaluate the effect of the press cake additives on the content of total phenolics, total anthocyanins, antioxidant activity and textural properties of the product (fruit leathers). In this study, fruit leather made of apple and black currant puree was enriched with two different berry press cake powders (1) freeze-dried raspberry press cake powder (dry-matter content 97.3%) (2) conventionally dried black currant press cake powder (dry-matter content 95.4%). The contents of total phenolics, total anthocyanins, antioxidant activity, colour and textural properties of the test samples was evaluated. The content of phenolic compounds in raspberry and black currant press cake powders was 28.5 and 25.4 mg g^{-1} respectively. The content of anthocyanins in black currant press cake powder was more than 19-fold higher than in raspberry press cake powder. The addition of berry press cake powder reduced hardness of the fruit leathers and samples with black currant press cake powder was two times softer than the control. Raspberry press cake additive increased the lightness ($L^* = 24.0$) and the redness ($a^* = 3.4$), whereas black currant press cake powder reduced the lightness ($L^* = 22.5$) and the redness ($a^* = 1.5$) of the product. The content of anthocyanins in the fruit leathers enriched with black currant press cake powder was significantly higher than in control sample (116.4 and 74.1 mg 100 g^{-1}, respectively). Berry press cake powder also increased antioxidant capacity of the fruit leathers. The results of the study can be useful for health-conscious food producers and consumers.

Keywords: fruit leathers, berry press cakes, phenolic, products, texture.

Introduction

Fruit leather is a dehydrated, dietary fruit product which is often eaten as snack or dessert. Fruit leathers are restructured fruit made from fresh fruit pulp or a mixture of fruit juice and other ingredients that involves a dehydration step (Huang, Hsieh, 2005). During manufacturing, fruit pulps are mixed with sugar, pectin, acid, and colourants and then dried into sheet-shaped products. Most fruit leathers are dried at 30 to 80 °C for up to 24 hours until the target moisture content (12–20%) is reached (Quintero Ruiz et al., 2012; Diamante et al., 2014). Fruit leathers are nutritious, tasty and retain substantial quantities of minerals, vitamins, and phenolic phytochemicals that are initially present in raw materials (fruits, berries and vegetables) (Diamante et al., 2014).

An important portion of fruits and berries are processed into juice, which generates high amounts of by-product (press cake residues). Berry press cake (pomace) comprises berry skins and seeds, which contain fibres and various bioactive substances (Kruczek et al., 2016). The levels of phenolic antioxidants in fruit and berry processing wastes are usually found to be higher than in the actual product itself (Tian, 2016). Epidemiological studies confirmed that consumption of phenolic phytochemicals reduces the risk of cardiovascular diseases, cancer, and other degenerative diseases (Shahidi, 1997).

Nowadays, food is not merely viewed as a source of essential nutrients to ensure proper growth and development, but as a route to optimal wellness. Because of the rising interest in functional foods, scientists and food producers are looking for new sources of bioactive substances and also carriers of those substances. One of the possibilities to increase the content of natural antioxidants in the diet is to enrich food products with concentrated fractions of plant polyphenolic compounds. For instance, it was reported that grape seed and peel extract additive improved biochemical composition and functional properties of the grape juice (Ghafoor et al., 2011). Furthermore, it was suggested that raspberry seed extract can be suitable antioxidant added to muesli and cereal products (Klensporf, Jelen, 2008). In the study reported by Gailite et al. (2006) raspberry marc was used to improve the nutritional value of wheat bread. The results showed that the contents of fibre, carotenoids and vitamin E were higher in wheat bread with berry marc additive (Gailite et al., 2006). Partial replacement of wheat flour with the raspberry and black currants press cake powders increased the amount antioxidants and dietary fibre in the cookies (Górecka et al., 2010; Molnar et al., 2015). The antioxidant rich raspberry marc extract added to different fruit purees increased their functionality (Bobinaitė et al., 2016).

The aim of this work was to enrich apple and black currant fruit leather with dried black currant and raspberry press cake powders, and to evaluate the effect of the press cake additives on the content of total phenolics, total anthocyanins, antioxidant activity and textural properties of the product (fruit leathers).

Materials and Methods

Fruit puree preparation

Fresh fruits and berries were blanched and their edible part was separated and pureed using machine EP1000 (Voran Maschinen GmbH, Pichl bei Wels, Austria). Fruit purees were prepared using standardized recipes developed in biochemistry and technology laboratory of Institute of Horticulture LRCAF.

