COMPONENT COMPOSITION AND ANTIOXIDANT ACTIVITY OF THE BLACKCURRANT (Ribesnigrum L.) AND APRICOT POMACE (Prunusarmeniaca L.) EXTRACTS

Viktoria Vorobyova1, Margarita Skiba2, Georgii Vasyliev1, Olena Chygyrynets1

1National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”
Prosp.Peremohy-03056, 37, Kyiv, Ukraine
E-mail: vorobyovavika1988@gmail.com
2Ukrainian State Chemical-Engineering University, Dnipro, Ukraine

ABSTRACT

Extracts from the blackcurrant and apricot pomaces were obtained by ultrasound-assisted extraction. Characterization by LC-MS and HPLC methods were performed and total phenolic compounds (TPC), total flavonoid compounds (TFC) and antioxidant activity were assayed. LC-MC and HPLC analysis indicated the presence of phenolic compounds, hydroxycinnamic acids and flavonoids. Various experimental models including iron (III) reducing capacity, total antioxidant capacity, DPPH radical scavenging activity and ABTS•+ radical cation scavenging assay were used for characterization of antioxidant activity of extracts. The blackcurrant and apricot pomaces extracts were tested using cyclic voltammetry (CV).

Keywords: blackcurrants pomace, apricot pomace, phenolic compounds, antioxidant capacity.

INTRODUCTION

Agri-food by-products produced during handling and processing of fruits and vegetables, including cake, pomace, peels, seeds, leaves, bracts, cull fruits and stones, represent a major waste disposal problem for industry [1 - 3]. By-products of agro-food industry can also be a source of “green” organic compounds which have antioxidants and radical scavenging capacity [4]. Accordingly, numerous studies have shown the possibilities of the use of the extractive part of fruit and vegetable wastage in various fields of chemical technology [5 - 7]. For instance, “green” organic substances can be used for synthesis of metal nanoparticles [8 - 11], as a natural preservative and antioxidant in cosmetics and foods products [12 - 14], for inhibition corrosion of metals in corrosive media [15, 16], as functional ingredients in nutraceuticals and dietary supplements [17 - 18].

The blackcurrant and apricot is widely cultivated in Ukraine and other European countries. Besides being consumed fresh, they are grown commercially to be processed into juice, jams, jellies and nutraceutical ingredients. Similarly, pomace account for approximately 40% of the total waste of apricot and 22% of the waste (rind plus seeds) of blackcurrant juice industry [19 - 20]. Considering the compositional profile of apricot and blackcurrant pomace which have been found to be major source of phenolic compounds and flavonoids, organic acids and terpenoid compounds have high potential for being used as antioxidants, “green reductant” to obtain nanoscale materials. Various model systems have been applied to measure the antioxidant activity, redox behavior of plant-based extracts. Different techniques including chemiluminescence, chromatography, fluorescence, spectrophotometry, and spectroscopy are also employed to investigate the role of the antioxidants against free radicals [21].

The critical discussion of the advantages/disadvantages of the seantioxidant activity methods continues to grow; however, the electrochemical approach using cyclic voltammetric technique is attracting attention because of its simplicity, sensitivity, versatility, quick screening, cost-effectiveness, and mechanistic information of redox reaction and the electrochemical behavior [22 - 25]. The literature lacks data on the redox characteristics of blackcurrant and apricot pomace extracts determination by use electroanalytical methods. Therefore, the objectives of this study were to determine the chemical composition profiles of apricot and blackcurrant pomace extracts and evaluate their antioxidant capacity and redox characteristics by use of cyclic voltammetry and spectrophotometric methods.
EXPERIMENTAL

Materials
Blackcurrant and apricot extracts, recovered from the pomace remaining after mechanical pressing of the fresh fruits to produce juices, were assayed for the composition of the main compounds and redox and antioxidant activity.

