

[Research]

Evaluation of the antioxidant activity of extracts from some fruit peels

Afsharnezhad M., Shahangian S.S., Panahi E., Sariri R.*

Department of Biology, University of Guilan, Rasht, Iran

Corresponding author's E-mail: sariri@guilan.ac.ir

(Received: April 04. 2017 Accepted: Aug. 09. 2017)

ABSTRACT

The growing interest on the replacement of synthetic antioxidants with natural ones has directed many research toward the plant-derived raw materials. The special attention is focused on inexpensive or residual sources from food agricultural industries. Fruit peels are valuable wastes obtained from domestic and industrial sources. The potential of fruit wastes as sources of natural antioxidants was explored in the present research. The peels of five kinds of fruits commonly used were obtained from domestic consumption. Antioxidant activity of their separate extract was assessed using DPPH radical scavenging activity and ferric-reducing antioxidant power. Besides, total phenol, flavonoid anthocyanin, protein and soluble sugar contents of the samples were also determined. According to the results, the apple peel extract contained the most content of total flavonoid, soluble sugar, protein and ferric-reducing antioxidant power. The maximum DPPH radical scavenging activity (256.78 ± 4.54 mg AA.g⁻¹ dry weight = DW), total phenol (13.17 ± 0.268 mg of GAE.g⁻¹ DW) and total anthocyanin (0.811 ± 0.024 mg.g⁻¹ DW) were observed in orange peel. This study demonstrated that fruit peels could serve as potential sources of antioxidants in the food and pharmaceutical industries.

Key words: Fruit wastes, DPPH, FRAP, Total phenol, Secondary metabolites.

INTRODUCTION

Reactive oxygen species (ROS), such as superoxide anion radical, hydroxyl radical and hydrogen peroxide are formed by exogenous chemicals or endogenous metabolic processes in the human body (Halliwell & Gutteridge 1984). In small amounts, these ROS can be beneficial as signal transducers and growth regulators (Henry & Martine 2002). However, during oxidative stress, large amounts of these ROS can be produced and may be dangerous as they are capable of oxidizing bio-molecules including nucleic acids, proteins, lipids and DNA and, therefore, initiate different degenerative diseases like neurological disorders, cancer, emphysema, cirrhosis, atherosclerosis, arthritis (Martinez-Cayuela 1995). The cell can reduce the effect of ROS either by an endogenous system implicating enzymes such as catalase, glutathione peroxidase and superoxide dismutase or by a

exogenous antioxidants (α -tocopherol, β -carotene, ascorbic acid, glutathione, uric acid), some hormones including estrogen and angiotensin (Halliwell & Gutteridge 1990; Cheeseman & Slater 1993).

The use of natural and low-cost antioxidants to replace synthetic butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) could be of interest due to the carcinogenic and toxic effects of the later (Hocman 1988). A number of epidemiological studies have suggested that the consumption of natural antioxidants such as fresh fruits and vegetables possess protective effects against various diseases. This type of protection has been partly ascribed to the presence of several components, such as vitamins, flavonoids, anthocyanins and other phenolic compounds (Knekt *et al.* 1996; Klimczak *et al.* 2007).

A number of studies have reported the antioxidant activity of juice and pulp from

edible fruits (Valcheva-Kuzmanova *et al.* 2004; Mokbel & Hashinaga 2006). However, there is a little information on the antioxidant activity in fruit peels. Peels are often the waste part of various fruits. These wastes have not generally received much attention with a view to being used or recycled rather than discharged. This might be due to their lack of commercial application (Soong & Barlow 2004). Interestingly, the peel and seed fractions of some fruits have higher antioxidant activity than the pulp fractions (Jayaprakasha *et al.* 2004). For example, a higher antioxidant activity has been found for pomegranate peel than its pulp (Li *et al.* 2006). Grape seed is higher than its pulp in antioxidant capacity and is a rich source of proanthocyanidin, which is very effective in scavenging various ROS (Guo *et al.* 2003).

