Zagazig Journal of Agricultural Research
http:/www.journals.zu.edu.eg/journalDisplay.aspx?JournalId=1&queryType=Master

PHENOLIC COMPOUNDS OF ETHANOLIC EXTRACTS FROM SOME FOOD BY-PRODUCTS

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ABSTRACT

Processing of fruits, vegetables and oilseeds results in high amounts of by-products which are rich in many of the phytochemicals compounds such as (polyphenols and flavonoid) than the edible parts. The main objectives of this study was to determine the chemical composition, total phenolics, total flavonoids and antioxidants activity of three by-products from food industry including red onion solid wastes, mango peels and olive pomace. The results showed that mango peels contain exceptionally high amounts of total polyphenols followed by red onion solid wastes revealing 9750.00 and 7270.10 mg GAE/100g dry powder, respectively. While, olive pomace had the lowest content 940.00 mg GAE/100g dry powder. Red onion solid wastes contain high amounts of total flavonoid 2323.70, mg QE/100g dry matter. In general, ethanol extracts showed these activity 90.43% 92.81% and 91.16% for red onion solid wastes, mango peels and olive pomace comparable with activity of the natural (vitamin C) and synthetic tert-butyl hydroquinone (TBHQ) antioxidants 94.71% and 94.94%, respectively.

Key words: Red onion waste, mango peels, olive pomace, phenolic compounds, antioxidant activity.

INTRODUCTION

Antioxidant is defined as ‘any substance that, when present at low concentrations compared to those of oxidisable substrate, significantly delays or prevents oxidation of that substrate (Halliwell and Gutteridge, 1990).

Antioxidant compounds such as flavonoids, tannins, coumarins, curcumanoids, xanthons, lignans and terpenoids are found in different plant parts (*e.g.*, fruits, vegetables, leaves and seeds). Therefore, there is growing interest in separating these bioactive compounds and using them as natural antioxidants. Processing of fruits, vegetables and oilseeds results in high amounts of waste materials such as peels, seeds, stones and oilseed meals (Jeong *et al.,* 2004).

Recently, growing interest in the substitution of synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are commonly used in processed foods by natural antioxidants, which now a days use of these synthetic antioxidants in food has been restricted because of their carcinogenecity and other toxic properties, one has led to tremendous development in the research on the screening of natural antioxidants from inexpensive and residual sources from agricultural industries (Sarafian *et al.,* 2002). Disposal of these by-products represents both a cost to the food processor and a potential negative impact on the environment (which can be harmful to the environment). Research over the past 20 years has revealed that many of these by-products could serve as a source of potentially valuable bio-active compounds such as polyphenols, flavonoids and lycopene and used it as a food ingredient due to their functional abilities such as gelling and water binding and their potential applications as nutritional new ingredients in foods (Herrero *et*

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al., 2006; Yeoh *et al.*, 2008 and O'Shea *et al.*, 2012).

Red onions solid wastes, Mango peels and olive pomace and others wastes which are by-products obtained during processing of their products. The outer dry layers and the other parts of onion (*Allium cepa.* L.) which are not edible and removed before processing have been shown to contain a wide spectrum of polyphenolic components (Ramos *et al.*, 2006).

Mango peel *(Mangifera indica* L.), is a waste from mango industry which contain various bioactive compounds such as polyphenols, carotenoids, enzymes and dietary fibers and the peel extract exhibited potential antioxidant properties. So, can be utilized for preparation new useful products. (Ajila *et al.*, 2010a).

Olive mill wastes (*Olea europaea* L.) represent an important environmental problem in Mediterranean areas where they are generated in huge quantities in short periods of time, but these wastes also contain valuable resources such as a large proportion of organic matter, nutrients and bioactive compounds such as biophenols that could be recycled (Roig *et al.*, 2006).

The main objectives of this study were: 1- Determination of the chemical composition, total phenolics, total flavonoids and free radical scavenging activity of three by-products from different plant food processing industries such as red onion solid wastes, mango peels and olive pomace. 2- Seperation and identification of phenolic compounds for ethanolic extracts by using HPLC.