Reagents
Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2’-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS), 6-hydroxy-2,5,7,8-tetra-methylchroman-2-carboxylic acid (Trolox), quercetin, caffeic acid, naringenin, rutin, chlorogenic acid were purchased from Sigma-Aldrich, St. Luis, Missouri, USA. All solvents used in this investigation were high-performance liquid chromatography grade.

Extract preparation
Blackcurrant or apricot pomaces were mixed with distilled water in 1:10 (w/v) ratio at 25°C. The mixture was placed in the ultrasound bath. Ultrasound-assisted extraction is a strategy to improve the extraction since it can decrease the solvent consumption and extraction time [18]. Because of that, the ultrasound procedure is also considered environmentally friendly. The ultrasound of 27 kHz frequency and 6 W cm\(^{-2}\) intensity was applied for 2 hours. Due to high intensity of sonication the ultrasound cavitation occurs in the solution intensifying the extraction process.

Identification of the Chemical Profile
Liquid chromatography-mass spectrometry analysis (LC-MS)
The obtained extracts were analysed with LC-MC technique. A Finnigan MAT (San Jose, CA, USA) Spectra System P4000 pump was used coupled with a UV6000LP diode array detector and a Finnigan AQA mass spectrometer. Analyses were carried out on a Superspher RP-18, 125×2 mm, 4 μm column (Macherey-Nagel, Germany), protected by a guard column packed with the same material and maintained at 40°C. Analyses were performed using electrospray ionization (ESI) in the positive ion mode, with acquisition set at 12 eV and 50 eV, capillary voltage at 4 kV, source voltage at 4.9 kV, detector voltage at 650 V and probe temperature at 400°C. Eluent A and eluent B were 2.5 % acetic acid and methanol, respectively. The flow rate was 0.33 mL min\(^{-1}\), and the elution programme used was as follows: 0 - 5 min, 0 % B; 5 - 30 min, 100 % B; 30 -35 min, 100 % B.

Determination of total phenolic (TPC) and total flavonoid (TFC) contents
The concentration of phenolic compounds in the extract was determined according to the Folin–Ciocalteu spectrophotometric method [26]. To 100 μL portion of the sample extract (100 mg mL\(^{-1}\)), 3.1 mL of deionized water was added. To this, 0.2 mL of the Folin-Ciocalteu reagent was added and kept as such for 6 minutes. After this, 0.6 mL of 20 % sodium bicarbonate was added and incubated for 1 h at room temperature (RT) (303 ± 1 K) to observe the formation of deep blue colour. All the final values were expressed as milligram gallic acid (GAE) equivalent per gram (mg GAE g\(^{-1}\)). All the measurements were performed in triplicate.

In total flavonoid contents determination (TFC) (Chang et al. 2002), 0.5 mL of 100 mg mL\(^{-1}\) prepared extract was added to 0.1 mL of 10 % aluminium chloride, 0.1 mL of 1 M potassium acetate and 4.3 mL of distilled water. This was incubated at RT (303 ± 1 K) for 30 minutes and then absorbance was measured at 415 nm using an ultraviolet spectrometer (UV-5800PC spectrophotometer, FRU, China). The final values were expressed in milligram quercetin (QCE) equivalent per gram (mg QCE g\(^{-1}\)).

Antioxidant activity
2, 2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay
The method is based on the purification of DPPH by adding radical particles or antioxidants that discolour the DPPH solution. The degree of colour change is proportional to the concentration and potency of the antioxidants. Antioxidant activity is then measured by the decrease in absorption at 517 nm. The BCPE or APE was dissolved in ethanol at various concentrations. Each dilution (0.5 mL) was mixed with 3 ml of an EtOH solution of DPPH (0.1 mmol). The mixture was incubated in the dark at room temperature and the absorbance of the DPPH solution was measured at \(\lambda = 517\) nm to \((A_{\text{control}})\) and 30 minutes after adding the extract (sample). In the blank, ethanol was used in place of the sample; BHT was used as a positive control. The ability to scavenge the DPPH free radical was calculated using the Eq (1):
DPPH radical scavenging activity (%) = 
\[
\frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100
\]  
(1)