It is known that many fruit wastes, including apple and banana are rich in vitamin B6, manganese, vitamin C, fiber, potassium, biotin, and copper. As a valuable help to reduce environmental pollution from their deterioration, fruit wastes could be recycled. If the process is done in a proper managed way, their secondary metabolite content can prevent high blood pressure and protect against atherosclerosis. The tryptophan content of many fruits is condensed into their peels. This essential amino acid can be converted into serotonin helping to reduce and overcome depression. Some fruit wastes have a considerable content of iron which can help to relieve anemia and have the power to counteract calcium loss and enable bone strengthening. Banana wastes are natural antacid and can provide relief from acid reflux, heart burn, and can restore electrolytes lost after dehydration from diarrhea. Considering an average consumption of mixed fruits 500 g.day⁻¹ for each individual and that about 40% of fruit weight is their wastes, it seems logic that instead of throwing this billion pounds of peels into the landfills and wasting their potential benefits, try out some of their potential uses for benefit of environment and lifestyle. The aim of this

study was, therefore, to investigate and compare the antioxidant activity of fruit peels commonly consumed in Iran, both in domestic and industrial preparations.

MATERIALS AND METHODS

Fruits

Five species of fruits most commonly consumed in Iran were purchased from a local market. The selected fruits, including apple (*Malus domestica*), orange (*Citrus sinensis*), banana (*Musa sapientum*), kiwi (*Actinidia deliciosa*) and pineapple (*Ananas comosus*), were washed with distilled water, ate by the research team and the peels were oven-dried at 37-40°C.

Chemicals

All chemicals including methanol, acetone, sodium carbonate, hydrochloric acid (HCl), acetic acid were of reagent grade and used without further purification unless otherwise stated. Folin-Ciocalteu's phenol reagent, gallic acid, tripyridyltriazine (TPTZ), ferric chloride (FeCl₃), aluminum chloride (AlCl₃) and 2, 2-diphenyl-1-picrylhy-drazyl (DPPH) were purchased from Merck (Darmstadt, Germany). Bovine serum albumin (BSA) was purchased from Sigma (St. Louis, MO, USA). All buffers were freshly prepared in Biochemistry Research Laboratory, University of Guilan, Rasht, Iran.

Sample preparation

The dried fruit peels were ground into fine powder and extracted by 85% methanol for two days, twice, at room temperature. The filtrates were pooled and concentrated by rotary evaporator at 40°C. The obtained extracts were kept in a desiccator at 4°C until further use.

DPPH radical scavenging activity

The antioxidant capacity of the different extracts was evaluated through their free radical scavenging activity on the 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical based on a method described in 2004 with

slight modifications (Miliauskas *et al.* 2004). Different aliquots of extract solutions were prepared and mixed with 2mL of DPPH methanolic solution 0.004%. The control solution contained 2mL DPPH and 2mL methanol. The mixture was mixed thoroughly and kept in the dark for 30 min. Then, absorbance was measured at 517 nm against methanol blank without DPPH. The inhibition

$$\text{inhibition rate of DPPH (\%)} = (A_{\text{control}} - A_{\text{sample}}) / A_{\text{control}} \times 100 \quad (1)$$

$$\text{AEAC (mg AA. g}^{-1} \text{ DW)} = \text{IC}_{50 \text{ ascorbate}} / \text{IC}_{50 \text{ sample}} \times 1000 \quad (2)$$

Ferric reducing antioxidant activity (FRAP)

The method described in Gue *et al.* (2003) was used with slight modifications. Briefly, FRAP reagent was prepared with sodium acetate buffer solution (300 mmol L⁻¹, pH 3.6), a tripyridyltriazine (TPTZ) solution (10 mmol L⁻¹ in 40 mmol L⁻¹ HCl) and FeCl₃ solution (20 mmol L⁻¹) in the proportion of 10:1:1 (v:v:v). 0.05 ml of fruit peels extracts prepared in distilled water was added to 1.5 mL of FRAP reagent. The mixture was incubated at room temperature for 30 minutes and its absorbance was measured at 593nm. The control solution was made of 0.05mL distilled water and 1.5mL FRAP reagent. The antioxidant capacity was determined using the calibration curve and represented as mmol FeSO₄ equivalents per 1 g⁻¹ of sample in dry weight (μmol FeSO₄ . g⁻¹ DW).

