



Ultrasound-assisted extraction of oils from berry seeds: A sustainable approach to agrofood waste valorisation

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Introduction



Fruit production only in Poland equals 4 million ton per year

Over 25% of fruits are processed

Pomaces are main by-products amounting up to 20% of origin mass of fruit and major pomace component are seeds

Circular economy policy

High nutritional value

Unique qualitative properties of oil



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Alternative extraction methods

Conventional extraction methods may contribute to natural environment damage due to high energy and solvent consumption

Alternative extraction methods involve applying new technologies to maximize the yield and quality of oil and minimize the impact on environment



Ultrasound-assisted extraction



Pulsed electric field assisted extraction



Microwave-assisted extraction



Pressurized liquid solvent extraction



Supercritical solvent extraction

Optimization and the influence on thermal properties and fatty acid share in obtained oils



The effects of US

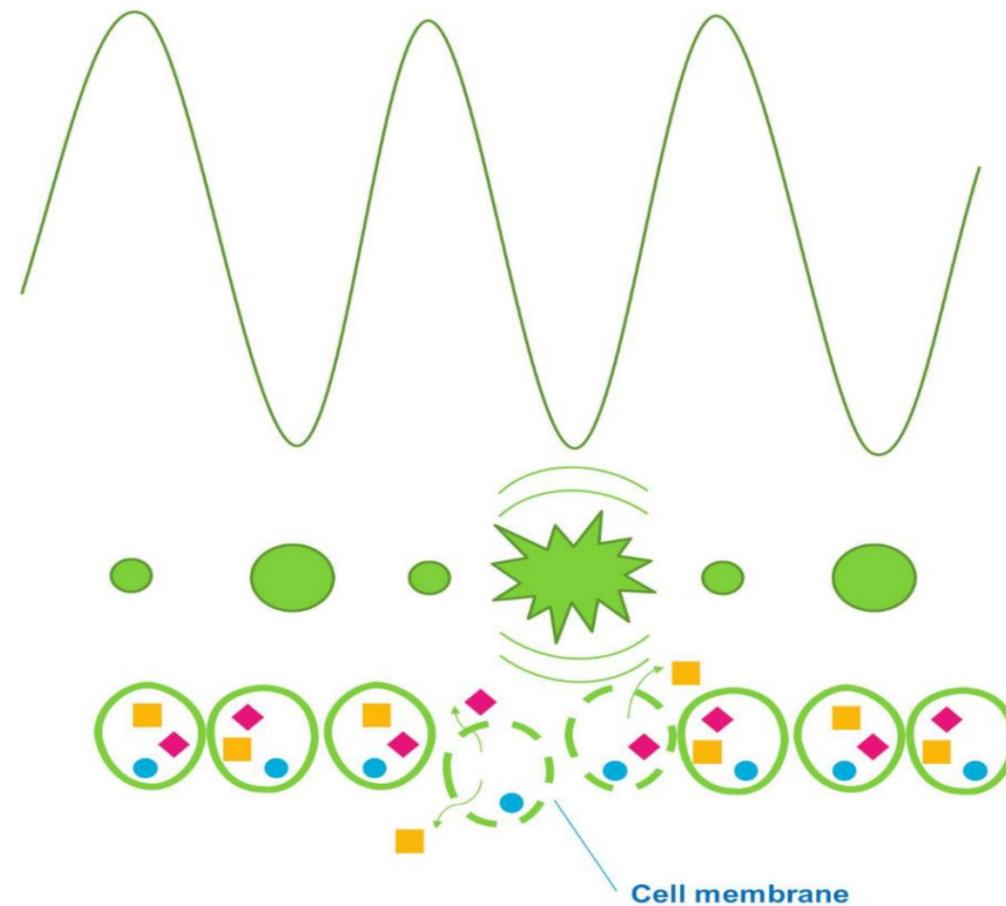


Fig. 1. The effects of ultrasound (US) on plant tissue [Piasecka et al., 2021].