MATERIALS AND METHODS

Materials

Three by-products were used as a source of natural antioxidants, red onions solids wastes (*Allium cepa* L.) were obtained from local restaurant at Zagazig city, Mango peels (zebda, baladi and sucari) (*Mangifera indica* L.) from freshly processed fruits were collected from mango pulp processing industry (Green land foods factory) at 10th Ramadan city, Egypt. Olive (*Olea europaea* L.) was obtained from the fruit of several cultivars of olive tree and olive pomace obtained from olive press station of Al Salhia, Sharkia Governorat, Egypt.

Folin-Ciocalteu's reagent, (TBHQ), L ascorbic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), rutin, Qurestin from Sigma (St. Louis, MO,USA). All other chemicals and reagents were of analytical quality grade.

Methods

Preparation of by-Products Samples

The three by-products were dried at room temperature and complete dried at air oven (40±2°C). The dried by-products were powdered using a café mill and were sieved through a 60 mesh screen and stored in a tightly sealed plastic container in the freezer at -20°C for further analyses.

Determination of Chemical Composition

By-Products samples were subjected to chemical analyses in order to determine moisture, crude protein, crude fat, ash and crude fibres and contents were determined in triplicates according to standard methods of AOAC (2000). Carbohydrate content was calculated by difference.

Preparation of Antioxidant Extracts

Extraction of antioxidants from defatted wastes of red onion solid wastes, mango peels and olive pomace was carried out using 80%aqueous ethanol (1:10 w/v), overnight at room temperature with shaking followed by filtration through Whatman No. 1. The residues were re-extracted under the same conditions (3 times) then the combined filtrate was evaporated in a rotary evaporator (BÜCHI-water bath-B-480) at 40°C. Extracts were freeze-dried (Thermo- Electron Corporation - Heto power dry LL300 Freeze Dryer). The dried extracts after evaporation of solvents were weighed to determine the yield and stored at -20°C until further use.

Determination of Total Phenolic Compounds

The concentration of total phenols in all extracts wsa measured by UV spectrophotometer (Jenway-UV–VIS Spectrophotometer), as described by Zheng and Wang (2001). Using Folin-Ciocalteu reagent (AOAS, 1990).

Determination of Total Flavonoids Compounds

Total flavonoid content was determined by the method according to (Ordon *et al.,* 2006).

Separation and Identification of Phenolic Compounds Using HPLC

High performance liquid chromatography (HPLC) was used to separate and identificate phenolic compounds present in the extracts from onions solids wastes, mango peels and Olive pomace. The analysis of extracts were performed with HPLC (Hewlett Packard Series 1050, USA) equipped with autosamplling injector, solvent degasser, ultraviolet UV 280 nm detector and quaternary HP pump (series 1100). The column (Hypersil BDS 5 um C 18) temperature was maintained at 35°C. Gradient separation was carried out with methanol and acetonitrile as a mobile phase at flow rate of 1 ml/min. Phenolic compounds standared from Sigma Co were dissolved in mobile phase and injected into HPLC. Retention time and peak area were used to calculation of phenolic compounds concentration by the data analysis of HEWLLET packared software, according to Goupy *et al.* (1999).

Determination of Antioxidants Activity of Extracts

DPPH radical scavenging activity

The free radical scavenging of different extracts was measured by 2.2- diphenyl-1 hydrazil (DPPH) method, according to Tepe *et al.* (2005). Inhibition of free radical DPPH in per cent was calculated using the following equation:

$$\text{DPPH scavenging activity\%} = (A_c\text{-}A_s/A_c)\times 100$$

Where A_c is the absorbance of control reaction (containing all reagents except the test extract) and A_s is the absorbance in the presence of the tested extracts.

RESULTS AND DISCUSSION

Proximate Chemical Composition

The results shown in Table 1 indicated that moisture content of red onion solid wastes, mango peels and olive pomace were 7.71%, 9.10% and 4.22%, respectively; while, crude fat were 1.51%, 3.44% and 20.53%, respectively. The crude protein and total carbohydrate were 7.25%, 5.78%, 6.98% and 54.66%, 58.99% and 25.74% for red onion solid wastes, mango peels and olive pomace, respectively. Morever, the crude fiber and ash were 21.70%, 19.18% and 39.66% and 7.17%, 3.51% and 2.87% for red onion solid wastes, mango peels and olive pomace, respectively. It could be noticed that olive pomace had the highest levels of fiber and fat. While, red onion solid wastes recorded a higher content of protein and ash.

