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Ultrasound-assisted extraction of bioactive compounds from black currant and chokeberry pomaces

INTRODUCTION

The fruit production has significantly increased reaching over 887 million metric tons per year. Despite the growing consciousness about sustainability in food industry, still large amounts of fruit waste, including pomace are generated [1]. Fruit pomace is still rich in bioactive compounds, which can be recovered. That brings financial and environmental benefits and complies with circular economy concept [2]. According to Schmid et al. [3] industrial chokeberry pomace total polyphenol content (TPC) reaches 5.5 g/100 g dry mass expressed as catechin monohydrate. Anthocyanins, followed by phenolic acids and flavonols are main polyphenolic compounds in chokeberry pomace detected using high performance liquid chromatography (HPLC). Industrial black currant pomace powder was characterized by TPC of 2241.6 mg epicatechin equivalent/100g of pomace with anthocyanins as the most abundant polyphenolic compound determined using HPLC [4]. The extraction of bioactive compounds is a way to recover them. However, conventional extraction methods may be energy consuming and require high volumes of harmful to environment organic solvents. Using alternative extraction methods, for example ultrasound assisted extraction (UAE) may result in high bioactive compounds yield without using organic solvents or much energy. **The aim of this study** was to compare black currant pomace and chokeberry pomace extracts obtained in UAE process and to identify the differences of TPC and antioxidant activity of pomace extracts obtained by applying different ultrasound amplitude and sonication time.

MATERIAL AND METHODS

MATERIAL

Chokeberry (*Aronia melanocarpa*) and black currant (*Ribes nigrum*) fruits obtained from local Polish suppliers were pressed using Bucher Guyer press, in batch of 10 kg, with pressure of 3 Bar. The pomace left after juice pressing was then dried using convective drier in temperature of 45°C and with 1.5 m/s air flow velocity to reach water activity on a level less than 0.6. After drying process, the pomace was sieved to obtain seedless fraction and seed fraction separately.

Figure 1. Chokeberry pomace before sieving (top) and after sieving and grinding (bottom).

EXTRACTS PREPARATION

Samples of around 2 g of dried pomaces were milled in a laboratory mill (IKA Tube Mill) at 20,000 rpm for 60 s. The extraction was carried out in the UP400S ultrasound processor (Hielscher Ultrasonics GmbH, Teltow, Germany) with the adjustable ultrasound wave amplitude level, the output power of 400 W. Extracting medium was distilled water used in solid/liquid ratio at level of 1:15. Water was added to the tube containing sample right before the ultrasound application. Amplitude values of 30%, 55% and 80% in time of 2 min, 6 min and 10 min were applied.

Figure 2. Ultrasound processor [5].

Sample	Amplitude [%]	Time [min]
US1	30	2
US2	80	2
US3	30	10
US4	80	10
US5	55	6
USC	0	0

Table 1. Conditions of the ultrasound-assisted extraction.

TOTAL POLYPHENOL CONTENT AND ANTIOXIDANT CAPACITY DETERMINATION

The total polyphenol content (TPC) of extracts was determined using Folin-Ciocalteu reagent, as described by Gao et al. [6]. The absorbance of samples was measured using Shimadzu UV-1650PC spectrophotometer with wavelength of 765 nm. The quantaties of milligrams of gallic acid (GA) were calculated from the calibration curve. Antioxidant capacity of extracts was determined in ABTS assay, according to method described by Re et al. [7]. The same spectrophotometer was used, and wavelength valued 734 nm. The results were expressed as µmol Trolox per mL of extract. Analyzes were done in triplicate, the one-way ANOVA followed by post-hoc Tukey test was performed.