Acoustic cavitation, sonoporation, improved mass transfer



Decreased time of extraction, energy and time consumption, natural environment saving

Materials and methods

Materials

Dried ($a_w < 0.4$), milled blackcurrant and chokeberry seeds obtained from pomace.

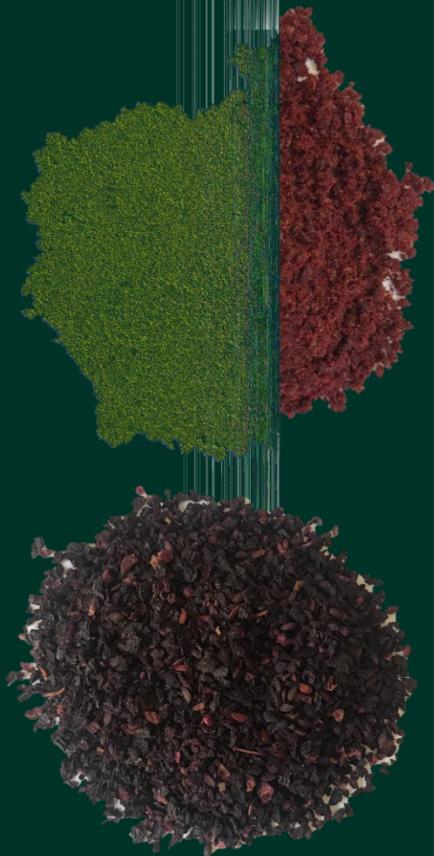


Figure 2. Black currant (BC), and chokeberry (CH) seeds.

Methods of extraction

US-assisted extraction was carried out in the UP200Ht ultrasound processor (Hielscher, Germany) with the output power of 200 W. Extracting medium was hexane used in solid/liquid ratio at level of 1:15. Amplitude and time of extraction were based on some previous optimization studies.

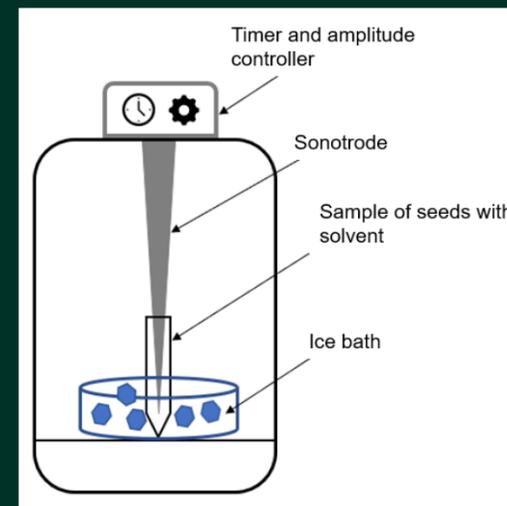


Figure 3. Ultrasound processor and scheme of extraction experiment.

Parameters for blackcurrant and chokeberry seed oil extraction

Sample	Amplitude (%)	Sonication time (min)
US60/12	60	12
US90/6	90	6

Control extraction solid-liquid extraction with hexane used as a solvent in a 1/15 m/v ratio. The seeds were mixed with hexane and stirred in a water bath for 2 hours in temperature of 40°C.

Cold pressed oils were purchased from the local market.

Analytical methods

PDSC: Oxidative stability was determined in PDSC study conducted using a DSC Q20 TA Instrument. Conditions: oxygen atmosphere with an initial pressure of 1400 kPa and with the 100 mL/min oxygen flow rate, isothermal 120°C. Oxidation induction time (OIT) and maximum oxidation time (tmax) were studied.

GC: The profile of fatty acids was analyzed using The YL6100 GC gas chromatograph apparatus coupled with FID. The fatty acids from samples were converted to fatty acid methyl esters (FAME) using methanolic KOH solution. FAMES were identified by retention time compared to the standard FAMES mixture.

Carotenoid content: Determined according to the procedure reported by Romanić et al., using spectrophotometer.