Determination of total phenols

Total phenols concentrations were measured using colorimetric Folin-Ciocalteu method. Briefly, 100μL of extracts were mixed with 2mL of sodium carbonate (2%), 2.8mL deionized water and 100μL of Folin-Ciocalteu reagent (50%). After incubation at room temperature for 30 min, the absorbance was read at 720 nm on a UV-Vis spectrophotometer. Concentration of total phenols was calculated using a standard curve of aqueous solutions of

rate (%) of the DPPH radical was then calculated using Eq. 1. Based on the obtained results, the value of IC₅₀ was calculated by plotting the concentrations of the extract solutions versus inhibition rate (%) of the DPPH radical. Using ascorbic acid as standard, the results were expressed as antioxidant activity equivalent ascorbic acid (AEAC) from Eq. 2.

gallic acid and expressed as mg gallic acid equivalents (GAE).g⁻¹ DW (Meda *et al.* 2005).

Determination of total flavonoids

The flavonoid content of the samples was determined according to methods described by Chang *et al.* (2002). In this method 500μL from each extracted sample was mixed with 1.5mL methanol (85%), 100μL of 10% aluminum chloride methanolic solution, 100μL of 1 M potassium acetate solution and 2.8mL distilled water. After incubation at room temperature for 40min, the absorbance of the reaction mixture was measured at 415 nm with a UV-Vis spectrophotometer. Concentration of total flavonoids of fruit peels was calculated using a standard curve of quercetin and expressed as mg quercetin equivalents (QEs). g⁻¹ DW.

Determination of total anthocyanin

For determination of total anthocyanin, 0.02 g of each sample was mixed with 4mL 1% methanolic solution of hydrochloric acid and kept for 24h in refrigerate. Then extracts were centrifuged at 13000 rpm for 10 min. The absorbance of supernatant was read in 530 nm and 675 nm using a UV-Vis spectrophotometer. Anthocyanin content for each extract which was calculated according to Equation 3 (Mita *et al.* 1997).

$$\text{Anthocyanin content (mg.g.DW}^{-1}) = A_{530} - (0.25 \times A_{675}) \quad (3)$$

Determination of soluble sugars

Measurement of soluble sugars was performed using the phenol-sulfuric acid method (Nowotny 1979). In this method 0.05g of each sample was mixed with 5mL of 70% methanol and kept in refrigerator for one week.

The extracts were centrifuged at 10000 rpm for 15 min at the end of one week and the supernatant of the each extract was used for soluble sugar analysis. 1.5mL distilled water, 1mL 5% phenol and 5mL sulfonic acid were added to each 0.5mL of supernatants. The mixture was shaken vigorously and incubated at room temperature for 30 min.

The absorbance of each mixture was then measured at 485 nm. A solution of glucose was used as a standard and the soluble sugar content was expressed as mg glucose.g⁻¹ DW.

Total protein concentration

The total protein content of the centrifuged saliva samples was determined by Bradford reagent using bovine serum albumin as standard (Bradford 1976).

Bradford reagent was prepared by dissolving 100mg Coomassie Brilliant Blue G-250 in 50mL 95% ethanol, then adding 100mL 85% (w/v) phosphoric acid.

The reagent was diluted to 1 liter when the dye was completely dissolved, followed by filtering through Whatman #1 paper just before use. For determination of total protein, 100mL of each sample was mixed with 5mL Bradford reagent, followed by incubating at room temperature for 20min, then the absorbance was measured at 595nm. Concentration of total protein expressed as mg albumin.g⁻¹ DW.

Statistical analysis

The SAS for Windows version 9.1 was used for the data analysis. All data were reported as mean ± standard deviation (SD) of three replicates.

Differences between means were determined by One-Way ANOVA using Tukey's test. Statistical significance was defined at a level of $P \leq 0.05$.

