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# Effect of solvents extraction on phenolic content and antioxidant activity of the byproduct of eggplant

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ABSTRACT

Eggplant is one of most common vegetables consumed all around the world. This study has assayed antioxidants from the byproduct (peel) of eggplant (*Solanum melongena*), using three extraction solvents: 70% methanol, 70% ethanol and 70% acetone. For each solvent, content of total phenolics, flavonoids, tannins, and total anthocyanins were quantified. Antioxidant activity of different extracts were screened using the ferric reducing power, 1,1-diphenyl-2-picryl hydrazyl (DPPH•) radical scavenging, hydrogen peroxide ($H_2O_2$) scavenging and metal chelating activities. The results showed that 70% methanol is the best solvent for the extraction of anthocyanins (82.83 ± 1.07 mg DGE/100 g DP), whereas, 70% acetone is the best solvent for the extraction of total phenolics, flavonoids and tannins (29.3 ± 1.23 mg GAE/100 g DE; 18.5 ± 0.07 mg QE/100 g DE and 5.37 ± 0.22 mg TAE/100 g DE, respectively). Anthocyanic extracts have exhibited the higher reducing power (39 ± 2.5 mg QE/100 g DE) and scavenging activity ($IC_{50}$ = 2.88 ± 0.02 mg/mL), whereas the phenolic extracts have shown the highest metal chelating activity (18.53 ± 0.4%).



## 1. Introduction

Antioxidant components are microconstituents present in the diet that can delay or inhibit lipid oxidation, by inhibiting the initiation or propagation of oxidizing chain reactions, and are also involved in scavenging free radicals (Othman et al., 2007). Epidemiological studies have shown that high fruit and vegetable consumption has health benefits in the prevention of chronic diseases (Cheel et al., 2007). These foods are reported to contain a wide variety of antioxidant components, including phenolic compound (Arancibia-Avila et al., 2008). Phenolics are antioxidants with redox properties, which allow them to act as reducing agents, hydrogen donators, and singlet oxygen quenchers. They have also metal chelation properties (Proestos et al., 2006). The oxygen consumption inherent in cell growth leads to generation of a series of reactive oxygen species (ROS), these ROS are molecules such as superoxide anion radicals ($O^{\bullet}_2$) and hydroxyl radicals ($OH^{\bullet}$). However, non free radical species such as hydrogen peroxide ($H_2O_2$) and singlet oxygen ($^1O_2$) are formed *in vivo* also. Both oxygen species play a positive role in energy production, phagocytosis, regulation of cell growth intercellular signaling, and synthesis of biologically important compounds (Gülçin et al., 2005). However during oxidative stress, large amounts of these ROS can be products and may be dangerous because of their ability to attack numerous molecules, including proteins, lipids (Halliwell et al., 1992) and DNA (Gülçin et al., 2005).

Eggplant, *Solanum melongena*, is a common and popular vegetable crop grown in the subtropics and tropics (Sarker et al., 2006). Eggplant is native to southeastern Asia and great proportion of world production is produced in Asia and Mediterranean basin. The most cultivated variety in Algeria is the elongated ovoid in a dark purple skin. Its fruit is primarily used as a cooking vegetable for the various dishes all over the world (Demir et al., 2002; Hanson et al., 2006). It contains ascorbic acid and phenolics, both of which are powerful antioxidants (Vinson et al., 1998). Studies have shown that eggplant extracts suppress the development of blood vessels required for tumor growth and metastasis (Matsubara et al., 2005), and inhibit inflammation that can lead to atherosclerosis (Han et al., 2003).

Different solvent systems have been used for the extraction of polyphenols from plant material. The yield and antioxidant activity of natural extracts is dependent on the solvent used for extraction. Several procedures have been proposed (Pokorny and Korczak, 2001): extraction using fats and oils, organic solvents, aqueous alkaline solutions and supercritical carbon dioxide.

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Aqueous mixtures of ethanol, methanol and acetone, are commonly used (Hayouni et al., 2007). Wang and Helliwell (2001) reported that aqueous ethanol was superior to methanol and acetone for extracting flavonoids from tea. However, in another work, water was found to be better solvent, for extracting tea catechins, than were 80% methanol or 70% ethanol (Hayouni et al., 2007). For this reason, the extraction method of phenolics differs from plant substrate to another and an ideal extraction method for particular phenolic classes has to be individually designed and optimized.

The choice of our investigation is based on two criteria: first, to enhance the peel (byproduct) of eggplant, which is a good source of bioactive substances (anthocyanins) as long as the Algerian people do not consume it. Therefore the first objective of this study is to evaluate several types of phytochemicals that are present in the dried powder of peel eggplant. The second criterion is to select the solvent that led to the extracts with the highest antioxidant capacity.