RESULTS

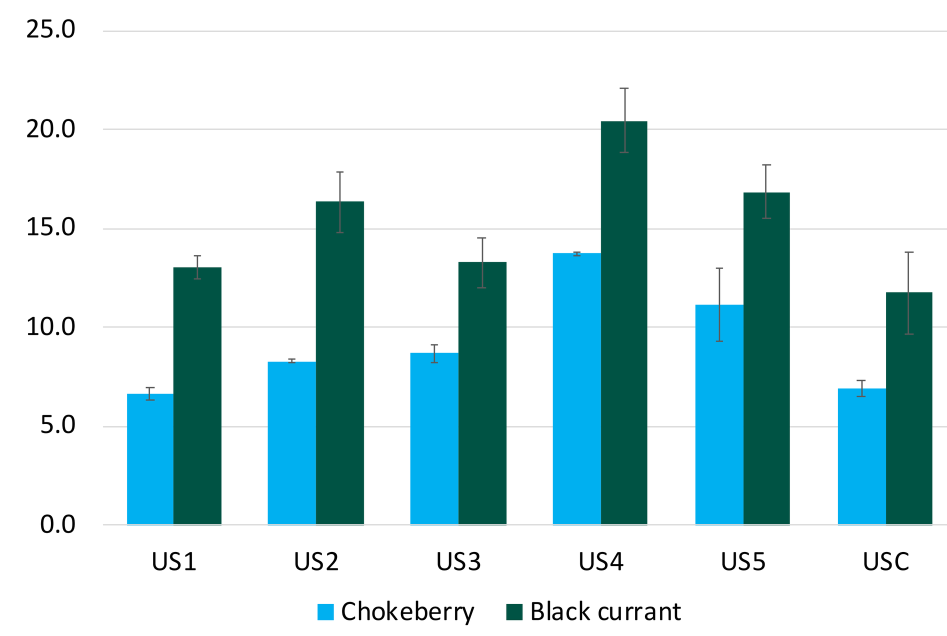

Figure 3. Antioxidant capacity of pomace extracts [µmol Trolox/mL]

ANTIOXIDANT CAPACITY

The antioxidant capacity measured in ABTS assay is presented on Figure 3. There is noticeable difference between antioxidant capacity of chokeberry pomace extracts and blackberry pomace extracts. The antioxidant capacity of chokeberry extracts ranged from 6.6 ± 0.3 (USC) to 13.7 ± 0.1 (US4) µmol Trolox/mL. In case of black currant extracts these values were between 11.8 ± 2.1 (USC) up to 20.5 ± 1.6 (US4) µmol Trolox/mL.

TOTAL POLYPHENOL CONTENT

The results of TPC analysis is presented on Figure 4. The tendency of TPC values is consistent with the ABTS assay results. However, the contrast between chokeberry and black currant extracts is less visible. TPC of chokeberry pomace extracts varied from 80.6 ± 4.0 mg GA/100 ml for USC sample to 139.5 ± 9.3 mg GA/100 ml in case of US4 sample. TPC results for black currant pomace extracts ranged from 107.0 ± 0.7 mg GA/100 ml (USC) to 169.8 ± 0.4 mg GA/100 ml (US4).