Chlorophyll content: Quantified based on the procedure outlined in AOCS method cc13i-96, using spectrophotometer.

ABTS/DPPH/TPC: Polyphenol fraction was extracted from oil using methanol and then TPC and antioxidant capacity against ABTS and DPPH were studied spectrophotometrically.



Figure 2. DSC Q20 Instrument.



Figure 3. Jenway 6305 spectrophotometer.



Figure 4. Gas chromatograph.

PDSC results

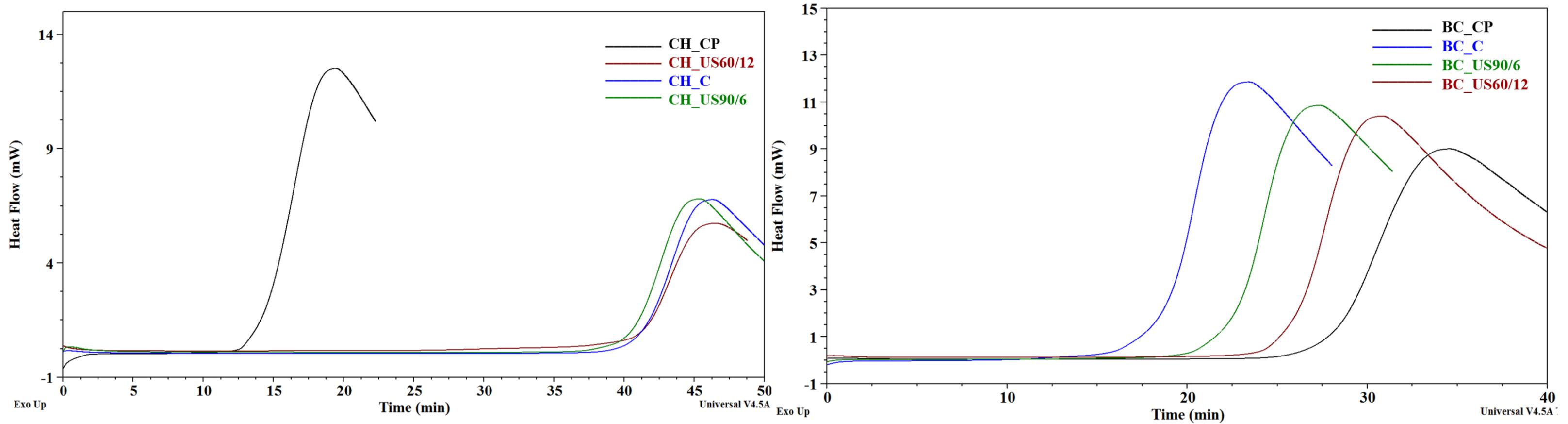


Fig. 5. PDSC curves of chokeberry seed oils and blackcurrant seed oils.