In this study extracts were obtained from dried powder of peels eggplant using different organic solvents: 70% methanol, 70% ethanol and 70% acetone. Efficiency of extraction was determined by measuring the total phenols, flavonoids, tannins, total anthocyanin and antioxidant activity (ferric reducing power, scavenging effect of 1,1-diphenyl-2-picryl hydrazyl (DPPH•) radical, scavenging capacity of hydrogen peroxide and metal chelating activity).

## 2. Materials and methods

### 2.1. Chemicals and sample preparation

All chemicals were purchased from Sigma (represented by Algerian Chemical Society, Setif, Algeria). Fresh eggplant (*S. melongena*) was purchased from local market, Bejaia city, Algeria. A previously developed method described and suggested peel separation from pulp tissue by immersion in ethylene glycol at 35 °C. But this practice did not preserve anthocyanin from polyphenol oxidase oxidative activity (Spagna et al., 2003), for this reason peels were removed using a sharp knife (Todaro et al., 2009), dried in the drying oven at 40 °C during 4 days, and ground to granulometry lower than 250 μm.

### 2.2. Quantification of antioxidants

#### 2.2.1. Carotenoids

Carotenoids are pigments insoluble in water and soluble in apolar solvents like hexane. The carotenoids content was evaluated by Soto-Zamora et al. (2005) method. 10 mL of solvent mixture (hexane, acetone and ethanol, 1:5/2:5/2, v/v/v) were added to 0.5 g of dried powder. After 3 min of stirring, 1 mL of potassium hydroxide (KOH, 1 M) was added and the mixture was incubated during 40 min, then the absorbance of upper phase was determined at 450 nm. β-Carotene was used as the standard and the results were expressed as mg β-carotene equivalent per 100 g of dry powder (mg βCE/100 g DP).

#### 2.2.2. Anthocyanins

10 mL of solvents (70% methanol, 70% ethanol and 70% acetone) containing 0.2% of formic acid were added to 1 g of dried powder. After stirring for 40 min, the homogenized samples were then centrifuged at 5000 rpm for 20 min at 4 °C. 5 mL of different solvents were added to the pellet, the same operation was repeated, then the supernatants were collected (Wang et al., 2008).

Total anthocyanins were determined by a pH differential method (Prior et al., 1998). Absorbance was measured at 510 nm and at 700 nm in buffers at pH 1.0 and 4.5. The concentration of anthocyanins was obtained using the following equation:

$$C\ \ (\mathrm{mg/l}) = \frac{A \cdot MW \cdot DF \cdot 1000}{\Sigma L}$$

where $A = [(A_{510} - A_{700})\ \mathrm{pH}_{1.0} - (A_{510} - A_{700})\ \mathrm{pH}_{4.5}]$, $MW$ (molecular weight) of delphinidin-3-glucoside (465 g/mol), $\Sigma$ is the molar extinction coefficient of delphinidin-3-glucoside (29,000 L/mol/cm), $DF$ is the dilution factor and $L$ is the length of vessel (1 cm).

Results were expressed as delphinidin-3-glucoside equivalent per 100 g of dry powder (mg DGE/100 g DP).

### 2.3. Phenolic compounds

#### 2.3.1. Preparation of the extracts

Dried powder (0.5 g) was extracted with 50 mL of 70% methanol, 70% ethanol and 70% acetone. The extraction was carried out at room temperature, using magnetic blender. After 40 min, the solution was centrifuged for 25 min at 4000 × *g* (10 °C), the supernatant was filtered (Whatman paper no. 4) and stored under refrigerated conditions until used.

#### 2.3.2. Quantification

The amount of total phenolics in the extract was determined using the Folin–Ciocalteu reagent and gallic acid as standard as described by Singleton and Rossi (1965).

The total flavonoids content was determined by the methodology of Quettier-Deleu et al. (2000) and quercetin was used as standard.

Tannins were estimated spectrophotometrically according to the protocol developed by Hagerman and Butler (1978) and tannic acid was used as standard. All analyses were performed in triplicate and the mean value was calculated.

### 2.4. Antioxidant activity

Several methods have been developed to assay free radical scavenging capacity and total antioxidant activity of plant extracts. The most common and reliable method involves the determination of the disappearance of free radicals using a spectrophotometer. In our study, we used four methods: reducing power, metal chelating activity, scavenging of the radical DPPH and $H_2O_2$ activities.