Ethanolic extracts yield, total polyphenols and total flavonoid

Extraction yield is dependent on both solvent and the method of extraction (Pinelo *et al.,* 2004). Red onion solid wastes and mango peels had the highest yield being 26.43and 23.34 respectively as shown in Table 2. While for olive pomace owing to its high lipid content the lowest yield was observed for ethanolic extract 9.16 g/100g DM. The total polyphenols content in the by- products were found to be 7270.10, 9750.00 and 940.00 mg GAE/100g DM for red onion solid wastes, mango peels and olive pomace, respectively. Mango peels contain exceptionally high amounts of total polyphenols.

Total flavonoids content were found to be 2323.70, 495.30 and 83.60 mg QE/100g DM for red onion solid wastes, mango peels and olive pomace, respectively. Results revealed that ethanol and water were more effective for extracting phenolic compounds owing to their higher polarity and good solubility (Wieland *et al.,* 2006).

Concerning total phenolic components for red onion solid wastes, these results are nearly in agreement with the previous reports by many authors. Kiassos *et al.* (2009) found that the highest total polyphenol yield was theoretically predicted to be 9342±1435 mg gallic acid equivalents per 100 g dry weight onion peel, under optimal conditions (60% EtOH, pH 2 and 4.2 hr). Also, Singh *et al.* (2009) cleared that the TPC showed wide variation from 23.1 ± 0.9 to 384.7 ± 5.0 mg GAE/g extract for onion peel and Boo *et al.* (2012) found that the polyphenol content was high in onion peel (400µg/ml).

Table 1. Proximate chemical composition of red onion solid wastes, mango peels and olive pomace (g /100 g dry matter)

Item (%)	Red onion solid wastes	Mango peels	Olive pomace
Moisture	7.71	9.10	4.22
Crude protein	7.25	5.78	6.98
Carbohydrates*	54.66	58.99	25.74
Crude fat	1.51	3.44	20.53
Ash	7.17	3.51	2.87
Crude fibre	21.70	19.18	39.66

* Calculated by differences.

Table 2. Total ethanolic extract 80%, polyphenols and flavonoids (g/100g dry matter)

By-products	Total yield g/100g	Total polyphenols mg/100g	Total flavonoids mg/100g
Red onion solid wastes	26.43	7270.10	2323.70
Mango peels	23.34	9750.00	495.30
Olive pomace	9.16	940.00	83.60

The obtained results in the present investigation were higher than those found by Makris *et al.* (2007) and Albishi *et al.* (2013b). They found that the total phenolic from onion peels was found to be 3727±771 mg GAE per 100 g dry weight, and 23.67 ± 0.16 as mg gallic acid equivalents (GAE)/g dried onion, respectively.

The results of total flavonoid agreed with the previous reported by Makris *et al.* (2007) who observed that the total flavonoid reached to 2212 ±18mg / per 100 g DM. Also, Jang and Im (2009) showed that the flavonoid levels in onion peel were 48-fold of that in its flesh. But, Singh *et al.* (2009) found that TFC varied from 1.3 ± 0.21 to 165.2 ± 3.2 mg QE/g extract for onion peel.

Concerning mango peels ethanolic extract, the obtained results are in line with many authors. Ajila and Prasada-Rao (2008) showed that the polyphenol content in acetone extract ranged from 90 to110 mg of GAE/g of unripe peel, whereas it ranged from 55–100 mg/g for ripe peel, Ajila *et al.* (2010[a]) found that the total polyphenol content in mango peel powder (MPP) was 96.17 mg GAE/ g peel powder. Elhassaneen *et al.* (2013) indicated that mango peel powder (MPP) contained high levels of many valuable antioxidants such as polyphenols being 9123 mg GAE.100g^{-1} DW.

With regard to total flavonoid, our obtained results was less than that reported by Ajila *et al.* (2007) who found that the content of flavonoids in unripe mango peels (UMP) and ripe mango peels (RMP) were 22.16 and 21.16 mg RE/g, revealing 3- and 6-fold higher than that of UMF and RMF, respectively.