2,2′-Azino-bis(3-ethylbenzothiazoline-6-sulphonic acid (ABTS) radical scavenging assay

The method comprises the generation of a blue-green ABTS chromophore by the reaction of ABTS and potassium persulfate. The ABTS cationic radical is generated by the oxidation of ABTS with potassium persulfate, its reduction in the presence of hydrogen donor antioxidants is measured spectrophotometrically at 734 nm. Bleaching analyzes measure the total antioxidant capacity of both lipophilic and hydrophilic substances. ABTS assay [27] was applied with some modifications. A stock solution was prepared by adding 10 mL of 7.4 mM ABTS solution to 10 mL of 2.6 mM K$_2$S$_2$O$_8$ and left at room temperature in the dark for 15 h and then stored at −20°C until required. The working solution was freshly prepared by diluting 1 mL of stock solution with approximately 60 mL of ethanol to obtain an absorbance value of 1.1 ± 0.02 at 734 nm at the day of analysis. The extract was dissolved in ethanol at various concentrations ranging from 0.01 to 0.5 mg mL$^{-1}$. Each dilution (0.1 ml) was mixed with 3 ml of reagent and the absorbance of the ABTS cationic radical was measured at λ = 734 nm ($A_{\text{control}}$) and 60 minutes after adding the extract ($A_{\text{sample}}$). Trolox was used as a positive control. The scavenging activity was calculated using the Eq. 2.

\[
\text{ABTS radical scavenging activity (\%)} = \left(\frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}}\right) \times 100
\]  
(2)

Determination of antioxidant activity in terms of reducing power

Fe(III) reduction is often used as an indicator of the electron donating activity, which is an important indicator of the phenolic antioxidant effect [27]. Extracts, which have reduction potential, react with potassium ferricyanide (Fe$^{3+}$) to form potassium ferrocyanide (Fe$^{2+}$), which then reacts with ferric chloride to form a ferric ferrous complex that has an absorption maximum at 700 nm. To prepare the reaction solution, different amounts of the extract (0.005, 0.01, 0.015, 0.02 and 0.025 g) were dissolved in an appropriate solvent (1 mL) plus 1 ml phosphate buffer (0.2 M, pH 6.6) and 1 mL of potassium ferricyanide solution (1 %). The resulting solution was incubated at 323 K for 20 minutes. Then, 1 mL of trichloroacetic acid (10 %) was added to terminate the reaction and was quenched under running water for 5 min. The resulting mixture was centrifuged at 3000 rpm for 10 min. An aliquot of 2 mL was then removed from the top layer of each solution, to which 2 mL of distilled water and 0.4 mL of ferric chloride solution (0.1 %) were added. The solution absorbance was measured at 700 nm. Increasing absorbance of the reaction mixture indicates an increase in the reducing power.

Determination of total antioxidant capacity by phosphomolybdenum method

The total antioxidant capacity of the BCPE was evaluated by the phosphomolybdenum method as described by the method of Prieto et al. [28]. The analysis is based on the reduction of Mo (VI) to Mo (V) with an extract and, as a consequence, the formation of a green phosphate/Mo (V) complex at acidic pH. The volume of the extract to the reagent was 1:10, 0.5 mL of each sample solution and ascorbic acid (100 μg mL$^{-1}$) was taken for the experiment with 5 mL of reagent (0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). The blank solution contained 5 mL of the reagent solution and the corresponding volume of the solvent used, which was applied to the sample. All the tubes were closed and incubated in a boiling water bath at 95°C for 90 minutes. After the samples had been cooled to room temperature, the absorbance of the solution of each sample was measured at 695 nm against the blank using a UV-Vis spectrophotometer (UV-5800PC spectrophotometer, FRU, China).