#### 2.4.1. Free radical-scavenging activity

The ability of the extracts to scavenge DPPH free radicals was determined by the method of Suja et al. (2005). 100 μL of various concentrations of the samples were mixed with 3 mL of DPPH in methanol (0.1 mM). After 30 min of incubation in the dark and ambient temperature, absorbance was measured at 515 nm. The percentage scavenging was calculated according to the following equation:

$$\%\mathrm{Scavenging} = \left[\frac{\mathrm{Abs}_{\mathrm{contr}} - A_{\mathrm{extr}}}{A_{\mathrm{contr}}}\right] \times 100.$$

where $\mathrm{Abs}_{\mathrm{contr}}$ is the absorbance of the control (without extract) after 30 min and $A_{\mathrm{extr}}$ is the absorbance of extract after 30 min. $IC_{50}$ was calculated as the concentration of extracts causing a 50% inhibition of DPPH radical.

#### 2.4.2. Reducing power

The reducing power of the extracts was evaluated according to the protocol of Hseu et al. (2008). 1 mL of different concentrations of the samples was mixed with phosphate buffer (1 mL, 0.2 M, pH = 6.6) and potassium ferricyanide [$K_3Fe(CN)_6$] (1 mL, 1 g/100 mL). The mixture was incubated at 50 °C for 20 min.

Trichloroacetic acid (TCA) (1 mL, 10 g/100 mL) was added to the solution which was then centrifuged for 10 min at 3000 × *g*. The supernatant was gathered and mixed with distilled water (1.5 mL) and $FeCl_3$ (150 μL, 0.1 g/100 mL), and the absorbance was measured at 700 nm, increased absorbance of the reaction mixture indicated increased reducing power. Results are expressed as mg quercetin equivalent per 100 g of dried extract (mg QE/100 g DE).

#### 2.4.3. $H_2O_2$ assay

$H_2O_2$ scavenging ability of the different extracts was determined according to Yousfi et al. (2006) method with slight modifications. 1.5 mL of different extracts were mixed with 0.02 mL of 30% of $H_2O_2$ solution. Absorbance was read at 530 nm at different times (5–60 min). Decreased absorbance of the reaction mixture indicated increased in scavenging ability. The percentage of inhibition of $H_2O_2$ radical is calculated using the following equation:

$$\%\,\text{Inhibition of } H_2O_2 = \left(\frac{\text{Abs}_{\text{contr}} - \text{Abs}_{\text{ext}}}{\text{Abs}_{\text{contr}}}\right) \times 100$$

where $\text{Abs}_{\text{contr}}$ is the absorbance of the control (without $H_2O_2$) and $\text{Abs}_{\text{ext}}$ is the absorbance in the presence of the extracts, then the time required to inhibit 50% ($IT_{50}$) of $H_2O_2$ radical was determined.

#### 2.4.4. Metal chelating activity

The chelating of ferrous ions by phenolic and anthocyanin extracts was estimated by the method of Lim et al. (2007). Accordingly, 1 mL of 0.125 mM $FeSO_4$ was added to 1 mL of 0.3125 mM ferrozine and 1 mL of different extracts. The mixture was shaken vigorously and left standing at room temperature for 10 min. The Absorbance of the solutions was then measured spectrophotometrically at 562 nm. The percentage of inhibition of ferrozine–$Fe^{2+}$ complex formation was calculated using the formula given bellow:

$$\%\,\text{Inhibition} = \left(\frac{A_{\text{contr}} - A_{\text{ext}}}{A_{\text{contr}}}\right) \times 100$$

where $A_{\text{contr}}$ is the absorbance of the control, and $A_{\text{ext}}$ is the absorbance in the presence of the extracts. The control does not contain $FeSO_4$ and ferrozine, complex formations molecules.

### 2.5. Statistical analysis

All experiments were conducted in triplicates and results are expressed as mean ± standard deviation (SD). Analysis of variance was performed by ANOVA procedure with one factor for the determination of phenolic and anthocyanin contents, the scavenging of DPPH and the metal chelating activities. Statistical analysis of the reducing power and scavenging of $H_2O_2$ were performed by analysis of variance with two factors in the software STATISTICA 5.5 Fr.