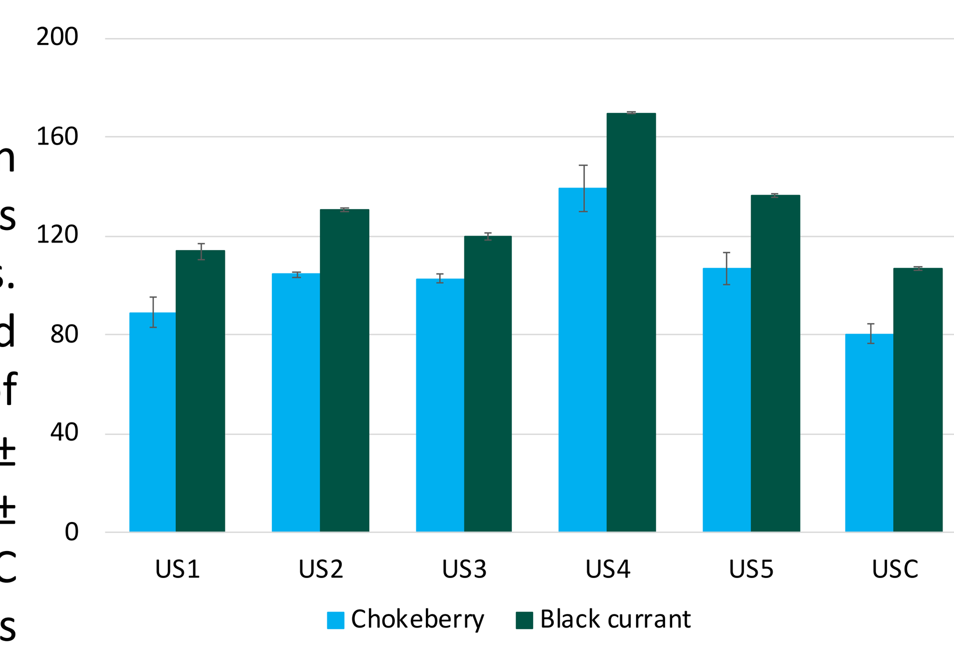

Figure 4. Total polyphenol content in pomace extracts [mg GA/100 ml].

SUMMARIZED RESULTS AND DISCUSSION

The values of antioxidant capacity and TPC differ in chokeberry and black currant pomaces extracts. That may be caused by the differences in polyphenol content in those fruits reported by Strugała et al. [8]. In both extracts applying maximum amplitude and time resulted in significantly the highest values of antioxidant capacity and TPC. Even applying the lowest values of amplitude and time- 30% and 2 min has improved significantly TPC value of chokeberry pomace extract and ABTS and TPC values of black currant pomace extract. The results are in accordance with those by Zafra-Rojas et al. [9] who studied UAE of blackberry pomace using water as a solvent. The optimum TPC and antioxidant capacity values were reached when the highest amplitude (91%) and time (15 min) was applied. Chokeberry pomace UAE was also described by Halasz et al. [10], however ethanol-water (1:1) mixture was used as a solvent with solid-liquid ratio of 1/10. Amplitude of 14 expressed in µm units and 10 min time were applied. The TPC value of extract was 104.6 mg GA/100 mL of extract, what is comparable to results obtained in the following study. The UAE efficiency improvement is caused by acoustic cavitation phenomenon, which causes damage of cell walls of plant material and enhances bioactive compounds release [11].

Sample	Chokeberry pomace extract		Black currant pomace extract	
	ABTS [µmol Trolox/mL]	TPC [mg GA/100 ml]	ABTS [µmol Trolox/mL]	TPC [mg GA/100 ml]
US1	6.6 ± 0.3^{a}	89.2 ± 5.9^{ab}	13.0 ± 0.6^{ab}	114.0 ± 3.2^{b}
US2	8.3 ± 0.1^{a}	104.5 ± 1.2^{bc}	16.3 ± 1.5^{b}	130.7 ± 0.9^{d}
US3	8.7 ± 0.5^{a}	102.9 ± 2.0^{bc}	13.3 ± 1.3^{ab}	119.8 ± 1.6^{c}
US4	13.7 ± 0.1^{c}	139.5 ± 9.3^{d}	20.5 ± 1.6^{c}	169.8 ± 0.4^{f}
US5	11.1 ± 1.8^{b}	107.1 ± 6.65^{c}	16.9 ± 1.4^{bc}	136.5 ± 0.5^{e}
USC	6.9 ± 0.4^{a}	80.6 ± 4.0^{a}	11.8 ± 2.1^{a}	107.0 ± 0.7^{a}

Table 2. Summarized results of antioxidant capacity (ABTS) and total polyphenol content (TPC) of studied extracts. Different letters in superscript represent homogenous groups at $\alpha = 0.05$.

CONCLUSIONS

- total phenolic content and antioxidant capacity may be useful indicators of extraction process efficiency
- applying sonication may be beneficial in bioactive compounds extraction process from chokeberry and black currant pomaces
- chokeberry and black currant process are characterized by different values of total phenolic content and antioxidant capacity
- higher values of ultrasound amplitude and time of sonication resulted in significantly increased TPC and antioxidant capacity of studied extracts

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