RESULTS AND DISCUSSION

DPPH scavenging activity and FRAP tests

The assay is based on the ability of the extract to scavenge free radicals through donation of hydrogen. DPPH radical is a stable free radical and when it reacts with an antioxidant compound which can donate hydrogen, it is reduced to diphenylpicrylhydrazine (Miliauskas *et al.* 2004). The deep violet color of the initial reaction mixture is changed to light yellow due to the reduction of DPPH with the antioxidant compounds present in the extracts from peels of our selected fruits. Table 1 shows the power of each fruit peel extracts to scavenge DPPH. As shown in this Table, maximum antioxidant activity (256.7%) was found in orange peels, while minimum (52.3%) was observed in pineapple peels. Antioxidant activity of apple, banana and kiwi were set within this range as 178.9%, 109.3% and 75.7% respectively. The antioxidant activity using DPPH free radical has been used for determination of antioxidant capacity in a number of medicinal and aromatic plant extracts (Miliauskas *et al.* 2004). They have reported that the presence and activity of antioxidants in medicinal plants have been related to their traditional pharmaceutical activity. The DPPH method has also been used to investigate the effect of far infrared radiation on antioxidant activity of rice hulls (Lee *et al.* 2003). We found the method to be suitable for determining the antioxidant capacity in various extracts from fruits, vegetables, leaves and various parts of plants. In our previous studies we also used a modified DPPH assay to determine antioxidant capacity in human salivary fluid and its alternation due to different conditions (Azadbakht *et al.* 2016; Moori *et al.* 2016).

The results of FRAP test are also presented in Table 1. It was observed that the highest reducing power for ferric ion was displayed by apple peel extracts (0.193 mmol FeSO₄.g⁻¹), while the pineapple peels had the lowest value (0.017 mmol FeSO₄.g⁻¹).

The reducing powers of other fruit peel extracts including orange, banana and

pineapple in DPPH test were found to be 0.141, 0.084 and 0.023 mmol FeSO₄.g⁻¹ respectively. Similar to our experiments, the assay has been used to compare antioxidant power in peels, pulps and seeds of some fruits (Meda *et al.* 2005). They found that fruit peels have stronger antioxidants than seeds. The power to reduce ferric ion examined by FRAP

method was also reported for celandine extracts (Then *et al.* 2003), supporting our findings.

Therefore, the FRAP assay is a precise and common method for measurement of antioxidant capacity in many natural sources including fruits and vegetables as well as their wastes.

Table 1. The results of DPPH and FRAP tests on methanolic extracts of selected fruit peels.

| Peel extracts | DPPH (mg AA.g ⁻¹ DW) | FRAP (mmol FeSO ₄ . g ⁻¹ DW) |
|---------------|---------------------------------|--|
| Orange | 256.78 ± 4.54 ^A | 0.141 ± 0.019 ^B |
| Apple | 178.92 ± 5.64 ^B | 0.193 ± 0.028 ^A |
| Banana | 109.28 ± 2.59 ^C | 0.084 ± 0.013 ^C |
| Kiwi fruit | 75.7 ± 1.91 ^D | 0.023 ± 0.015 ^D |
| Pineapple | 52.32 ± 2.7 ^E | 0.017 ± 0.012 ^D |

Repeated measures ANOVA test followed by Tukey's post-hoc test. Dissimilar letters represents significant difference between the groups, the level of significance set at 5% (P < 0.05).

Total phenols, flavonoids and anthocyanins

It is known that the radical scavenging activity of peels is due to the presence of polyphenols and flavonoids. Therefore, as shown in Table 2, the higher antioxidant activity of orange and apple peel is due to the higher content of polyphenols and flavonoids. Similar results have been reported for pomegranate peels (Jayaprakasha *et al.* 2001; Negi *et al.* 2003). The results of present study are also in agreement with our previous research on citrus peel extracts (Nasuti *et al.* 2011) and results reported by others who studied the effect of ultrasonic treatment on antioxidants of citrus species (Ma *et al.* 2008). It has been reported that flavonoids could protect human heart when taken as a supplement (Knekt *et al.* 1996). They found that antioxidant activity exhibited by the flavonoid drug supplements could reduce the mortality rate from coronary heart diseases. Interestingly, the presence of flavonoids plays a major role in the traditional goodness known for honey. Researchers have reported considerable amounts of flavonoids in propolis (Chang *et al.* 2002) and honey (Meda *et al.* 2005). In the present study, unlike other antioxidants, apple peels possessed the highest flavonoid content. This could be a reason for traditional belief that recommends eating apples unpeeled and the common phrase "an apple a day keeps the doctor

away". We are currently investigating the antioxidant properties of various types of honey produced in Iran (unpublished research)