## 3. Results and discussion

### 3.1. Antioxidant concentrations

#### 3.1.1. Anthocyanins content

Anthocyanins are the largest class with antioxidant activity in the peel eggplant (Yi et al., 2009). Therefore, it is necessary to extract them efficiently. For this purpose, three solvents were chosen (70% acidified methanol, 70% acidified ethanol and 70% acidified acetone). Table 1 shows the contents of the three anthocyanin extracts, which are significantly different ($p < 0.05$), they are about 51.56 ± 4.87 and 82.83 ± 1.07 mg DGE/100 g DP for acetone and methanolic extracts, respectively. Value obtained for ethanolic extract is about 62.92 ± 0.15 mg DGE/100 g DP. Todaro et al. (2009) reported a value of 76.44 ± 3.82 mg of delphinidin-3-rutinoside equivalent/100 g of fresh peel, using acidified ethanol as solvent. However, a study on the whole fruit of eggplant, has shown a content of 0.53 ± 0.012 mg cyanidin-3-glucoside equivalent/100 g of fresh fruit (Nisha et al., 2009). This data confirms that anthocyanins are concentrated in the peel of the fruit.

#### 3.1.2. Carotenoids content

The high hydrophobicity of carotenoids determines their distribution in the cellular environment, these compounds are associated with lipid bilayer membranes. The carotenoids content of the sample was about 0.74 ± 0.013 mg EβC/100 g DP. No results have been published on the carotenoids composition of the peel eggplant. However, Couplan (1998) reported a value (0.65 mg/100 g of fresh weight of eggplant fruit) close to that obtained in the present study. These results show that carotenoids are concentrated in the peel of the fruit.

#### 3.1.3. Phenolic contents

*3.1.3.1. Total phenolic contents.* Total phenolic contents varied in the different extracts (Table 1). It is about 29.39 ± 1.23 mg GAE/100 g DE, 26.61 ± 0.67 mg GAE/100 g DE and 13.53 ± 0.21 mg GAE/100 g DE, for 70% aqueous acetone, 70% aqueous methanol and 70% aqueous ethanol, respectively. Todaro et al. (2009) found that the phenolic content of acidified ethanolic extract of fresh eggplant peels is 188.73 ± 73 μg GAE/mL of extract. In the other hand, Nisha and his collaborators (2009) have reported 49.02 ± 1.3 mg GAE/100 g DE in the methanolic extract and Eun-Ju et al. (2011) have found 55.19 ± 1.3 mg GAE/100 g DE in 70% ethanolic extract of fresh eggplant peel. These values are significantly higher than those obtained in our study. These differences in phenolic contents might be due to the condition of the peel fruit (fresh or dried).

*3.1.3.2. Flavonoids contents.* Flavonoids contents of different extracts are given in Table 1. There was a significant difference between flavonoids content of acetonic extract and the two other extracts ($p < 0.05$); but there is no difference between methanolic and ethanolic extracts ($p < 0.05$). The highest level has been detected in acetonic extract (18.52 ± 0.07 mg QE/100 g DE), followed by methanolic and ethanolic extracts (16.26 ± 0.26 and 16.13 ± 0.12 mg QE/100 g DE, respectively). Eun-Ju et al. (2011) have estimated the total flavonols contain in 70% ethanol extract of fresh peel eggplant, they found about 6.19 ± 0.28 mg catechin equivalent/100 g DE. No results have been published on the flavonoids content of the peel eggplant.

*3.1.3.3. Tannins content.* Results shown in Table 1 reveals a significant difference between tannin contents of the three solvents extracts ($p < 0.05$). Indeed, content of 70% acetone extract present the highest level among the three extracts, it is about 5.37 ± 0.22 mg TAE/100 g DE, followed by the methanol extract with a value of 4.26 ± 0.28 mg TAE/100 g DE; the ethanol extract has the lowest content (3 ± 0.11 mg TAE/100 g DE). No results have been published on the tannins composition of the peel eggplant. However, Alkurd et al. (2008) obtained 413.7 mg TAE/100 g DE in the eggplant whole fruit, this content is 100 times higher than that obtained in our study.

The levels of antioxidants in peel eggplant are significantly different ($p < 0.05$). They are classed as follows: Anthocyanins > total polyphenols > flavonoids > tannins > carotenoids. The results of different extracts shows that peel of eggplant contain the highest level of anthocyanins in comparison with the total polyphenols, tannins, flavonoids and carotenoids; these data indicate that the majority of polyphenols from the peel of eggplant are anthocyanins. Because anthocyanins belong to the group of polyphenols and flavonoids subgroup, the highest content of anthocyanins, compared to that

**Table 1**
Concentration of antioxidants in peel eggplant.

| Solvents | Total phenolic (mg GAE/100 g DE) | Flavonoids (mg QE/100 g DE) | Tannins (mg TAE/100 g DE) | Anthocyanins (mg βCE/100 g DM) |
|---|---|---|---|---|
| Methanol | 26.61 ± 0.67[b] | 16.26 ± 0.26[b] | 4.26 ± 0.28[b] | 82.83 ± 1.07[a] |
| Ethanol | 13.53 ± 0.21[c] | 16.13 ± 0.12[b] | 3 ± 0.11[c] | 62.92 ± 0.15[b] |
| Acetone | 29.39 ± 1.23[a] | 18.52 ± 0.07[a] | 5.37 ± 0.22[a] | 51.56 ± 4.87[c] |

Values are averages ± standard deviation of triplicate analysis; different letters in same column indicate significant difference ($p < 0.05$). Results are ranked in ascending order; a > b > c.

of total polyphenols and flavonoids, can be explained by the conditions of extraction of anthocyanins (Brouillard and Dubois, 1977).