Electroanalytical assays

The electrochemical activity of the extracts was studied using the electrochemical technique of cyclic voltammetry. The three-electrode system is composed of Glassy Carbon Electrode (GCE) as the working electrode, a saturated silver chloride electrode (E = +0.2 V/ NHE) as the reference electrode and a platinum plate as an auxiliary electrode. The potential scan rate was 100 mV s$^{-1}$ in the potential range from 0 to +1.0 V/SSCE. The portion of the extract was mixed with acetate buffer 0.1 M (pH 4) and NaClO$_4$ (70:28:2).

HPLC-DAD analysis of blackcurrant and apricot pomace extracts

The identification and quantification of phenolic compounds in the blackcurrant and apricot pomace ex-
tracts were performed by HPLC-DAD [29]. For HPLC analysis, 1 g dry mass sample was mixed with 10 mL distilled water followed by filtration using nylon syringe filter (pore size 0.45 µm). Chromatographic separation was performed on an ACE 5 C18 column (Bath V13-7473) (250 mm x 4.6 mm, 5-µm particle size, 110 Å particle porosity). The column temperature was 35°C and the flow rate was constant at 1.2 mL min⁻¹. The mobile phase was composed of 0.1 % (v/v) water:formic acid (mobile phase A) and acetonitrile (mobile phase B). The elution conditions were as follows: 0 - 15 min, B from 8 % to 30 % (5 min); 22 - 35 min, B from 30 % to 70 % (10 min); and 35 - 40 min, B from 70 % to 8 %. The DAD recorded the spectra from 200 nm to 400 nm and quantification was performed using the following specific wavelengths: 270 (Rutin and Naringenin) and 313 nm (caffeic acid and chlorogenic acid). The hydroxycinnamic acids were quantified using a calibration curves with caffeic acid (linearity range 0 - 1.2 mg mL⁻¹; \( R^2 = 1.0 \)) and chlorogenic acid (linearity range 0 - 1.5 mg mL⁻¹; \( R^2 = 1.0 \)) as external standard (purity ≥ 99 %). The content of Rutin and Naringenin were determined using a calibration curves with Rutin (linearity range 0 - 0.2 mg mL⁻¹; \( R^2 = 1.0 \)) and Naringenin(linearity range 0 - 1.0 mg mL⁻¹) as external standard (purity ≥ 95 %).

### Statistical analysis

Statistical analysis of the experimental data was performed using soft-ware SPSS for Windows version 22.0 (IBM SPSS Inc., Chicago, IL, USA). Data were analyzed using a one-way analysis of variance (ANOVA). The difference between means (p < 0.05) was determined using the multiple-comparison Tukey’s HSD (honestly significant difference) multiple comparison test.

### RESULTS AND DISCUSSION

**Characterization of blackcurrant and apricot pomace extracts**

The water extracts from blackcurrant and apricot pomace extracts were analysed by liquid chromatography-mass spectrometry (LC-MS). The relative retention times (Rt) and mass spectra of the extracts components were compared with those of authentic samples and with mass spectra from a data library. The result of LC-MS of the blackcurrant pomaces extract is exhibited in Table 1 and Fig. 1.

Black currant pomaces extract mainly consists of phenolic compounds, predominantly chlorogenic acid (5.4 %), protocatechuic acid (15.6 %) and caffeic acid (10.1 %) and minor quantities of flavonoids.

Phenolic derivatives and anthocyanidins were detected in the water extract of apricot pomace by LC-MS (Table 2, Fig. 2). Chlorogenic acid (4.6 %), Catechin (5.8 %) and Caffeicacid (8.2 %) were found in large amounts in the sample of apricot pomace extract. This extract is characterized by the presence of phenolic compounds such as Quinic acid (7.1 %), Kaempferol (5.6 %).

Chlorogenic acid is the predominant phenolic acid present in the blackcurrant and apricot pomaces extract along with other hydroxycinnamic acids and its derivatives such as caffeic acid, p-coumaroylquinic, 1-caffeoylquinic acid.

The chemical molecular structures of the predominant compounds identified in the studied blackcurrant and apricot pomace extracts are presented in Table 3.