TPC results

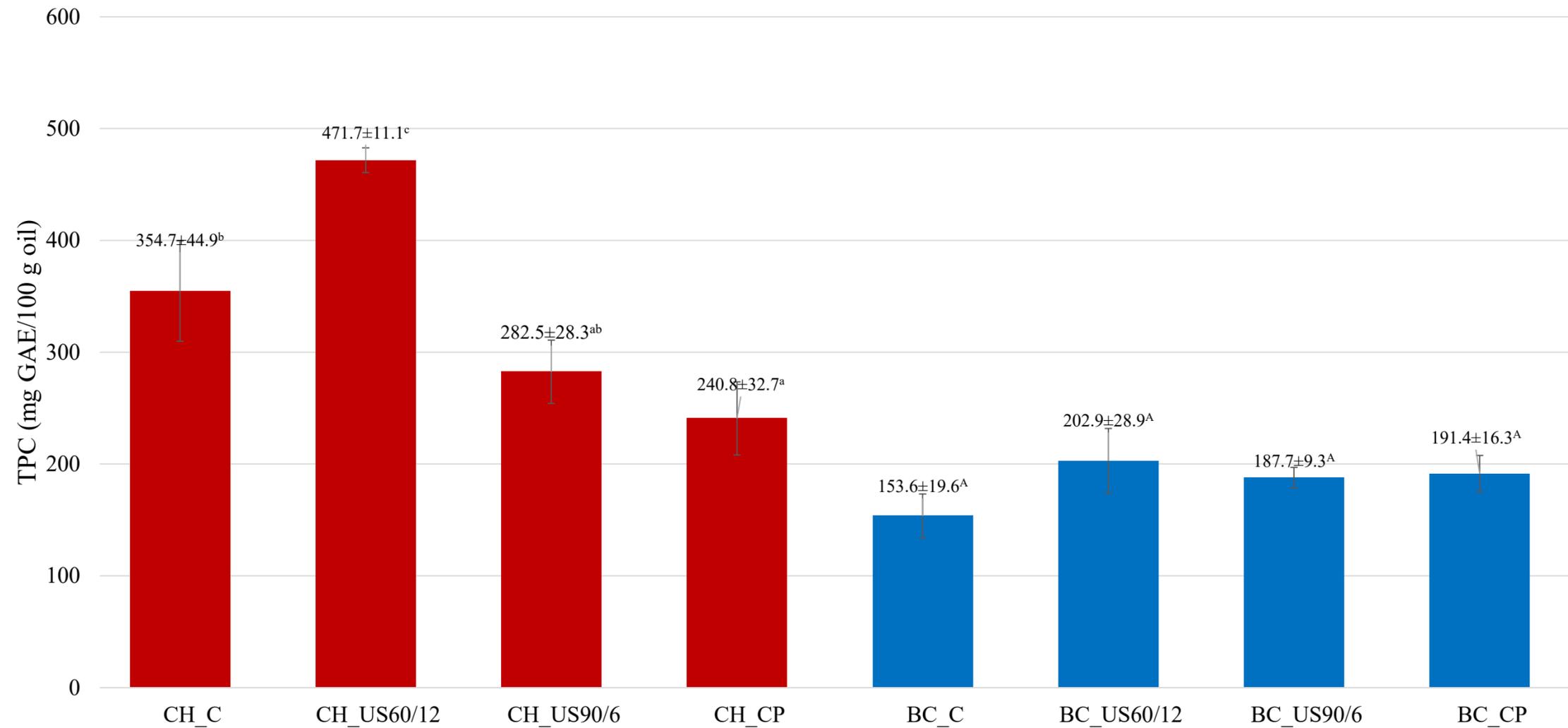


Fig. 6. Total polyphenol content of chokeberry and blackcurrant seed oils.