### 3.2. Antioxidant activity of the extracts

#### 3.2.1. Free radical scavenging activity

Solvents used for polyphenol extraction had significant effects on DPPH scavenging capacity determination for peel eggplant (Table 2). This activity varied significantly ($p < 0.05$) between 58.81 ± 1.1% and 63 ± 0.48%. Methanol extract exhibit the highest activity, comparatively to the acetonic and ethanolic extracts. Activity of anthocyanin extracts is significantly different ($p < 0.05$) and the methanolic extract exhibited the highest capacity (68.08 ± 0.57%). Statistical analysis revealed a significant difference ($p < 0.05$) between the radical scavenging activity of polyphenolic and anthocyanin extracts. Indeed, anthocyanin extracts showed the best activity.

The concentration of an antioxidant needed to decrease the initial DPPH concentration by 50% ($IC_{50}$) is widely used to evaluate the antioxidant activity (Atoui et al., 2005). Results presented in Table 2 shows that for polyphenolic extracts, the acetonic extract does not require a high concentration (3.97 ± 0.95 mg/mL) to inhibit 50% of DPPH comparatively to the two other polyphenolic extracts ($p < 0.05$). As for anthocyanin extracts, the methanolic extract requires only 2.88 ± 0.02 mg/mL to inhibit 50% of DPPH radical. Indeed, considering the polyphenolic extracts, methanolic and acetonic extracts exhibit similar activity (4 ± 0.20 and 3.97 ± 0.95 mg/mL, respectively) which is statistically higher ($p < 0.05$) than that of ethanolic extract (4.05 ± 0.08 mg/mL). In the case of anthocyanin extracts, among solvents tested the highest antioxidant activity was observed for methanol followed by acetone and ethanol extracts ($p < 0.05$). It is also noteworthy that the anthocyanin extracts showed the highest antiradical power ($p < 0.05$) compared to phenolic extracts for all the solvents used. Eun-Ju et al. (2011) reported that 70% ethanol extract of fresh peel of *S. melongena* decrease 50% of DPPH radical at a concentration of 0.98 ± 0.33 mg/mL, this value is lower than that found in our study (4.05 ± 0.0.8 mg/mL) with the same solvent. In the other hand, Nisha et al. (2009) reported an $IC_{50}$ value (0.228 mg/mL) lower than that obtained in our study for methanolic extract (4 ± 0.2 mg/mL). These differences can be explained by the different states of the fruit (fresh or dried).

#### 3.2.2. Reducing power

Figs. 1 and 2 depict the reducing power of the phenolic and anthocyanin extracts, respectively. The phenolic extract with 70% acetone exhibited the highest reducing power than those obtained for the two other solvents. The order of the antioxidant activity was: 70% acetone > 70% methanol > 70% ethanol ($p < 0.05$). This difference is probably due to the degree of solubility of phenolic compound in the different solvents.

The anthocyanin extract with 70% methanol, exhibited the highest reducing power, while ethanol and acetone extracts have the lowest reducing power ($p < 0.05$). The order of the antioxidant activity was: 70% methanol > 70% ethanol > acetone 70% ($p < 0.05$).

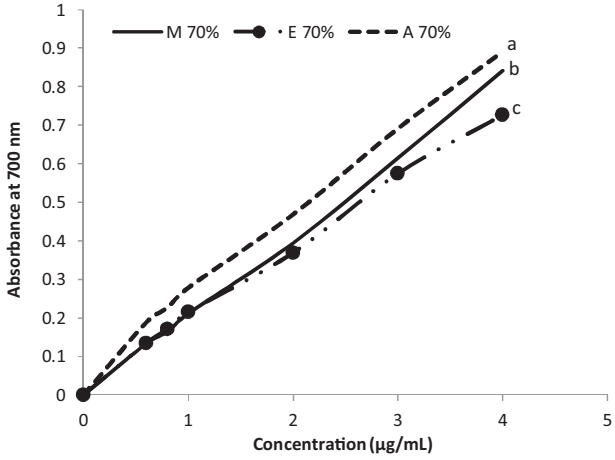


**Fig. 1.** Reducing power of phenolic compound of peel eggplant extracts. Different letters in same column indicate significant difference ($p < 0.05$). Results are ranked in ascending order; a > b > c.