Higher phenolic concentration and total flavonoid content in blackcurrant and apricot pomaces were observed, and thus these pomaces could be used as potential sources of natural antioxidants.
content was found in blackcurrant pomace extract. The total phenolic content of the black currant pomaces extract was 69 ± 0.03 mg GAE g⁻¹ of the extract, and the total flavonoid content was 51.3 ± 0.10 mg QCE g⁻¹ of the extract (Fig. 3). The total phenolic content of the apricot pomace extract was 15.43 ± 0.03 mg GAE g⁻¹ of the extract, and the total flavonoid content was 11.9 ± 0.10 mg QCE g⁻¹ of the extract (Fig. 3).

Several studies have shown that phenolic compounds are highly effective as antioxidants [3, 12, 18, 22, 26, 33, 34]. Thus, the analysis of the composition of the aqueous black currant and apricot pomaces extracts indicate that it contains a wide range of organic substances and therefore is a potential raw material for the use as source of antioxidants.

### Table 1. LC-MS analysis result of aqueous blackcurrant pomaces extract.

<table>
<thead>
<tr>
<th>Compound</th>
<th>RT (min)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocatechuic acid</td>
<td>6.69</td>
<td>15.6</td>
</tr>
<tr>
<td>Caffeic acid</td>
<td>8.04</td>
<td>10.1</td>
</tr>
<tr>
<td>Naringenin</td>
<td>8.10</td>
<td>5.4</td>
</tr>
<tr>
<td>Apigenin</td>
<td>9.28</td>
<td>8.8</td>
</tr>
<tr>
<td>p-Coumaroylquinic acid</td>
<td>9.53</td>
<td>0.8</td>
</tr>
<tr>
<td>Chlorogenic acid</td>
<td>9.66</td>
<td>5.4</td>
</tr>
<tr>
<td>Ferulic acid-O-glucoside</td>
<td>9.90</td>
<td>0.9</td>
</tr>
<tr>
<td>Isoquercitrin (quercetin-3-O-glucoside)</td>
<td>11.56</td>
<td>7.1</td>
</tr>
<tr>
<td>Kaempferol-O-glucoside</td>
<td>10.12</td>
<td>1.4</td>
</tr>
<tr>
<td>Cyanidin-3-O-glucoside</td>
<td>10.35</td>
<td>8.7</td>
</tr>
<tr>
<td>Cynaroside (luteolin-7-O-glucoside)</td>
<td>10.68</td>
<td>10.1</td>
</tr>
<tr>
<td>Narirutin (naringenin-7-O-rutinoside)</td>
<td>11.73</td>
<td>2.4</td>
</tr>
<tr>
<td>Naringenin-O-diglucoside</td>
<td>12.43</td>
<td>16.9</td>
</tr>
<tr>
<td>Quercetin 3-O-diglucoside</td>
<td>12.73</td>
<td>5.8</td>
</tr>
</tbody>
</table>

![Fig. 2. LC-MS spectrum for aqueous apricot pomaces extract.](image1)

![Fig. 3. Total phenolic compounds (TPC) and total flavonoid content (TFC) in the blackcurrant (1) and apricot pomace (2) extract. (TPC content expressed as mg gallic acid equivalent g⁻¹ of dry fraction of extract; TFC expressed as mg quercetin equivalent g⁻¹ of dry fraction of extract).](image2)
The identification of these compounds is important in order to try to identify which components can be responsible for antioxidant activity. Detailed extensive phytochemical characterization studies are necessary to identify these compounds and understand their antioxidant activity in plant extracts. Table 4 shows the content of selected compounds: naringenin, caffeic acid, rutin, chlorogenic acid identified and quantified by HPLC-DAD. The blackcurrant and apricot pomace extracts are characterized by being abundant in caffeic acid 10.472 and 8.261 μg/g (Table 4).

In the case of extract from black currant pomace, rutin were the dominating constituent, their content amounted 310.8 μg mL⁻¹. The blackcurrant also presented the highest levels of naringenin (233.21 μg g⁻¹) and chlorogenic acid (517.02 μg g⁻¹) when compared to the apricot pomaces extract.

