CHOKEBERRY (*ARONIA MELANOCARPA* (MICHX.) ELLIOTT) WASTE – FROM WASTE TO FUNCTIONAL PHARMACEUTICAL PRODUCTS

Milica Milutinović[1], Nada Ćujić Nikolić[2], Katarina Šavikin[2], Dragana Pavlović[1], Milica Ranđelović[1], Bojana Miladnović[1], Dušanka Kitić[1]

[1]University of Niš - Faculty of Medicine, Department of Pharmacy, Niš, Serbia
[2]Department for Pharmaceutical Research and Development, Institute for Medicinal Plant Research "Dr. Josif Pančić", Belgrade, Serbia

Due to the high content of various bioactive components, primarily polyphenolic compounds, but also vitamins and minerals, the berries of *Aronia melanocarpa* (chokeberries) exhibit positive effects on human health. The sour taste and astringent properties of chokeberry fruit reduce its direct use as natural fresh fruits (1). The residue left behind during the processing of the chokeberry fruit (chokeberry waste), most often after squeezing the juice, is considered a waste product and as such is not used as nutrition or pharmaceutical product (2). Our research aimed to examine the chemical composition and antioxidative effects of the chokeberry waste extract, as well as to compare the obtained results with the effects and bioactive compounds content of whole chokeberry fruit extract and juice. Dried berries and the waste material were extracted with 50% ethanol under the optimal extraction conditions of the chokeberry polyphenols (3). After the extraction process, the chokeberry extract (CE), waste extract (CWE), and juice (CJ) were lyophilized to further preserve the active principles. Total phenolic, anthocyanins, proanthocyanidins, and flavonoid content were determined using appropriate spectrophotometric methods. The single anthocyanins and flavonoids quantification was carried out by the HPLC method. Antioxidative activity of the chokeberry fruit extracts and juice was determined using two *in vitro* methods, DPPH (1,1-diphenyl-2-picrylhydrazyl) and *β*-carotene-linoleic acid assay (BKL). The largest amount of phenolic compounds was quantified in CWE (702.77±95.30 mgGAE/g). Anthocyanins were the most abundant phenolic compounds in chokeberry preparations. CWE was the richest in anthocyanins (456.82±12.36 mg cyanidin-3-*O*-glucoside equivalents/g) and proanthocyanidins (140.18±8.07 mg catechin equivalent/g), while flavonoid compounds were found in the largest amount in CE (49.36±6.88 mg catechin/g). The highest content of cyanidin-3-*O*-galactoside (6.63±0.23 mg/g) as the most abundant anthocyanin, was also determined in CWE. CWE exhibited the most pronounced antioxidant activity in the DPPH- system (IC_{50}=0.14±0.01 mg/ml). In contrast, another *in vitro* antioxidative method (BKL- test) showed that CWE exhibited the weakest antioxidant activity (IC_{50}=0.68±0.11 mg/ml) compared to the other two chokeberry preparations. Complex intermolecular interactions among the pharmacologically active ingredients of chokeberry fruit, in addition to various human health promotion properties, indicated the required further studies on its chemical composition and biological effects. Some of the biological activities such as antispasmodic, antimicrobial and vasoralaxant were included in our further research. It has been shown that chokeberry waste could be a rich source of bioactive compounds and potentially usable raw material for the preparation of dietary supplements or nutraceuticals, pharmaceutical and cosmetic products.

References:

1. Ćujić N, Kardum N, Šavikin K, Zdunić G, Janković T, Menković N. Potential of Chokeberry (*Aronia melanocarpa* L.) as a Therapeutic Food. In Handbook of Food Bioengieneering; Holban AM, Grumezescu AM, Eds.; Andre GerhardWolff: London, UK, 2018; Volume 8, pp. 209–237.
2. Jurendić T, Ščetar M. *Aronia melanocarpa* Products and By-Products for Health and Nutrition: A Review. Antioxidants 2021; 10:1052.
3. Ćujić N, Šavikin K, Janković T, Pljevljakušić D, Zdunić G, Ibrić S. Optimization of polyphenols extraction from dried chokeberry using maceration as traditional technique. Food Chem. 2016; 194:135–42.

Acknowledgment

The authors would like to thank the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant No: 451-03-9/2021-14/200113) for financial support.