The reducing power expressed as quercetin equivalent (mg QE/100 g of DE) is significantly different ($p < 0.05$) for the phenolic extracts. Indeed, 70% acetone extract shows the highest content (27 ± 1.02 mg QE/100 g DE) but no difference ($p < 0.05$) was observed between methanolic and ethanolic extracts (21 ± 0.9 mg QE/100 g DE and 21 ± 1.4 mg QE/100 g DE, respectively).

Concerning anthocyanin extracts, and as can be seen in Fig. 2, their reducing power are significantly different ($p < 0.05$), the highest amount is presented by the methanolic extract (39 ± 2.5 mg QE/100 g DE), followed by acetonic and ethanolic extracts (33 ± 1.6 mg and 30 ± 0.6 mg QE/100 g DE, respectively).

Statistical analysis revealed a significant difference ($p < 0.05$) between the reducing power of polyphenolic and anthocyanin

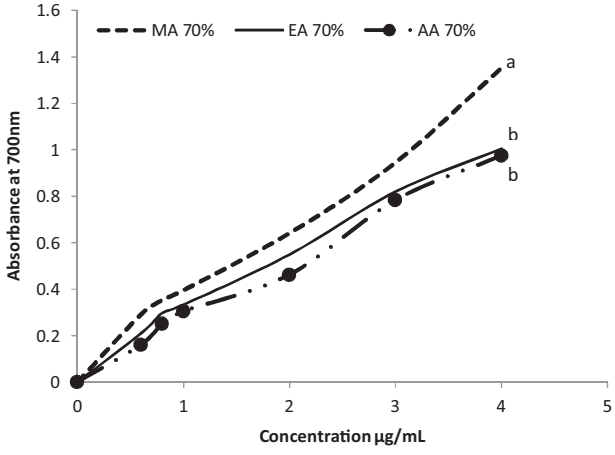


**Fig. 2.** Reducing power of anthocyanins of peel eggplant extracts. Different letters in same column indicate significant difference ($p < 0.05$). Results are ranked in ascending order; a > b > c.

extracts. Indeed, anthocyanin extracts showed the best activity. This difference is probably due to the high content of antioxidants (anthocyanins) in anthocyanin extracts, which are the dominant class in the peel eggplant (Yi et al., 2009). Difference found between extracts, are probably due to the difference in their phenolic contents (polyphenolic and anthocyanins extracts), and/or their electron-donating activity.

### 3.2.3. Scavenging effect of hydrogen peroxide

The ability of the extracts of peel eggplant to scavenge hydrogen peroxide is shown in Figs. 3 and 4, respectively. The decrease in the intensity of the color of different extracts in the presence of $H_2O_2$, resulting in the decrease of absorbance. This discoloration is the result of the oxidation of phenolic compound present in the extracts, after the reduction of $H_2O_2$.

Another parameter used in order to evaluate the inhibitory effect of $H_2O_2$ radical, is the time required to inhibit 50% of the $H_2O_2$ radical ($IT_{50}$). The lowest the $IT_{50}$ or the higher is the antioxidant activity. The obtained data (Table 2), shows that the polyphenolic extract with 70% acetone requires only $26.1 \pm 0.53$ min to scavenge 50% of the $H_2O_2$ radical, so its activity is stronger compared with the other two polyphenolic extracts ($p < 0.05$). Similarly, the anthocyanin extract with 70% methanol, requires only $22.68 \pm 0.54$ min