Both HPLC-DAD analysis and LC-MS confirmed that the extract contains phenolic compounds. Caffeic acid, chlorogenic acid, p-coumaricacid are widely distributed in berry crops as natural antioxidants [30 - 31].

Reducing power is associated with the antioxidant activity and can serve as a significant reflection of antioxidant activity (Fig. 4.). Higher absorbance of the reaction mixture indicates a higher reductive potential. Fig. 4 shows the concentration-absorbance relation

<table>
<thead>
<tr>
<th>Compound</th>
<th>RT (min)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,4-dihydroxybenzaldehyde</td>
<td>13.99</td>
<td>3.4</td>
</tr>
<tr>
<td>4-Hydroxybenzoic acid</td>
<td>14.93</td>
<td>3.8</td>
</tr>
<tr>
<td>Caffeic acid</td>
<td>15.14</td>
<td>8.2</td>
</tr>
<tr>
<td>3,4-dimethoxybenzoic acid</td>
<td>15.92</td>
<td>5.7</td>
</tr>
<tr>
<td>Quinic acid</td>
<td>16.99</td>
<td>3.1</td>
</tr>
<tr>
<td>Kaempferol (3,4',5,7tetrahydroxyflavone)</td>
<td>17.85</td>
<td>3.4</td>
</tr>
<tr>
<td>Naringenin</td>
<td>18.13</td>
<td>5.5</td>
</tr>
<tr>
<td>Catechin</td>
<td>18.58</td>
<td>5.8</td>
</tr>
<tr>
<td>Epicatechin</td>
<td>19.18</td>
<td>7.2</td>
</tr>
<tr>
<td>Caffeicacid-O-glucoside</td>
<td>21.30</td>
<td>5.8</td>
</tr>
<tr>
<td>Delphinidin</td>
<td>19.27</td>
<td>11.8</td>
</tr>
<tr>
<td>Chlorogenic acid</td>
<td>19.78</td>
<td>6.8</td>
</tr>
<tr>
<td>Neochlorogenic acid</td>
<td>22.51</td>
<td>2.9</td>
</tr>
<tr>
<td>I-Caffeoylquinic acid</td>
<td>22.53</td>
<td>4.6</td>
</tr>
<tr>
<td>Kaempferol-O-glucoside</td>
<td>23.00</td>
<td>4.7</td>
</tr>
<tr>
<td>Malvidin 3-O-glucoside</td>
<td>23.43</td>
<td>6.8</td>
</tr>
<tr>
<td>Rutin</td>
<td>23.96</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Table 2. LC-MS analysis result of aqueous apricot pomes extract.

Table 3. Chemical structures of the main constituents of blackcurrant and apricot pomace extracts.

![Chemical structures](image)

Caffeic acid | Chlorogenic acid | Naringenin

Table 4. Concentration of phenolic compounds (μg g⁻¹).

<table>
<thead>
<tr>
<th>Extract</th>
<th>Naringenin</th>
<th>Caffeic acid</th>
<th>Rutin</th>
<th>Chlorogenic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black currant pomace extract</td>
<td>233.21</td>
<td>10.472</td>
<td>310.8</td>
<td>517.02</td>
</tr>
<tr>
<td>Apricot pomace extract</td>
<td>104.78</td>
<td>8.261</td>
<td>-</td>
<td>704.65</td>
</tr>
</tbody>
</table>
for the reducing powers of the extract. The reducing power of the extract increased with an increase in their concentrations.

**Voltammetric characterization and redox profile**

The antioxidants properties of the extracts have connection with their redox behavior and the electrochemical behaviour [23 - 25, 32]. Thus, in this work the electrochemical oxidation of the blackcurrant and apricot pomace extracts was tested.