Total anthocyanin content was also measured in the methanolic peel extracts of all the five fruits. As shown in Table 2, orange peels possessed the highest anthocyanins followed by apples, bananas and kiwifruits respectively, while the extracts of pineapple peels contained the lowest anthocyanins and flavonoids. In support of our study, the antioxidant activity in seeds of some fruits has been reported in terms of total phenols (Soong & Barlow 2004). Noteworthy, medicinal benefits of fruits and their natural juices is a well-known fact and has been studied specifically. For example the hepatoprotective effect of orange juice on the injuries caused by carbon dioxide has been studied in detail (Valcheva-Kuzmanova *et al.* 2004).

As shown in Table 2, the maximum total phenol content (TPC) was found in orange peel (13.17 mg.g⁻¹), followed by apples, banana and kiwifruit respectively, whereas minimum observed in pineapple peels (3.09 mg.g⁻¹). The special conditions used for extraction of antioxidants from fruit peel as well as the environmental conditions influencing a botanical type of fruit, can affect the results (Singh *et al.* 2002). It has been reported that

methanol is the most suitable solvent for extraction of phenolic compounds because of its ability to inhibit the reaction of poly phenol oxidase (PPO) that causes oxidation of phenolic and its ease of evaporation, compared to water (Yen & Chen 1994). However, compared to the non-polar acetone, both methanol and ethanol are reported to offer best result to extract phenolic compounds (Moure *et al.* 2001).

In the present study, the total flavonoid content had the highest amount in methanolic extracts of apple peel with 10.15mg quercetin equivalent.g⁻¹ followed by orange peel methanolic extract (9.9313mg quercetin

equivalent.g⁻¹), while the minimum was found in kiwifruit peels (4.13mg quercetin equivalent.g⁻¹). In the present study, the result for the orange peel flavonoid was found to be in contrast with the result of Singh & Immanuel (2014) who reported that value for the orange peel extract was the lowest, compared to the lemon and pomegranate peel extract (They used fruit peel extract to increase shelf-life of a special type of cheese by inhibiting formation of peroxide).

The total flavonoid content has also been previously studied and the results are in agreement with our orange peel extract (Ghafar *et al.* 2010).

Table 2. Total phenol, flavonoids and anthocyanins in extracts of selected fruits peels.

| Methanolic peel extract | Total phenol (mg of GAE. g ⁻¹ DW) | Total flavonoids (mg of quercetin. g ⁻¹ DW) | Total anthocyanins (mg. g ⁻¹ DW) |
|-------------------------|--|--|---|
| Orange | 13.17 ± 0.268 ^A | 9.93 ± 0.226 ^A | 0.811 ± 0.024 ^A |
| Apple | 11.48 ± 0.249 ^B | 10.15 ± 0.388 ^A | 0.43 ± 0.063 ^B |
| Banana | 9.66 ± 0.266 ^C | 6.29 ± 0.313 ^C | 0.24 ± 0.001 ^C |
| Kiwi fruit | 5.89 ± 0.338 ^D | 4.13 ± 0.22 ^D | 0.116 ± 0.001 ^D |
| Pineapple | 3.09 ± 0.133 ^E | 6.95 ± 0.12 ^B | 0.105 ± 0.001 ^D |

Repeated measures ANOVA test followed by Tukey's post-hoc test. Dissimilar letters represents significant difference between the groups, the level of significance set at 5% (P < 0.05).