Total phenolic results of olive pomace ethanolic extract were higher than that reported by many authors. Suarez *et al.* (2009) extracted 2.5 mg phenol/g solid residue using spanish commercial olive cake obtained from a two phase continuous system employing ASE at 80°C and ethanol/water (80:20) as extraction mixture. Cioffi *et al.* (2010) found that the phenolic content for olive oil pomace cultivar

''La Pepa'' and olive oil pomace cultivar ''Severini'' (207.4 ± 10.5 and 210 ±8.2 mg / kg) and for virgin olive oil ''La Pepa'' and ''Severini'', (350 ± 4.2 and 343 ± 5.0 mg / kg,) respectively. Meanwhile, the obtained results found to be less than that found by Aliakbarian *et al.* (2011) who found that total polyphenolic yield was 45.2 mg CAE/g DM. Also, Ramos *et al.* (2013) reported that the total phenolic for olive pomace and dry olive mill residue from portuguese industries varied from 33.36 ± 0.46 mg to78.20 ± 1.61mg GAE/g Extract DW, respectively.

Concerning our results of total flavonoids, it found to be less than that of Suarez *et al.* (2009) who found that total flavonoids extracted from olive pomace ranged from 3.9 mg CE/g DP (100 ^{O}C and 150 min) to 15.3 mg CE/g DP (150^{o}C and 60 min).

Identification of the Phenolic Compounds in Red Onion Solid Wastes, Mango Peels and Olive Pomace Ethanolic Extract by Using HPLC

Results in Table 3 showed that seventy one compounds were separated and thirteen compounds were tentatively identified of phenolic compounds in red onion solid wastes ethanolic extract. It can be noticed that ellagic acids are the most abundant phenolic compound being1930.38 mg / 100g DM in red onion solid wastes ethanolic extract. Furthermore, galic and syringic acids were found in small amounts being 2.52 mg and 6.98 mg/100g DM, respectively. These results are in agreement with those reported by Singh *et al.* (2009) who examined all the extracts/fractions of red onion peels for their specific phenolics composition by the HPLC to evaluate the presence of phenolic acids. The ethanol extract fraction was found to be the richest source of polyphenolics such as ferulic acid (19.6 ± 2.3 μg/g), protocatechuic acid (53.3 ± 2.0 μg/g), Highest quantity of gallic acid (74.9 ± 4.8 μg/g) was detected in the n-butanol fraction.

Albishi *et al.* (2013a) showed that the onion and potato peels samples had the highest phenolic content and were most effective as free radical scavengers. HPLC-MS analysis showed that quercetin 3,4O-diglucoside, quercetin, and kaempferol were the predominant phenolics in all onion extracts, while chlorogenic, caffeic, p-coumaric and ferulic acids predominated in the potato peel samples.

The present study illustrated that, seventy one compounds were separated and thirteen compounds were tentatively identified of phenolic compounds in mango peels ethanolic extract as shown in Table 4. It can be noticed that vanillic acid and caffeine were the major phenolics in mango peels ethanolic extract being 680.94 mg /100 g and 700.58 mg /100 g DM, respectively. Furthermore, syringic and p-coumaric acid were the lowest component being 32.72 mg /100 g and 38.63 mg /100 g DM, respectively. These results are in agreement with these reports by Ajila and Prasada-Rao (2008) found that gallic acid, protocatechuic acid, syringic acid and ferulic acid were found to be the phenolic acids identified in the bound phenolic fractions. Ajila *et al.* (2010b) reported that acetone extract of Badami peel contained gallic, protocatechuic, gentisic and syringic acids as bound phenolic acids. Prasad *et al.* (2011) used liquid chromatography-mass spectrometry as optimally obtained extracts from mango peel powder (MPP) revealing the major phytochemicals as mangiferin, gallic acid and catechin.

Data illustrated in Table 5 comprised eighty four compounds and thirteen compounds were tentatively identified of phenolic compounds in olive pomace ethanolic extract. It can be noticed that pyrogllol and polyhydroxy benzoic acid were the major phenolic compounds being 90.90 mg/100 and 37.45 mg/100g DM, respectively. While, chrysisin was a minor component; 0.98 mg / 100 g DM.