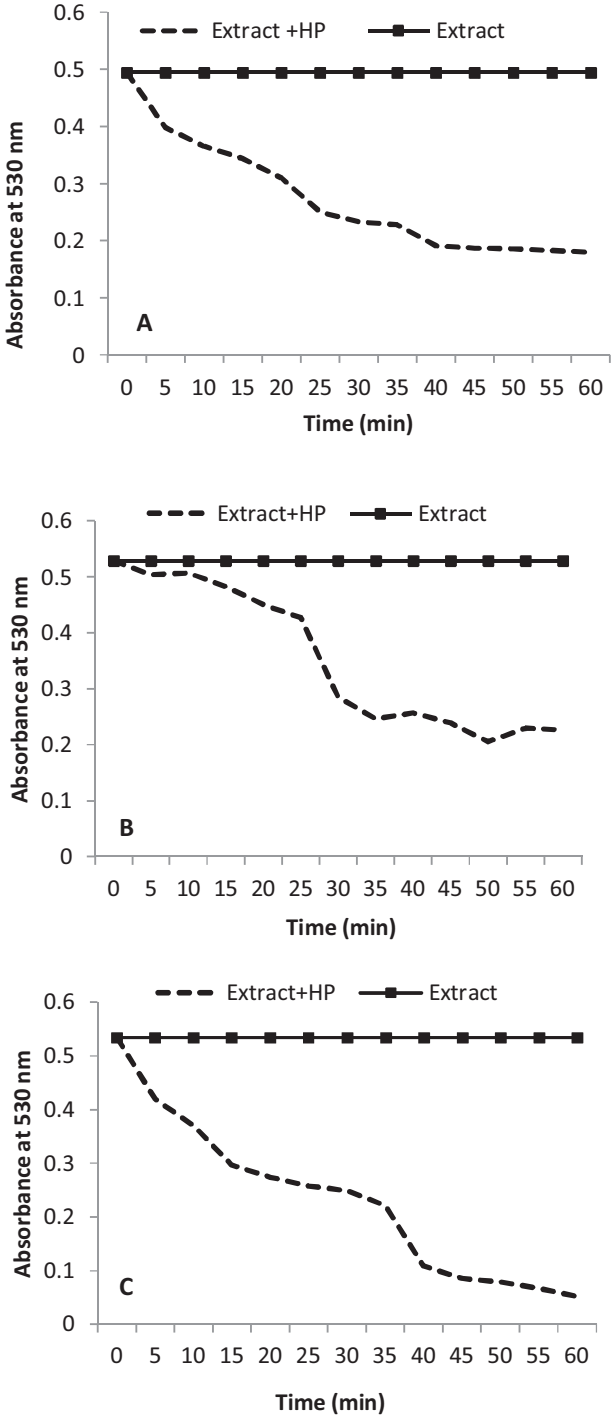


**Fig. 3.** Absorbance of the phenolic extracts: (A) methanol, (B) ethanol, and (C) acetone HP: hydrogen peroxide.

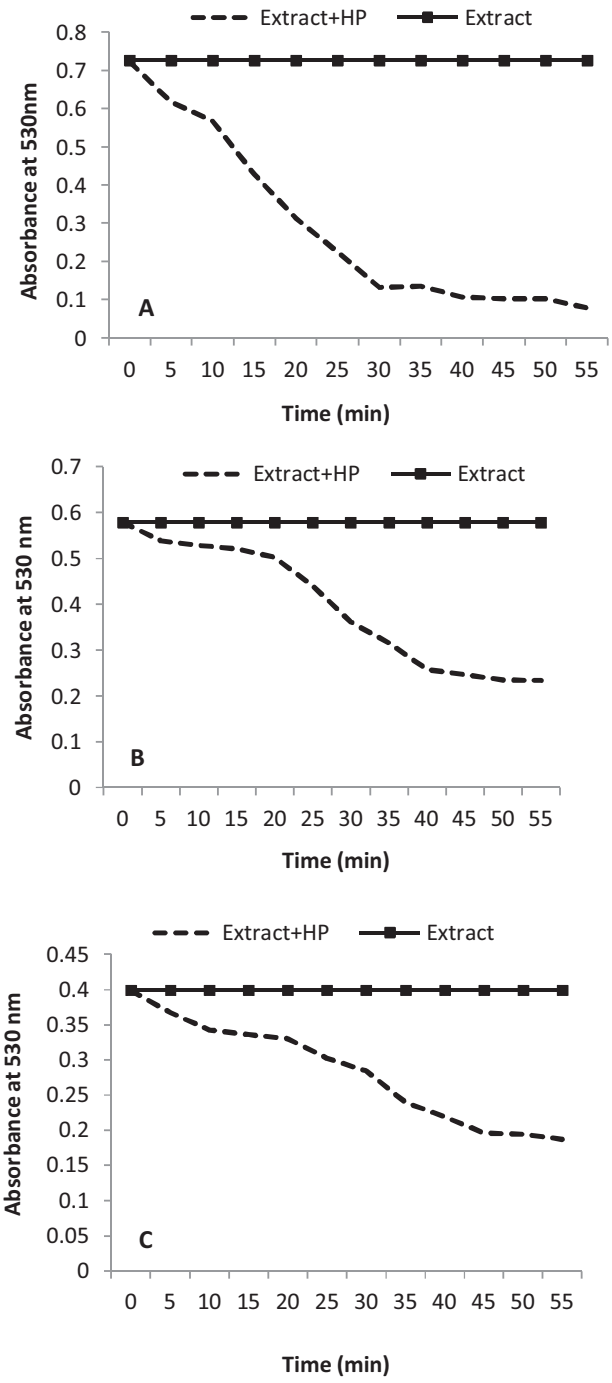


**Fig. 4.** Absorbance of the anthocyanic extracts: (A) methanol, (B) ethanol, and (C) acetone HP: hydrogen peroxide.

**Table 2**
Antiradical (DPPH, $H_2O_2$) and metal chelating activities of different extracts.

| Extract | Antiradical activity | | Metal chelating activity | Scavenging effect of $H_2O_2$ |
|---|---|---|---|---|
| | % inhibition | $IC_{50}$ (mg/mL) | (% inhibition) | $IT_{50}$ (min) |
| M70% | 63% ± 0.48[a] | 4 ± 0.20[b] | 14.24 ± 1.26[b] | 36.97 ± 2.19[b] |
| E70% | 58.81% ± 1.1%[b] | 4.05 ± 0.08[c] | 3.71 ± 0.21[c] | 46.21 ± 1.50[a] |
| A70% | 59.29% ± 2.25%[b] | 3.97 ± 0.95[b] | 18.53 ± 0.47[a] | 26.1 ± 0.53[c] |
| MA70% | 68.08% ± 0.57%[a′] | 2.88 ± 0.02[c′] | 5.46 ± 0.99[b′] | 22.68 ± 0.54[c′] |
| EA70% | 64.47 ± 1.53%[c′] | 3.32 ± 0.01[a′] | 11.23 ± 1.93[a′] | 44.4 ± 1.91[b′] |
| AA70% | 66.44 ± 2.02%[b′] | 3.09 ± 0.73[b′] | 2.8 ± 0.05[b′] | 48.86 ± 2.45[a′] |

Different letters in same column indicate significant difference ($p < 0.05$). Results are ranked in ascending order: a > b > c for phenolic extracts; a′ > b′ > c′ for anthocyanin extracts.

to scavenge 50% $H_2O_2$, this time is considered lower compared to that of the acetonic (48.86 ± 2.45 min) and ethanolic anthocyanin extracts (44.4 ± 1.91 min) ($p < 0.05$). This difference is probably due to the type of the solvents, the nature of the extracted compounds and the high ability of anthocyanins to scavenge $H_2O_2$ radical.

### 3.2.4. Metal chelating activity

Foods are often contaminated with transition metal ions which may be introduced by processing methods. Bivalent transition metal ions play an important role as catalysts of oxidative processes, leading to the formation of hydroxyl radicals and hydroperoxide decomposition reactions *via* Fenton chemistry (Halliwell et al., 1992).