Total protein and soluble sugar contents

Table 3 presents both total protein content in terms of albumin and the amount of soluble sugar in methanolic extracts of all the fruit peels. Based on a literature survey, only little reports are found for the content of protein and sugar in peels of different fruits. This may be due to their negligible amounts or perhaps their change during storage. We found the highest protein and soluble sugar in apple peels (0.093 mg.g⁻¹ and 0.83 mg.g⁻¹, respectively). The lowest total protein content found to be in pineapple peels (0.011 mg.g⁻¹), with the minimum soluble sugar in kiwifruit peels (0.17 mg.g⁻¹). Total protein has been detected in some plant parts including potatoes (Burlingame *et al.* 2009), watermelon rinds as 11.1% and melon peel powder as 9.07% (Al-Sayed & Ahmed 2013). The amount of soluble sugar is usually higher as most sugars can survive the storage conditions and they even concentrate due evaporation of moisture from wastes during storage. It has

been reported that carbohydrate content of watermelon rinds is about 56% which is slightly higher than the value reported for melon peel powder (48.6%) and differ from the results obtained in the present study for the peel extracts (0.17-0.83 mg.g⁻¹ DW).

Industrial and health benefits of antioxidants

Production of free radicals through oxidation of biological molecules may damage cells. Antioxidants such as uric acid, thiols and ascorbic acid can terminate these chain reactions. The term "antioxidant" is used for two different groups of substances: industrial chemicals which are added to products to prevent oxidation, and natural chemicals found in foods and body tissue which are said to have beneficial health effects. Antioxidants can be added to processed foods in order to protect the product against oxidative deterioration. As oxidation reactions can occur relatively rapidly in frozen or refrigerated food, antioxidants are a very important class

of preservatives. Antioxidant preservatives include natural antioxidants such as ascorbic acid and tocopherols. The use of fresh fruits and vegetables can, therefore, help the body's general health. Antioxidants are frequently added to industrial. A common use is as stabilizers in fuels and lubricants to prevent

oxidation, and in gasolines to prevent the polymerization that leads to the formation of engine-fouling residues. They are widely used to prevent the oxidative degradation of polymers such as rubbers, plastics and adhesives that causes a loss of strength and flexibility in these materials (Al-Malaika 2003).

Table 3. Total protein content and soluble sugars in extracts of selected fruits peels.

| Peel extract | Soluble sugar (mg glucose. g ⁻¹ DW) | Total protein (mg albumin.g ⁻¹ DW) |
|--------------|---|--|
| Orange | 0.76 ± 0.029 ^B | 0.071 ± 0.018 ^B |
| Apple | 0.83 ± 0.016 ^A | 0.093 ± 0.032 ^A |
| Banana | 0.46 ± 0.01 ^C | 0.045 ± 0.013 ^C |
| Kiwi fruit | 0.17 ± 0.022 ^E | 0.018 ± 0.003 ^D |
| Pineapple | 0.37 ± 0.036 ^D | 0.011 ± 0.019 ^C |

Repeated measures ANOVA test followed by Tukey's post-hoc test. Dissimilar letters represents significant difference between the groups, the level of significance set at 5% ($P < 0.05$).

CONCLUSIONS

Antioxidants were measured in extracts from peel of oranges, apples, banana, kiwifruit and pineapple. Based on the results, the maximum antioxidants in terms of total phenol, FRAP and total flavonoid content was found in apple peels followed by orange, banana, kiwifruit and pineapple respectively.

However, the order was different for total anthocyanins, total proteins, DPPH test and soluble sugars. So that, orange peel showed higher values than that of apple. The rest of fruit peels followed the same order above.

It was, therefore, concluded that apple and orange peels have stronger antioxidants as well as higher protein and sugar content. We recommend that, peels could be dried under appropriate conditions and used as strong antioxidants to replace with the synthetic antioxidants.

Peels can be obtained free of charge or with a low cost from fruit juicing and processing industries and have the advantage of containing natural antioxidants which are safe and suitable for food industries to extend the shelf-life of many processed foods.

REFERENCES

- Al-Malaika, S 2013, Oxidative degradation and stabilization of polymers. *International Materials Reviews* 45: 165-185.
- Al-Sayed, HMA & Ahmed, AR 2013, Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake. *Annals of Agricultural Sciences* 58: 83-95.
- Azadbakht, M, Sariri, R, Molasoltani, F, Ghafoori, H, Aghamaali, MR & Erfani Karimzadeh Toosi, A 2016, Salivary antioxidant power of passive smokers. *Journal of Nanomedicine and Biotherapeutic Discovery*, 2: 142-148.
- Bradford, MM 1976, A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical Biochemistry*, 72: 248-254.
- Chang, CC, Yang, MH, Wen, HM & Chern, JC 2002, Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *Journal of Food and Drug Analysis* 10: 178-182.