Antioxidant capacity

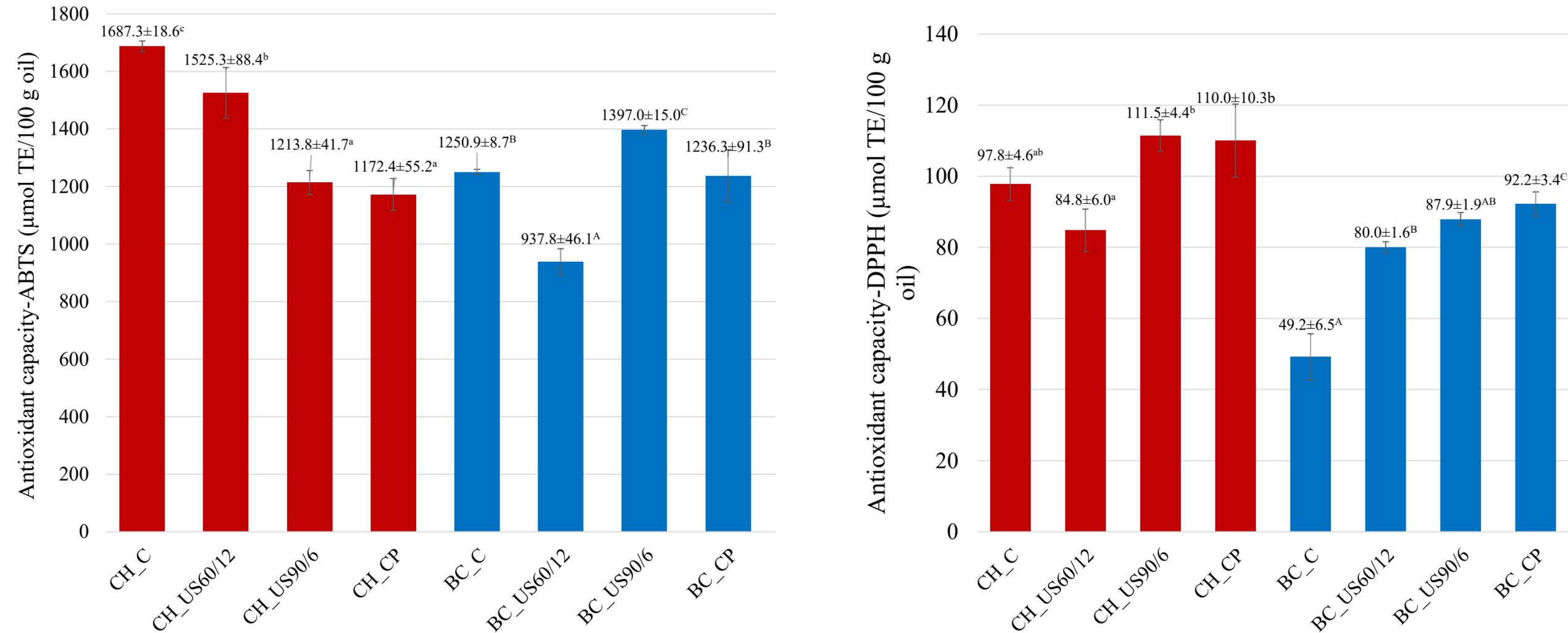


Fig. 7. Antioxidant capacity against ABTS and DPPH.