Some of identifiad compounds were found to be agree with the previous data reported by Cioffi *et al.* (2010) who found that phenolic compounds identified and quantified in the two olive oil pomace cultivars ''La Pepa'' and ''Severini'', as described in the experimental section, simple phenols (gallic acid 11.4 ± 0.35 and 12.6 ± 0.65 mg /kg,, caffeic acid13.5 ± 1.04 and 6.7 ± 0.66 mg /kg,, syringic acid not found, and ferulic acid 12.6 ± 0.61 mg /kg for olive oil pomace cultivar ''Severini'', oleuropein83.0 ± 3.60 and 81.7 ± 2.40 mg /kg and Vanillic acid 10.4 ± 0.66 and 8.8 ± 0.65 mg /kg, respectively.

Table 3. Fractions of phenolic compounds of red onion solid wastes ethanolic extract (mg /100 g dry matter)

Identified compounds		Retention time (min)	Conc. (mg / 100 g dry matter)
1	Galic acid	7.451	2.52
2	Protocatechuic	8.830	266.56
3	Chlorogenic acid	9.434	70.42
4	Vanillic acid	10.773	16.59
5	Syringic acid	10.949	6.98
6	Caffeine	11.107	75.83
7	Ferulic	12.366	19.28
8	Ellagic	13.543	1930.38
9	P-Coumaric	14.119	23.50
10	Coumarin	14.240	50.17
11	Salicylic	14.730	160.71
12	Cinnamic	15.828	20.42
13	Chrysisin	19.218	26.77

Table 4. Fractions of phenolic compounds of mango peels ethanolic extract (mg/100 g dry matter)

Identified compounds		Retention time (min)	Conc. (mg/100 g dry matter)
1	Galic acid	7.433	111.04
2	Protocatechuic	8.698	48.22
3	Catachin	8.991	74.85
4	Chlorogenic acid	9.590	70.11
5	Catechol	9.821	135.78
6	Vanillic acid	10.803	680.94
7	Syringic acid	10.889	32.72
8	Caffeine	11.060	700.58
9	Ellagic	13.653	107.02
10	P-Coumaric	13.836	38.63
11	Polyhydroxy-benzoic	13.965	244.50
12	Coumarin	14.245	61.98
13	Salicylic	14.710	80.02

Table 5. Fractions of phenolic compounds of olive pomace ethanolic extracts (mg/100 g dry matter)

Identified compounds		Retention time(min)	Conc. (mg / 100 g dry matter)
1	Pyrogllol	7.433	90.90
2	Catachin	9.025	14.04
3	Chlorogenic acid	9.581	5.67
4	Catechol	9.830	11.90
5	Caffeic acid	10.640	2.22
6	Vanillic acid	10.779	9.38
7	Syringic acid	10.951	1.89
8	Caffeine	11.048	9.24
9	Ellagic	13.682	27.99
10	P-Coumaric	13.753	1.43
11	Polyhydroxy-benzoic	14.027	37.45
12	Coumarin	14.258	12.52
13	Chrysisin	19.133	0.98

DPPH radical-scavenging activity

The results of red onion solid wastes ethanolic extract radical scavenging activity (RSA) were compared with natural and synthetic antioxidants as vitamin C and tert-butyl hydroquinone (TBHQ), respectively. The assays at zero time, 30, 60 and 120 min with DPPH and DPPH as a control are shown in Fig. 1, results indicated that ethanolic extract had higher values of radical scavenging activity (RSA) being 90.43%, at 120 min, compared with 94.71% and 94.94% for vitamin C and TBHQ at 120min, respectively at a dose of 100 µg mL^{-1}. The obtained results are in line with many authors. Prakash *et al.* (2007) observed that outer layer of red onion had the highest antioxidants and antioxidant activities than the purple, white and green varieties of onion, as determined *in vitro* antioxidant and free radical scavenging activities. Lee *et al.* (2012) studied the antioxidant activity of red onion, garlic, and white onion compared with red onion peel which exhibited approximately six and five fold higher DPPH radical-scavenging activity than garlic and white onion, respectively.