- Cheeseman, K & Slater, T 1993, An introduction to free radical biochemistry. *British Medical Bulletin*, 49: 481-493.
- Guo, C, Yang, J, Wei, J, LiYXu, J & Jiang, Y 2003, Antioxidant activities of peel, pulp and seed fractions of common fruits as determined by FRAP assay. *Nutrition Research*, 23: 1719-1726.
- Halliwell, B & Gutteridge, J 1984, Oxygen toxicity, oxygen radicals, transition metals and disease. *Biochemical Journal* 219: 1-8.
- Halliwell, B, Gutteridge, JM 1990, Role of free radical and catalytic metal ions in human disease: an overview. *Methods in Enzymology*, 186: 1-85.
- Henry, J, Martine & T 2002, Reactive oxygen species and cell signaling. *American Journal of Respiration and Critical Care Medicine*, 166: S4-S8.
- Hocman, G 1988, Chemoprevention of cancer: phenolic antioxidants (BHT, BHA). *International Journal of Biochemistry*, 20: 639-651.
- Jayaprakasha, GK, Singh, RP, Sakariah & KK 2001, Antioxidant activity of grape seed (*Vitisvinefera*) extracts on peroxidation models In vitro. *Food Chemistry* 73: 285-290.
- Klimczak, I, Małeczka, M, Szlachta, M & Gliszczyńska-Świągło, A 2007, Effect of storage on the content of polyphenols, vitamin C and the antioxidant activity of orange juices. *Journal of Food Composition and Analysis*, 20: 313-322.
- Knekt, P, Jarvinen, R, Reunanen, A & Maatela, J 1996, Flavonoid intake and coronary mortality in Finland: a cohort study. *British Medical Journal* 312: 478-481.
- Lee, SC, Kim, JH, Jeong, SM, Kim, DR & Nam, KC 2003, Effect of far-infrared radiation on the antioxidant activity of rice hulls. *Journal of Agricultural and Food Chemistry*, 51: 4400-4403.
- LiY, Guo, C, Yang, J, Wei, J, Xu, J & Cheng, S 2006, Evaluation of antioxidant properties of pomegranate peel extract in comparison with pomegranate pulp extract. *Food Chemistry*, 96: 254-260.
- Ma, YQ, Chen, JC, Liu, DH & Ye, XQ 2008, Effect of ultrasonic treatment on the total phenolic and antioxidant activity of extracts from citrus peel. *Journal of Food Sciences* 73: 115-120.
- Martinez-Cayuela, M 1995, Oxygen free radicals and human disease. *Biochimie*, 77: 147-161.
- Meda, A, Lamien, CE, Romito, M, Millogo, J & Nacoulma, OG 2005, Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity. *Food Chemistry*, 91: 571-577.
- Miliauskas, G, Venskutonis, P & Van Beek, T 2004, Screening of radical scavenging activity of some medicinal and aromatic plant extracts. *Food Chemistry* 85: 231-237.
- Mita, S, Murano, N, Akaike, M & Nakamura, K 1997, Mutants of *Arabidopsis thaliana* with pleiotropic effects on the expression of the gene for β -amylase and on the accumulation of anthocyanin that are inducible by sugars. *The Plant Journal*, 11: 841-851.
- Mokbel, MS & Hashinaga, F 2006, Evaluation of the antioxidant activity of extracts from buntan (*Citrus grandis* Osbeck) fruit tissues. *Food Chemistry*, 94: 529-534.
- Moori, M, Ghafoori, H & Sariri, R 2016, Nonenzymatic antioxidants in saliva of patients with systemic lupus erythematosus. *Lupus* 3:265-272.
- Moure, A, Cruz, JM, Franco, D, Dominguez, JM, Sineiro, J *et al.* 2001, Natural antioxidants from residual sources. *Food Chemistry*, 72: 145-117.
- Nasuti, S, Sariri, R, Aghamaail, MR, Ghafoori, H & Shahmohamadi, R 2011, In vitro antioxidant activity of extracts from wastes of five Iranian citrus species. *Pharmacology online*, 3: 853-858.
- Negi, PS, Jayaprakasha, GK & Jena, BS 2003, Antioxidant and antimutagenic activities of pomegranate peel extracts. *Food Chemistry*, 80: 393-397.
- Nowotny, A 1979, Carbohydrate determination by phenol-sulfuric acid.