The cyclic voltammograms for the blackcurrant and apricot pomace extracts showed no clear reversible peaks but only gave a shoulder and a monotonously increasing peak (Fig. 5). The potentials of anodic oxidation of the compounds (E\text{a}_1) were given preliminary from the anodic wave of the voltammogramme. A number of parameters can be extracted from the cyclic voltammetry curves to characterise the apricot pomace and blackcurrant pomace extracts as antioxidants (Table 5). The top scan represents the oxidation of the compounds that are contained in the extracts, generating a positive (anodic) current I\text{a} = 3 \, \mu\text{A}, peaking at a particular electrode potential E\text{a}_1 = 0.52 \, \text{V} and E\text{a}_1 = 0.7 \, \text{V} for blackcurrant and apricot pomace extract, respectively (Table 5). Thus, the antioxidant capacity is higher for aqueous black currant pomace extract than that for apricot pomace extracts.

On the reverse scan a negative (cathodic) peak is not produced, this indicates that the oxidized form of the compounds contained in the extract cannot be reduced back to its original form [23, 32].

Both the extracts were evaluated for antioxidant activity using phosphomolybdate assay. The total antioxidant activity is 560.96 ± 1.01 and 370.45 ± 1.01 mg of ASE g\text{-1} of the apricot pomace and blackcurrant extract, respectively. The total antioxidant activity of blackcurrant and apricot pomaces extracts is the result of the total amounts individual activities of each of the antioxidant compounds present such as phenolic acids, flavonoids the latter being the major phytochemicals responsible for the antioxidant activity of plant materials.

To compare the antioxidant potential of the aqueous black currant and apricot pomaces extracts, DPPH and ABTS radical scavenging activities, were tested, being the results presented in Fig. 6 and Fig. 7. BHT (butylated hydroxyl toluene) and Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) were used as a positive control.

### Table 5. Cyclic voltammetry characteristics of aqueous black currant and apricot pomaces extracts.

<table>
<thead>
<tr>
<th>Extract</th>
<th>I\text{a}(\mu\text{A})</th>
<th>E\text{a}_1(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black currant pomace extract</td>
<td>3</td>
<td>0.52</td>
</tr>
<tr>
<td>Apricot pomace extract</td>
<td>3</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Fig. 4. Reducing power of the aqueous black currant and apricot pomaces extracts.

Fig. 5. Cycling voltammogram for the black currant and apricot pomace aqueous extractsin acetate buffer 0.1 M (pH 4) and NaClO\text{4}. Scan rate 100 mV s\text{-1}.
The blackcurrant pomace extract demonstrated a higher antioxidant capacity for all the assays. These differences can be due to the higher antioxidant capacity polyphenols of blackcurrant. The concentration bound phenolics of the sample blackcurrant pomace extract were higher than the free phenolics concentration, which probably provides higher antioxidant properties. The DPPH scavenging activity (%) of blackcurrant extract 60.2 %, and apricot pomaces extract 41.5 % at 80 mg mL\(^{-1}\). The results are in good accordance with polyphenolic and flavonoid content, where a similar trend was observed. In present study, ABTS scavenging activity (%) of extracts were found to vary from 31.5 % - 50.1 % at a concentration of 80 mg mL\(^{-1}\) (Fig. 7). Trolox has been used as a positive control having compelling ability to scavenge ABTS free radicals with % inhibition of 97.5 at 80 mg mL\(^{-1}\). Thus, the ABTS scavenging activity was higher for aqueous blackcurrant extracts than that for apricot pomaces extract.

**CONCLUSIONS**

According to LC-MS and HPLC-DAD analyses the main components of the black currant and apricot pomaces extract are as follows: phenolic compounds, hydroxycinnamic acids and flavonoids. Chlorogenic acid and caffeic acid were the major hydroxycinnamic acid in black currant and apricot pomace extracts. The blackcurrant and apricot pomace extracts possessed the antioxidant activities, which were proven by commonly used antioxidant assays. The voltammetric profile obtained for each extract showed distinguishable features that were correlated with their main markers, being also useful for evaluation antioxidant activity.

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