The results of mango peels ethanolic extract radical scavenging activity (RSA) compared with natural and synthetic antioxidants at zero time, 30, 60 and 120 min with DPPH and DPPH as a control are shown in Fig. 2, the antioxidant activity found to be 92.81%, compared to 94.71% and 94.94% for vitamin C and TBHQ, respectively;, at a dose of 100 µg mL^{-1}. These values were observed to be similar for vitamin C and TBHQ at 120min, respectively. The obtained results are in agreement with Berardini *et al.* (2004) who established that the anti-oxidative capacity of mango peel extract was higher than that of standard mangiferin and quercetin 3-O-glucoside indicating that the anti-oxidative capacity of the peel extract cannot be attributed to a single component but to the synergistic effect of all the compounds present. Ethanolic extract of mango peel was found to contain high antioxidant activities associated with its phenolic and flavonoid composition (Ling *et al.,* 2009). The obtained results are in accordance with Kim *et al.* (2010) who found that the scavenging activities of unripe mango flesh, unripe mango peel, ripe mango flesh and ripe mango peel extracts at 500 µg/ml were 91.05%, 88.86%, 91.61% and 89.61%, respectively. There were no significant differences among the extracts and the activities were higher than that of catechin, which was used as a positive control, and exhibited 89.53% scavenging activity at 1000 µg/ml.

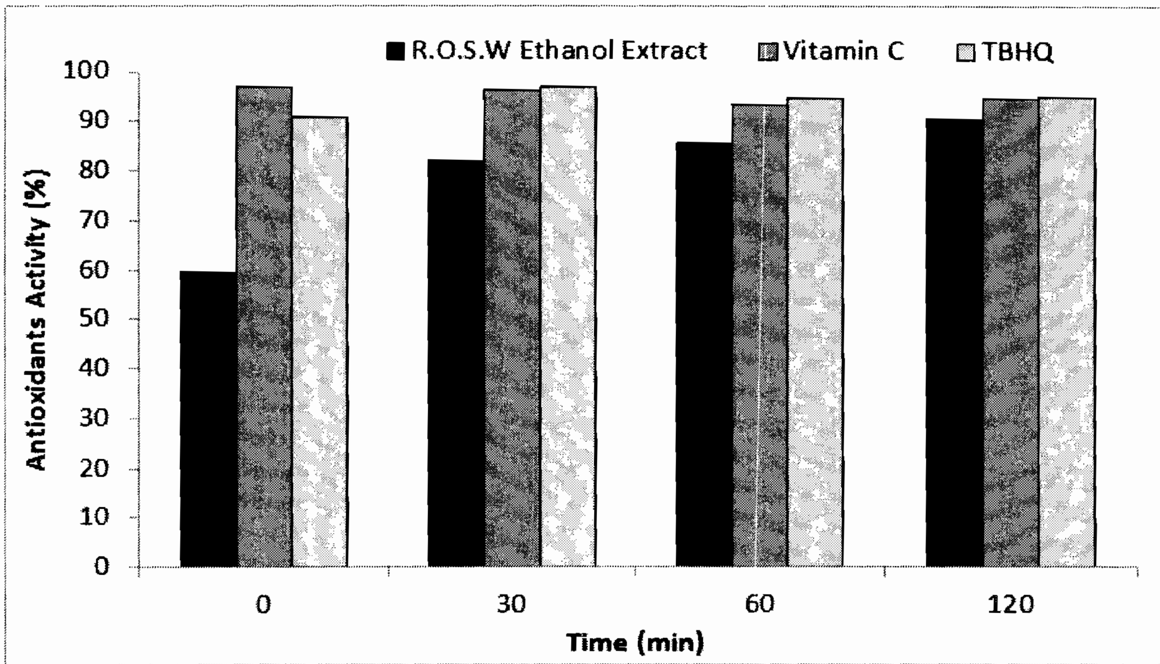

Fig. 1. Scavenging activity of red onion solid wastes (R.O.S.W) ethanol 80% extract against DPPH radical compared with ascorbic acid and tert-butyl hydroquinone (TBHQ)