- Basic Exercises in Immunochemistry: Springer pp. 171-173.
- Singh, RP, Murthy, KNC & Jayaprakasha, GK 2002, Studies on the antioxidant activity of pomegranate (*Punica granatum*) peel and seed extracts using in vitro models. *J Agric Food Chemistry*, 50: 81-86.
- Soong, Y-Y, Barlow & PJ 2004, Antioxidant activity and phenolic content of selected fruit seeds. *Food Chemistry*, 88: 411-417.
- Then, M, Szentmihályi, K, Sarkozi, A & Varga, IS 2003, Examination on antioxidant activity in the greater celandine (*Chelidonium majus* L.) extracts by FRAP method. *Acta Biologica Szegediensis*, 47: 115-117.
- Valcheva-Kuzmanova, S, Borisova, P, Galunska, B, Krasnaliev, I & Belcheva, A 2004, Hepatoprotective effect of the natural fruit juice from *Aronia melanocarpa* on carbon tetrachloride-induced acute liver damage in rats. *Experimental and Toxicologic Pathology*, 56: 195-201.
- Yen, GC & Chen, HY 1994, Comparison of anti-mutagenic effect of various tea extracts (green, oolong, pouchong and black tea). *Journal of Food Protection*, 57: 54-58.

ارزیابی فعالیت آنتی اکسیدانی پوست برخی از میوه‌ها

افشار نژاد م.، شاهنگیان س.ش.، پناهی الف.، سریری ر.*

گروه زیست شناسی، دانشکده علوم، دانشگاه گیلان، رشت، ایران

(تاریخ دریافت: ۹۶/۰۱/۱۵ تاریخ پذیرش: ۹۶/۰۵/۱۸)

چکیده

توجه روز افزون به جایگزینی آنتی اکسیدان‌های سنتزی با ترکیبات طبیعی، بسیاری از تحقیقات را به سوی مواد خام مشتق از گیاهان کشانیده است. منابع ارزان قیمت و بازمانده‌های صنایع غذایی و کشاورزی مرکز توجه بیشتری هستند. پوست میوه‌ها ضایعات با ارزشی هستند که می‌توانند از مصارف صنعتی و خانگی تهیه شوند. در تحقیق حاضر قدرت ضایعات میوه‌ها به عنوان منبعی برای آنتی اکسیدان‌های طبیعی ارزیابی شد. پوست پنج نوع میوه که مصرف بیشتری دارند از مصارف خانگی تهیه شد. فعالیت آنتی اکسیدانی عصاره‌های هر یک با استفاده از روش مهار رادیکال DPPH و قدرت احیاء یون فریک و هم-چنین اندازه‌گیری مقدار کل فنل، فلاونوئید، آنتوسیانین بررسی شد. غلظت قند محلول و پروتئین‌ها نیز در هر مورد اندازه‌گیری گردید. نتایج نشان دادند که پوست سیب دارای بیشترین مقدار فلاونوئید، قند محلول و پروتئین بوده و هم‌چنین قدرت احیاء یون فریک آن بیشتر از سایر میوه‌ها است. عصاره پوست پرتقال دارای بیشترین قدرت برای مهار رادیکال DPPH ($13.17 \pm 0.268 \text{ mg of GAE. g}^{-1} \text{ DW}$) مقدار کل فنل ($256.78 \pm 4.54 \text{ mg AA.g}^{-1} \text{ dry weight} = \text{DW}$)، مقدار کل آنتوسیانین ($0.811 \pm 0.024 \text{ mg. g}^{-1} \text{ DW}$) بود. نتایج تحقیق نشان داد که عصاره پوست میوه‌ها می‌تواند به عنوان منبع آنتی اکسیدان خوبی در صنایع غذایی و دارویی استفاده شوند.

*مؤلف مسئول