ARONIJA (*ARONIA MELANOCARPA* (MICHX.) ELLIOTT) OTPADNI PROIZVOD – OD OTPADNOG MATERIJALA DO FUNKCIONALNIH FARMACEUTSKIH PROIZVODA

Milica Milutinović[1], Nada Ćujić Nikolić[2], Katarina Šavikin[2], Dragana Pavlović[1], Milica Ranđelović[1], Bojana Miladnović[1], Dušanka Kitić[1]

[1]Univerzitet u Nišu - Medicinski fakultet, IAS Farmacije, Niš, Srbija
[2]Odsek za farmaceutska istraživanja i razvoj, Institut za proučavanje lekovitog bilja "Dr. Josif Pančić", Beograd, Srbija

Zahvaljujući visokom sadržaju različitih bioaktivnih jedinjenja, prvenstveno polifenola, ali i vitamina i minerala, plodovi aronije (*Aronia melanocarpa*) ispoljavaju pozitivne efekte na zdravlje ljudi. Kiseli ukus i adstrigentna svojstva ploda aronije utiču na smanjenje direktne upotrebe ploda kao prirodno svežeg voća (1). Ostaci koji ostanu pri preradi ploda aronije, najčešće nakon ceđenja soka, smatraju se otpadnim proizvodom i kao takvi se ne koriste kao prehrambeni ili farmaceutski proizvod (2). Naše istraživanje imalo je za cilj ispitivanje hemijskog sastava i antioksidativnih efekata ekstrakta otpadnog materijala ploda aronije (ekstrakt ostatka nakon ceđenja soka), kao i upoređivanje dobijenih rezultata sa efektima i sadržajem bioaktivnih jedinjenja u ekstraktu i soku ploda aronije. Osušene plodovi i otpadni materijal ekstrahovani su 50% etanolom pod optimalnim uslovima ekstrakcije polifenola aronije (3). Nakon procesa ekstrakcije, ekstrakt aronije (AE), ekstrakt ostatka nakon ceđenja soka (AOE) i sok (AS) su liofilizovani radi boljeg očuvanja aktivnih principa. Sadržaj ukupnih fenola, antocijanina, proantocijanidina i flavonoida određen je primenom odgovarajućih spektrofotometrijskih metoda. Kvantifikacija pojedinačnih antocijana i flavonoida urađena je pomoću HPLC metode. Antioksidativna aktivnost ekstrakta i soka ploda aronije određena je pomoću dve *in vitro* metode, DPPH (1,1-difenil-2-pikrilhidrazil) i *β*-karoten-linolna kiselina testa (BKL). Najveća količina fenolnih jedinjenja kvantifikovana je u AOE (702,77±95,30 mgGAE/g). Antocijani su bili najzastupljenija fenolna jedinjenja u preparatima aronije. AOE je bio najbogatiji antocijanima (456,82±12,36 mg cijanidin-3-*O*-glukozid ekvivalenata/g) i proantocijanidinima (140,18±8,07 mg katehin ekvivalenta/g), dok su flavonoidna jedinjenja zastupljena u najvećoj količini u AE (49,36±6,88) mg katehina/g). Najveći sadržaj cijanidin-3-*O*-galaktozida (6,63±0,23 mg/g) kao najzastupljenijeg antocijana takođe je utvrđen u AOE. AOE je pokazao najizraženiju antioksidativnu aktivnost u DPPH-sistemu (IC_{50}=0,14±0,01 mg/ml). Nasuprot tome, druga *in vitro* antioksidativna metoda (BKL-test) pokazala je da je AOE ispoljio najslabiju antioksidativnu aktivnost (IC_{50}=0,68±0,11 mg/ml) u poređenju sa druga dva ispitivana preparata aronije. Složene intermolekulske interakcije između farmakološki aktivnih sastojaka ploda aronije, iako oni doprinose očuvanju zdravlja, ukazuju na potrebna dalja istraživanja vezana za hemijski sastav i biološke efekte ovog ploda. Neke od bioloških aktivnosti poput spazmolitičke, antimikrobne i vazorelaksantne, bile su obuhvaćene našim daljim istraživanjima. Pokazano je da bi otpadni proizvodi koji zaostaju pri preradi ploda aronije mogli biti bogat izvor bioaktivnih jedinjenja i potencijalno upotrebljiva sirovina za izradu dijetetskih suplemenata, farmaceutskih i kozmetičkih proizvoda.

Literatura

1. Ćujić N, Kardum N, Šavikin K, Zdunić G, Janković T, Menković N. Potential of Chokeberry (*Aronia melanocarpa* L.) as a Therapeutic Food. In Handbook of Food Bioengieneering; Holban AM, Grumezescu AM, Eds.; Andre GerhardWolff: London, UK, 2018; Volume 8, pp. 209–237.
2. Jurendić T, Ščetar M. *Aronia melanocarpa* Products and By-Products for Health and Nutrition: A Review. Antioxidants 2021; 10:1052.
3. Ćujić N, Šavikin K, Janković T, Pljevljakušić D, Zdunić G, Ibrić S. Optimization of polyphenols extraction from dried chokeberry using maceration as traditional technique. Food Chem. 2016; 194:135–42.

Zahvalnica

Autori se zahvaljuju Ministarstvu prosvete, nauke i tehnološkog razvoja Republike Srbije (Grant No: 451-03-9/2021-14/200113) za finansijsku podršku.