Chlorophyll and carotenoid content

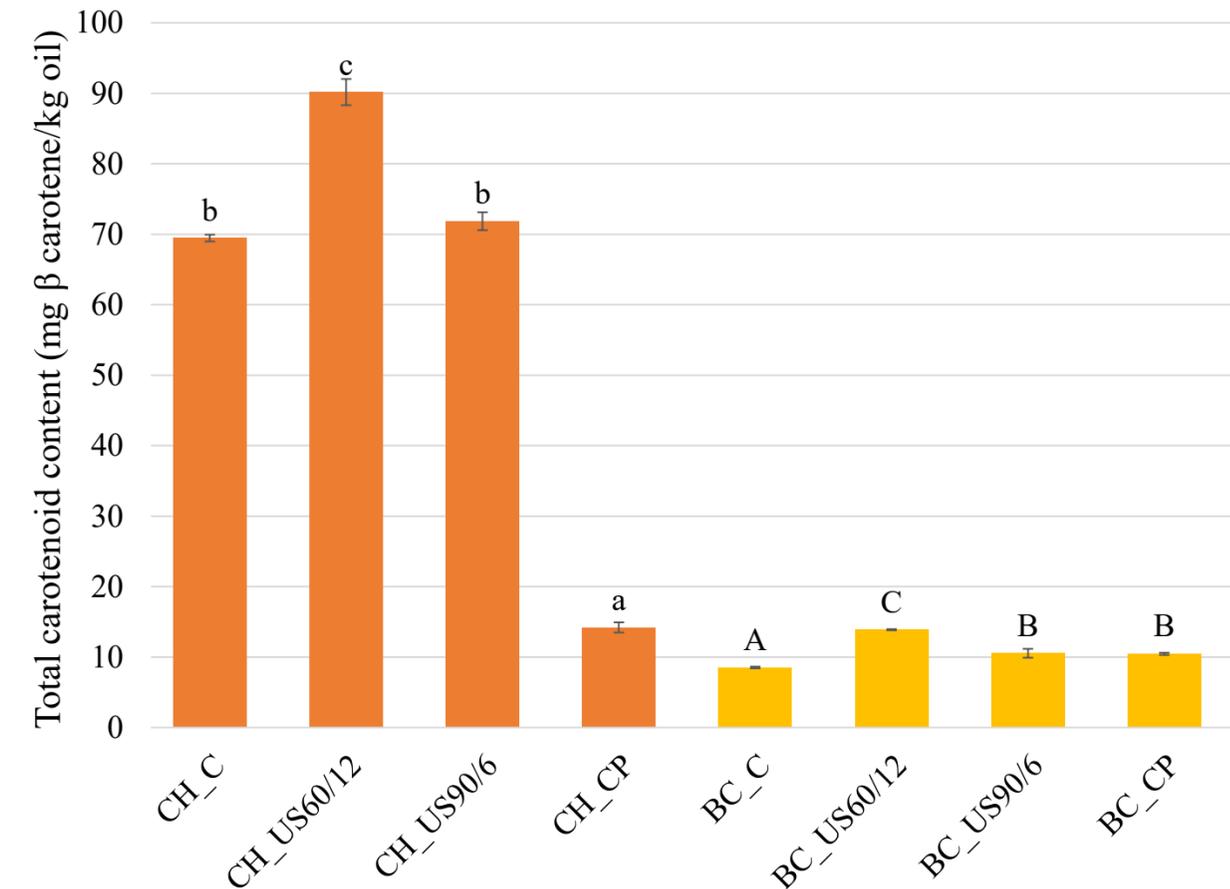