These processes can be delayed by iron chelation and deactivation. The metal chelating capacity is expressed by the percentage of inhibition of ferrozine–$Fe^{2+}$ complex formation by different extracts. In this assay both extracts of peel eggplant are interfered with the formation of ferrous and ferrozine complex, suggesting that they have chelating activity and are able to capture ferrous ion before ferrozine. As shown in Table 2, the polyphenolic extract with 70% acetone exhibit the highest percentage of metal scavenging capacity (18.53 ± 0.47%), compared to that of the other two polyphenolic extracts, which are about 14.24 ± 1.26% for the ethanolic extract and 3.71 ± 0.21% for the methanolic one ($p < 0.05$). Concerning, the anthocyanic extract, ethanolic extract shows the better activity (11.23 ± 1.93%) comparatively to the methanolic and acetonic extracts which are 5.46 ± 0.99% and 2.8 ± 0.05%, respectively.

## 4. Conclusion

Eggplant, *S. melongena*, is a common and popular vegetable crop largely consumed in the world. It contains polyphenols, flavonoids, minerals, vitamins, *etc.* These are reported to possess numeral medicinal proprieties as well. The present study evaluated *in vitro* antioxidant activities of three solvents extracts of the byproduct of eggplant. Results shows that acetone is the better solvent for phenolic, flavonoids and tannins extraction, while, methanol is better for anthocyanin extraction. In this study we found that peel eggplant is poor in carotenoids. Concerning the antioxidant activity, high reducing power and inhibition of $H_2O_2$ activities of phenolic extract was observed for acetone, while that of anthocyanic extract was observed for the methanol. Both of phenolic and anthocyanic extracts issued from methanol showed the best scavenging activity of DPPH radical. Otherwise, metal chelating activity is better for phenolic extract issued from acetone and anthocyanic extract issued from ethanol. Therefore, peel of *S. melongena* may be considered a source of important phytochemicals with important antioxidant properties.

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