Apple / black currant puree was prepared by blending 78.0% of apple puree and 16.5% of black currant puree, and adding 5.5% of sugar (control sample). Prepared puree was then enriched with either 1% of milled, freeze-dried raspberry press cake powder or 2% milled, conventionally (convection drying) dried black currant press cake powder.

Drying of fruit puree

Apple / black currant leathers were made by pouring pureed fruit onto a flat surface for drying. Fruit puree was dried using a convection drying method and performed in a UDS-150/1 hot-air laboratory dryer (Utena, Lithuania) at a temperature of 55±2 °C and an air-flow rate of 1.5 m s^{-1}. After drying fruit leathers were cut into strips.

Colour and texture measurement

The colour of raspberry and black currant press cake powders and fruit leathers was measured with a spectrophotometer MiniScan XE Plus (Hunter Associates Laboratory, Inc., Reston, Virginia, USA). In the reflectance mode, CIE L*a*b* colour parameters were recorded as L* (lightness), a* (+ redness), and b* (+ yellowness). The chroma ($C = (a^{*2} + b^{*2})^{1/2}$) and hue angle ($h° = \arctan(b^*/a^*)$) were also calculated (McGuiere, 1992). The total colour differences (ΔE) between dried fruit leather without additives and with berry press cake powder additive were calculated using following formula:

$$\Delta E = \sqrt{\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2}$$

Data was presented as the average of three measurements. Colour coordinates were processed with the program Universal Software V.4-10.

The texture of fruit leathers was measured using a TA.*XTplus* Texture Analyzer (Stable Micro Systems, Godalming, England), with 2 mm-diameter flat head probe. The analysis data was processed with "Texture Exponent" program.

Extract preparation

Dried berry press cake was ground in an ultra-centrifugal rotor mill Retsch ZM200 (Retsch, Haan, Germany) using 0.2 mm particle size sieve, then 5 grams of powder was extracted with 50 mL of 70% methanol at room temperature for 60 min under constant shaking (Sklo Union LT, Teplice, Czech Republic). After decantation the residue was re-extracted second time under the same conditions. The combined extracts were filtered and subjected to further analysis.

Dried fruit leather (5 g) was added to 50 mL of 70% methanol and homogenized using Polytron PT 1200E homogenizer (Kinematica, Luzern, Switzerland). The extraction was carried out at room temperature for 120 min under constant shaking. The extract was then filtered and analysed.

Analysis of total anthocyanins, total phenolics and antioxidant activity

The content of total phenolic compounds in the extracts of dried berry press cake powders and dried leathers was measured using the Folin-Ciocalteu procedure (Slinkard, Singleton, 1977). The total anthocyanins content in the extracts of dried berry press cake powders and dried leathers was determined using the pH differential method (Giusti, Wrolstad, 2003). The concentration of anthocyanins was expressed in mg of cyanidin-3-glucoside in 100 g of press cake powder or fruit leather (dry weight, d.w.).

Three different methods were used to test the antioxidant activity of the methanolic fruit leather extracts: FRAP assay (Ferric reducing antioxidant power) (Benzie, Strain, 1996), DPPH radical scavenging assay (1,1-diphenyl-2-picryl hydrazyl radical reducing power) (Brand-Williams, 1995), and ABTS (2,2′-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid) assay (Re et al., 1999).

Antioxidant activity of the samples was expressed in micromoles (μmol) of Trolox equivalents (TE) per one gram of dried (d.w.) fruit leather.

Statistical analysis

All measurements were performed in triplicate and data was reported as mean ± standard deviation. Mean values were further compared using Turkey's test, and differences were considered to be statistically significant when $p<0.05$.

Results and Discussion

The chemical composition of dried berry press cake powders is presented in Table 1. The content of phenolic compounds was extremely high in both investigated press cake powders. The content of total phenolics in freeze-dried raspberry press cake powder was only slightly higher than in dried black currant press cake powder. However, the amount of total anthocyanins in raspberry and black currant press cake powder was significantly different. The concentration of anthocyanins in the dried black currant press cake powder was almost 19 times higher than in freeze-dried raspberry press cake powder. These findings are not surprising since anthocyanins account for up to 80% of the total phenolic compounds present in black currants (Borges et al., 2010; Anttonen, Karjalainen, 2006), whereas the major phenolic compounds found in red raspberries are ellagitannins (Määttä-Riihinen et al., 2004; Vrhovsek et al., 2008). The strong positive correlation between total phenolics content and ellagitannins of raspberries was reported in different studies (Anttonen, Karjalainen, 2005; Bobinaite et al., 2012).