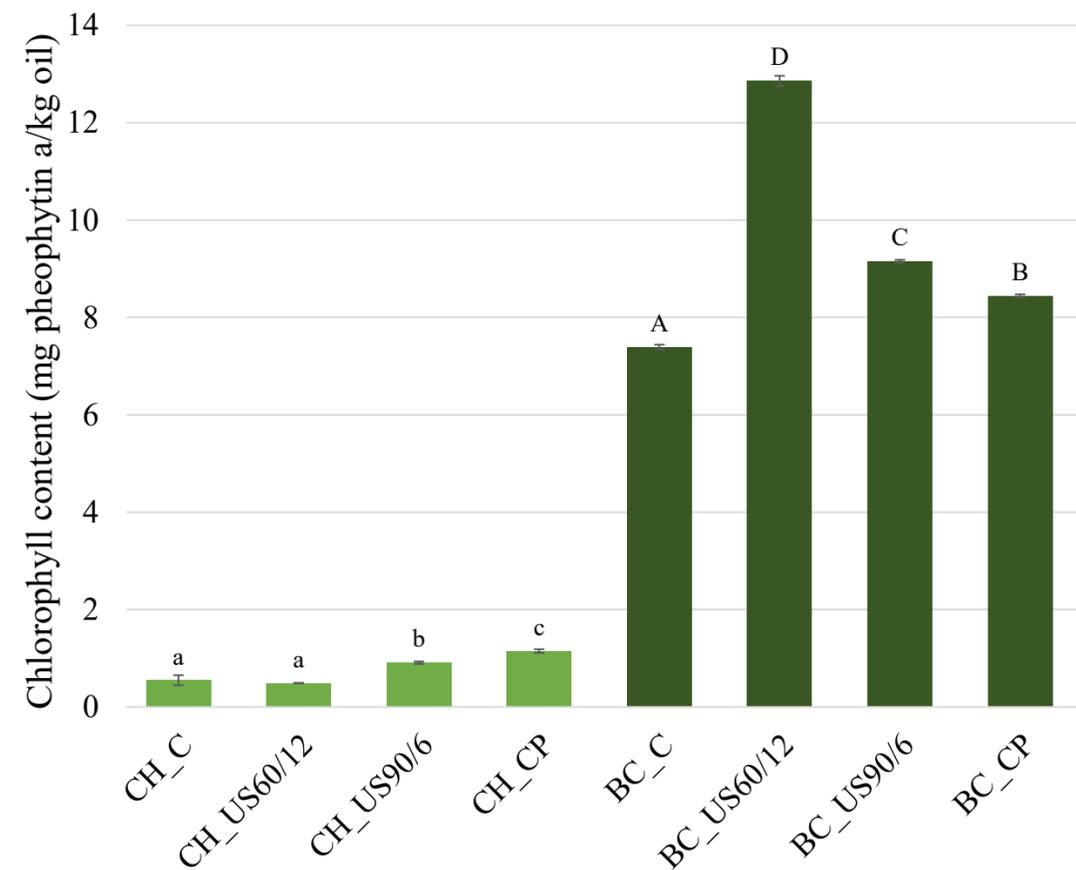
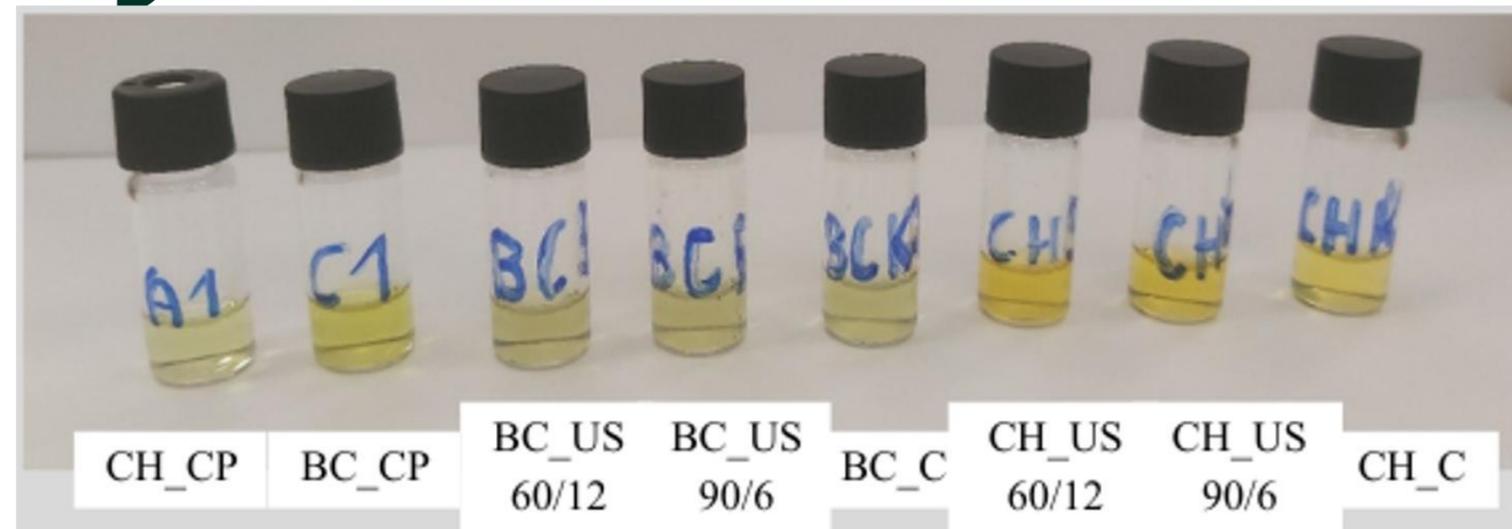