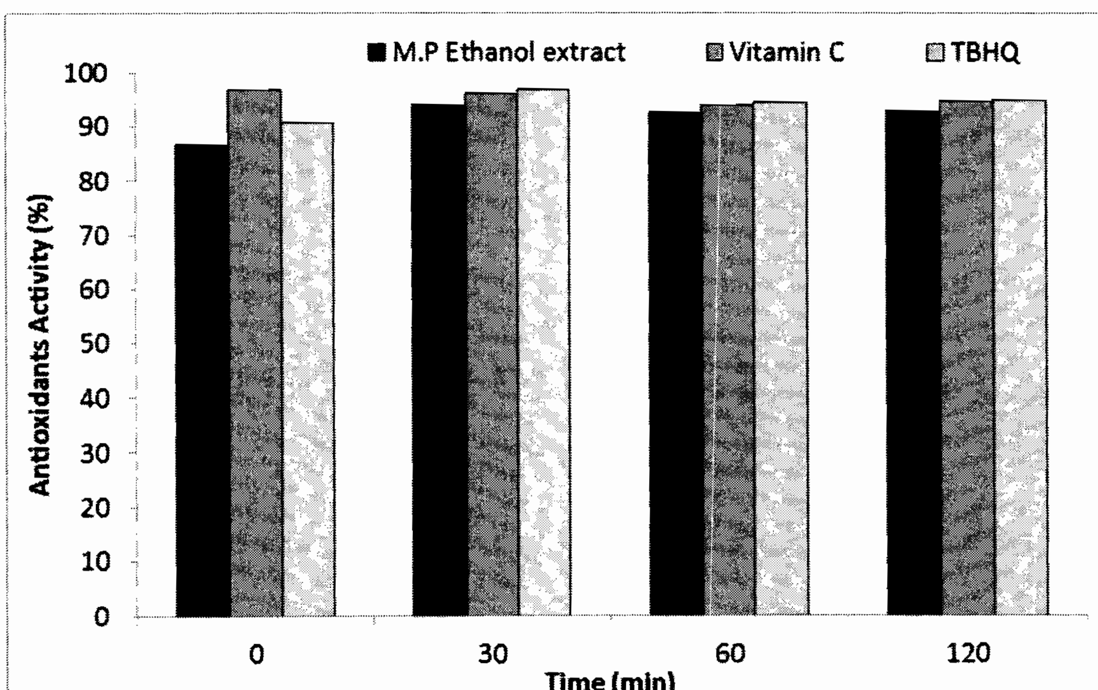

Fig. 2. Scavenging activity of mango peels (M.P) ethanol 80% extract against DPPH radical compared with ascorbic acid and tert-butyl hydroquinone (TBHQ)

The antioxidant activity of olive pomace found to be 91.16%, compared to 94.71% and 94.94% for vitamin C and TBHQ, respectively; at a dose of 100 μg mL^{-1} (Fig. 3). These values were observed to be nearly similar for vitamin C and TBHQ at 120min, respectively. As previously, it is observed from figures that three ethanol extracts show high antioxidant activity being 90.43%, 92.81% and 91.16% for red onion solid wastes, mango peels and olive pomace ethanolic extract compared to 94.71% and 94.94%, for vitamin C and TBHQ at 120min, at a dose of 100 μg mL^{-1}, respectively; indicating high radical scavenger activity.

So, the results of the DPPH• free radical scavenging assay suggest that components involving the extracts are capable of scavenging free radicals *via* electron- or hydrogen-donating mechanisms and thus might be able to prevent the initiation of deleterious free radical mediated chain reactions in susceptible matrices.

This further shows the capability of the extracts to scavenge different free radicals in different systems, revealing that they may be useful therapeutic agents for treating radical-related pathological damage.

Conclusion

In general, it could be concluded that red onion solid wastes and mango peels had high phenolic content and phenolic compounds. Also, three ethanolic extracts showed effective radical scavengers. Furthermore, it is notable that ethanol extracts exhibited strong antioxidant capacity comparable activity to vitamin C and TBHQ.