It is worth noting that anthocyanins in the food industry are increasingly utilized not only as natural colorants (E163) substituting synthetic colorants, but also because of their biofunctional properties.

The chemical composition of dried fruit leathers is presented in Table 2. The dry matter content of fruit leathers was very similar. As it was mentioned in the introduction the moisture content of fruit leathers should not be higher than 20% (Diamante et al., 2014) since the preservation of fruit leathers depends on residual moisture content. The moisture content of the investigated fruit leathers varied from 16.1 to 17.8%.

Table 1

Total phenolics, anthocyanins and dry-matter content of berry press cake powders

Examples	Anthocyanins, mg 100 g^{-1} (d.w.)	Phenolics, mg 100 g^{-1} (d.w.)	Dry-matter content, %
Raspberry press cake powder	134.02±5.39^{b}	2846.9±145^{a}	97.3±0.05^{ba}
Black currant press cake powder	2539.4±19.09^{a}	2428.2±114^{b}	95.4±0.06^{ba}

Different letters in the same column indicates significant differences between the means (p≤0.05).

Table 2

Total phenolics, total anthocyanins and dry-matter content of dried fruit leathers

Samples	Anthocyanins, mg 100 g^{-1} (d.w.)	Phenolics, mg 100 g^{-1} (d.w.)	Dry-matter content, %
Control	74.1±2.21^{c}	949.36±11.0^{bc}	83.7±0.06^{bc}
RP	80.5±4.10^{b}	961.76±15.41^{b}	83.9±0.05^{bc}
BC	156.37±7.39^{a}	1001.98±25.74^{a}	82.2±0.02^{b}

RP – fruit leather with raspberry press cake powder; BC – fruit leather with black currant press cake powder.
Different letters in the same column indicates significant differences between the means (p≤0.05).

Table 3

Antioxidant activity of fruit leathers, µmol TE g^{-1} (d.w.)

Samples	DPPH	FRAP	ABTS
Control	19.0±0.57^{b}	33.3±0.17^{c}	72.9±0.92^{c}
RP	20.1±0.97^{a}	36.9±1.20^{b}	74.9±0.23^{b}
BC	21.3±0.33^{a}	38.0±0.50^{a}	80.0±1.31^{a}

RP – fruit leather with raspberry press cake powder; BC – fruit leather with black currant press cake powder. Different letters in the same column indicates significant differences between the means (p≤0.05).

Table 4

CIEL*a*b* colour parameters of dried fruit leathers

Samples	L*	a*	b*	h°	ΔE
Control	23.9±0.79^{a}	2.1±0.17^{b}	0.4±0.18^{b}	349.7±4.67^{a}	–
RP	24.0±0.97^{a}	3.4±0.84^{a}	0.1±0.32^{a}	0.8±4.63^{c}	1.33^{b}
BC	22.5±1.95^{b}	1.5±0.31^{c}	0.6±0.27^{b}	337.3±10.1^{b}	1.82^{a}

RP – fruit leather with raspberry press cake powder; BC – fruit leather with black currant press cake powder. Different letters in the same column indicates significant differences between the means (p≤0.05).

Higher contents of total phenolics and total anthocyanins were detected in the fruit leathers enriched with dried berry press cake powders. Higher content of anthocyanins and phenolics compounds was found in the fruit leather with dried black currant press cake powder. The content of total phenolics was by 1.3 and 5.5% higher in the fruit leathers enriched with raspberry and black currant press cake powder, respectively (Table 2). The content of total anthocyanins in the fruit leather enriched with dried black currant press cake powder was more than 2 times higher compared to control sample (fruit leather without berry press cake additive). Compared to control sample, the content of total anthocyanins in the fruit leather enriched with freeze-dried raspberry press cake powder was by 8.6% higher.