Fig. 8. Chlorophyll and total carotenoid content of chokeberry and blackcurrant seed oils.

GC results

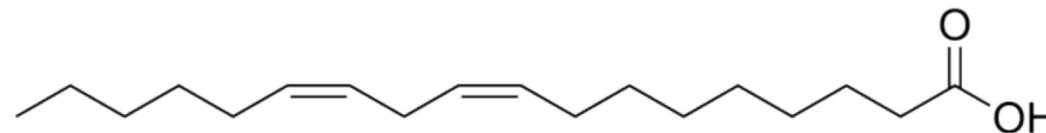


Fig. 9. Linoleic fatty acid.

Fatty acid	Chokeberry seed oil			
	CH_C	CH_US60/12	CH_US90/6	CH_CP
C16:0	6.49 ± 0.08	5.46 ± 0.08	6.46 ± 0.45	6.22 ± 0.13
C18:0	1.57 ± 0.00	1.62 ± 0.05	1.43 ± 0.09	2.60 ± 0.16
C18:1 n-9	17.79 ± 0.11	18.61 ± 0.02	18.12 ± 0.21	24.99 ± 0.06
C18:2 n-6	70.26 ± 0.37	71.95 ± 0.06	71.85 ± 0.04	65.70 ± 0.30
C18:3 n-3	1.88 ± 0.11	0.96 ± 0.01	1.01 ± 0.04	0.76 ± 0.01
other	2.02 ± 0.08	1.41 ± 0.06	1.26 ± 0.00	0.74 ± 0.03
ΣSFA	8.68 ± 0.06 ^a	7.98 ± 0.04 ^a	8.49 ± 0.23 ^a	9.22 ± 0.34 ^a
ΣMUFA	18.22 ± 0.13 ^a	19.07 ± 0.03 ^b	18.48 ± 0.23 ^a	25.32 ± 0.03 ^c
ΣPUFA	73.11 ± 0.18 ^b	72.95 ± 0.06 ^b	73.04 ± 0.01 ^b	65.46 ± 0.03 ^a

Fatty acid	Blackcurrant seed oil			
	BC_C	BC_US60/12	BC_US90/6	BC_CP
C16:0	7.07 ± 0.24	7.17 ± 0.20	7.39 ± 0.01	7.07 ± 0.01
C18:0	1.87 ± 0.00	1.91 ± 0.01	1.88 ± 0.01	3.50 ± 0.01
C18:1 n-9	15.80 ± 0.04	15.81 ± 0.05	15.67 ± 0.04	28.37 ± 0.02
C18:2 n-6	44.99 ± 0.13	44.48 ± 0.10	44.20 ± 0.06	51.90 ± 0.02
C18:3 n-3	12.13 ± 0.04	12.37 ± 0.04	12.30 ± 0.01	4.25 ± 0.01
C18:3 n-6	13.96 ± 0.02	14.07 ± 0.01	14.42 ± 0.04	3.64 ± 0.01
other	4.20 ± 0.05	4.20 ± 0.08	4.17 ± 0.06	1.30 ± 0.06
ΣSFA	11.62 ± 0.25 ^b	11.75 ± 0.21 ^b	11.99 ± 0.02 ^b	11.18 ± 0.01 ^a
ΣMUFA	17.31 ± 0.08 ^b	17.33 ± 0.10 ^a	17.11 ± 0.02 ^b	29.05 ± 0.06 ^c
ΣPUFA	71.07 ± 0.13 ^b	70.92 ± 0.10 ^b	70.91 ± 0.06 ^b	59.78 ± 0.04 ^a

Conclusion

Fruit processing generates large volumes of seed by-products that are often underutilized or discarded. Our results show that chokeberry and blackcurrant seeds should be viewed not as waste, but as valuable agricultural resources. This study highlights that losses occurring after harvest do not have to be avoided only by reduction, but can also be mitigated through valorisation, transforming unavoidable residues into functional ingredients.

Ultrasound-assisted extraction (UAE) proved to be an efficient and environmentally friendly method for recovering high-quality oils from berry seed residues, using less time and less solvent than conventional extraction techniques.

From an agricultural sustainability perspective, UAE enables loss reduction by extending the value chain beyond primary fruit use and juice production.

The oils obtained were rich in polyunsaturated fatty acids, particularly linoleic acid, and showed high oxidative stability and antioxidant capacity, indicating that seed by-products can yield stable, high-value outputs suitable for food, feed, or non-food agricultural applications.

Importantly, US processing preserved sensitive bioactive compounds, demonstrating that low-impact technologies can be integrated into systems.



Thank you



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