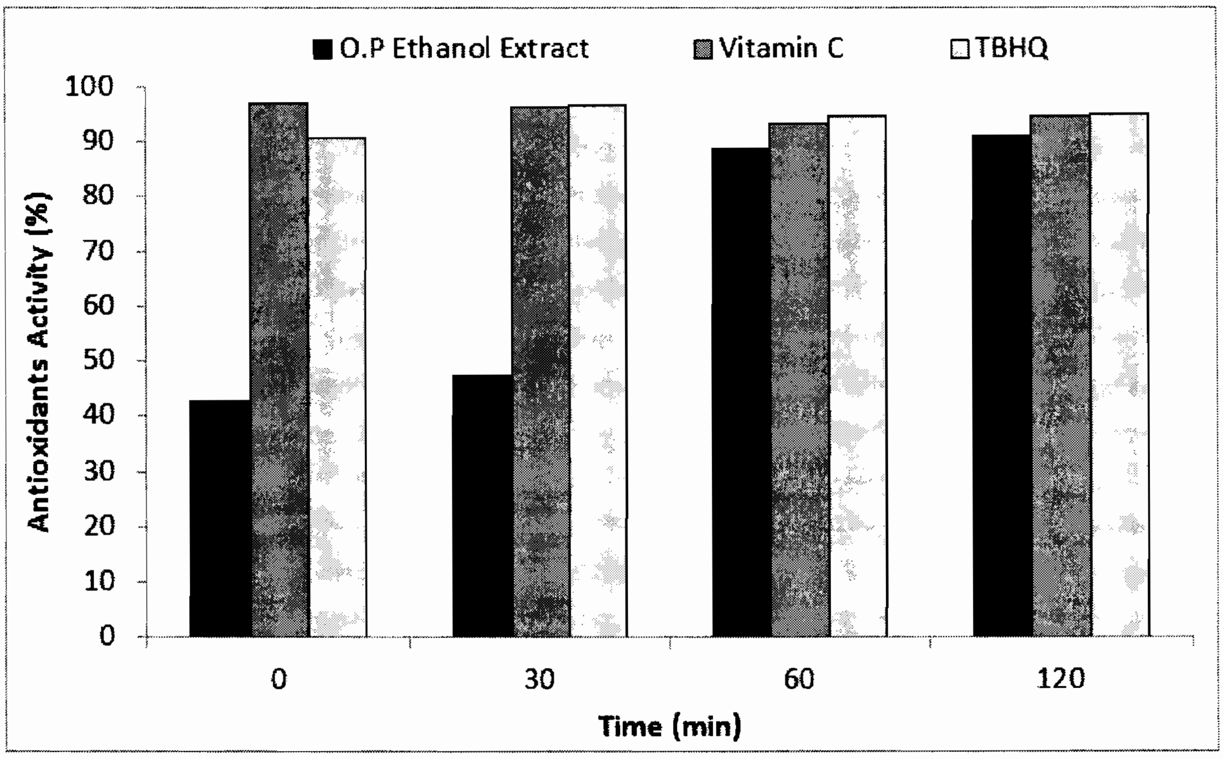

Fig. 3. Scavenging activity of olive pomace (O.P) ethanol 80% extract against DPPH radical compared with ascorbic acid and tert-butyl hydroquinone (TBHQ)

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المـركبـــات الفينـــوليـــــة لمستخلصـــــــات الإيثـــانــــول مـن بعض مخلفـــات الأغــذيـة

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ينتج عن تصنيع الفاكهة والخضر والبذور الزيتية كميات هائلة من المخلفات حيث تعد هذه المخلفات مصدرا جيدا للعديد من المركبات الحيوية مثل المركبات الفينولية والفلافونيدات، والهدف من هذا البحث هو دراسة الخواص المضادة للأكسدة وكذلك المحتوي الكلي للمركبات الفينولية والفلافونيدات الموجودة فى المستخلص الإيثانولى ٨٠% لثلاث أنواع من المخلفات وهى: مخلفات البصل الأحمر الصلبة وقشور المانجو ومخلف تصنيع زيت الزيتون، وأوضحت النتائج أن قشور المانجو كانت لها أعلى محتوى من المركبات الفينولية تبعه مخلف البصل الأحمر ثم مخلف زيت الزيتون بقيم ٩٧٥٠، ٧٢٧٠,١ و٩٤٠ ملجم مكافىء حامض جاليك لكل ١٠٠ جم مادة جافة على التوالى، وسجل المستخلص الإيثانولى لمخلف البصل الأحمر أعلى محتوى من مركبات الفلافونيدات الكلية ٢٣٢٣,٧٠ ملجم مكافىء كيورستين لكل ١٠٠ جم مادة جافة، وأظهرت المستخلصات الإيثانولية نشاطا عاليا كمضادات للأكسدة بلغ ٩٠,٤٣، ٩٢,٨١ و٩١,١٦% لكل من مخلف البصل الأحمر، قشور المانجو ثم مخلف زيت الزيتون على التوالى مقارنة بمضاد الأكسدة الطبيعى (حامض الأسكوربيك) ٩٤,٧١% وكذلك الصناعى بيوتيل هيدروكينون (TBHQ) ٩٤,٩٤%.

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