The berry press cake powders also increased antioxidant activity of the investigated fruit leathers (Table 3). The highest antioxidant activity possessed fruit leathers enriched with dried black currant press cake powder. The antioxidant activity of fruit leathers enriched with dried black currant press cake powder was by 9.7, 12.1 and 14.1% higher (ABTS, DPPH and FRAP assay, respectively) compared to the control sample. Compared to control sample, the antioxidant activity of fruit leathers enriched with raspberry press cake powder was by 2.7, 5.8 and 10.8% higher (determined by ABTS, DPPH and FRAP assay, respectively).

The lower antioxidant activity of fruit leathers with raspberry press cake powder compared to black currant press cake powder enriched product most probably is only due to the lower percentage of raspberry press cake powder used. Anthocyanins appear to be the main contributors to the antioxidant potential of black currants (Bordonaba, Terry, 2012; Borges et al., 2010). As reported previously, although raspberries had a lower content of anthocyanins than black currants there was only a slight difference in the antioxidant capacities of those two berries (Borges et al., 2010). The authors concluded that high antioxidant capacity of raspberries is because of the presence of the ellagitannins sanguine H-6 and lambertianin C, which were responsible for 58% of the total antioxidant capacity of raspberries (Borges et al., 2010). Furthermore, it has been shown that the content of ellagitannins was considerably higher in raspberry press cake extracts than in fruit or fruit pulp extracts (Bobinaitė et al., 2013).

The colour measurement results of dried fruit leathers are presented in Table 4. The raspberry press cake powder additive increased the lightness (L*) and redness (a*) of fruit leather, whereas the black currant press cake powder reduced the lightness (L*) and redness (a*) of the product. Furthermore, black currant press cake powder shifted the colour of the fruit leather slightly more to the blue (reduced b* value). The fruit leather with black currant press cake powder additive was the darkest.

The colour difference (ΔE), between control fruit leather and fruit leathers enriched with berry press cake powders, shows that black currant press cake powder additive changed the colour of the control (apple/black currant) fruit leather more noticeably than freeze-dried raspberry press cake powder (Table 4).

The press cake powder additive had significant influence on the texture properties of dried fruit leathers (Figure 1).

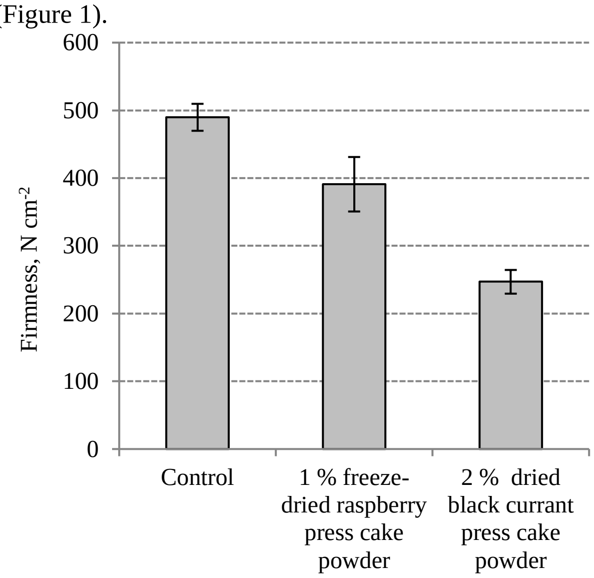

Figure 1. Firmness of dried fruit leathers

The addition of freeze-dried raspberry press cake powder reduced firmness of the fruit leather from 489.78 to 390.9 N cm^{-2} (product was 1.2 times softer), whereas 2% of dried black currant press cake powder reduces firmness of the product to 247.4 N cm^{-2} (fruit leather was 2 times softer).

Conclusions

Freeze-dried raspberry and dried black currant press cake powders contain high amounts of phenolic compounds (2846.9 mg 100 g^{-1} and 2428.2 mg 100 g^{-1}, respectively). The concentration of anthocyanins in the dried black currant press cake powder was 19 times higher than in the freeze-dried raspberry press cake powder.

The addition of berry press cake powders during the manufacturing of dried fruit leather significantly enhanced its biochemical composition and reduced firmness of the final product.

The highest content of anthocyanins and phenolics compounds was found in the apple / black currant leather with dried black currant press cake powder. The firmness of fruit leather with dried black currant press cake powder was 2 times lower compared to the control sample (fruit leather without press cake additive).

Enrichment of fruit leathers with dried raspberry and black currant press cake powders effectively enhance their polyphenolic composition and increase their antioxidant activity, thus improving functional properties of the product.

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