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Nutritive value and antioxidant activity of some edible wild fruits in the Middle East

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The encroachment of urbanization over the rural environment and deterioration of large areas of wilderness in the Middle East make many people weaned away from appreciation of wild plant food resources. The studies on wild edible fruits are deemed essential and open the possibility for its use as source of nutritional and pharmaceutical materials. Fruits of three species *Arbutus pavarii*, *Ficus palmata* and *Nitraria retusa* were analyzed for evaluation of their nutritive values and antioxidant capacities. The protein, carbohydrate and lipid content of the fruits may exceed or coincide the reported values of other wild and cultivated edible fruits. The energy content reached 790 kcal/ 100 g fresh weight. The mineral composition reaches high quantities of K, Ca, Mg, Na and other essential elements including P, Fe, Zn and Cu. The total antioxidant phenolic compounds content ranged from 10.31 to 16.46 mg/g with major constituents of tannins, anthocyanins and carotenoids. Vitamin C content varied between 25.33 to 85.00 mg/ 100 g fresh weight. The antioxidant activity and DPPH free radical scavenging demonstrated concentration dependent increase. Considering the quality rather than quantity, the nutritional value and pharmaceutical potential of the study wild fruits may outweigh the traditionally cultivated fruits.

Key words: Macronutrients, minerals, energy, phenolics, scavenging activity.

INTRODUCTION

The global overpopulation needs parallel increase in food and nutrition sources. Food security becomes vulnerable when it is only dependent on a few numbers of traditional crop plants and domestic animals. Food and nutrition security need to be addressed in the context of biodiversity, an important asset to domesticate new crops or improve the quality of traditional crop plants. Food biodiversity is defined as the diversity of plants, animals and other organisms used for food, covering the genetic resources within species, between species and provided by ecosystems (FAO, 2010; Johns and Eyzaguirre, 2007; Dhar et al., 2012). Therefore, not only the quantity and energy contribution of foods are important to combat malnutrition but also their quality, including macro-and micronutrient content, and antioxidant activities. The gap between wild edible fruits and cultivated ones is wide and needs to be bridged by shedding more light on potential wild food biodiversity.

Although wild food plants (WFPs) represent a minor contribution to family meals, they are potentially important nutrient and cultural resources for local people around the world. They often contain higher amount of nutrients

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and bioactive compounds than many cultivated species, especially those which have been under cultivation for many generations (Martins et al., 2011; Stadlmayr et al., 2011; Heinrich et al., 2006; Trumbo et al., 2002; Getahun, 1974). The interest on WFP stems from: (i) their use in local remote regions, (ii) biodiversity conservation and sustainable use, (iii) their potential as new or underutilized crops, and iv) their inclusion in daily diets as potential sources of novel nutraceuticals; that suggests their inclusion in the diet for prevention of age-related diseases.

Recently, there has been some interest to develop and conserve WFPs, because of over-collection by plant collectors and local populations for sale or use (Delang, 2006; Michael Arnold and Ruiz Pérez, 2001). They have great potential as high-value nutraceuticals, and source of bioactive compounds for dietary supplements or functional foods. Edible wild plant fruits are important food items in traditional diets of local people, and especially in the arid and Mediterranean regions, making an important contribution to the health of local communities. The edible fruits have been employed, for a long, in traditional and popular medicine.

Antioxidants are substances that prevent or reduce the oxidative damage of lipids, proteins and nucleic acids by reactive oxygen species (ROS) (Insel et al., 2002). Vitamin C is a dietary antioxidant required as a co-factor for many enzymes. The reduced form of vitamin C, L-ascorbic acid, is the main biologically active form of this vitamin and it is an effective antioxidant due to its high electron-donating power and ready conversion back to the active reduced form. The importance of antioxidants or what is commonly known as oxygen-derived free radicals or reactive oxygen species, in health and disease is now recognized in medicine and biological sciences (Oliveira et al., 2009). ROS are chemically reactive molecules that are derived from the successive reduction of molecular oxygen to H_2O. They included free radicals, such as superoxide anion radicals, hydroxyl radicals, and non-free-radical species (Aruoma, 1996; Gülcin, 2007). Wild plant fruits contain many natural antioxidants compounds such as carotenoids, vitamins, phenols, tannins, flavonoids, and many secondary metabolites; which have been identified as a free radical or active oxygen scavengers (Zheng and Wang, 2001). Therefore, wild plant food sources are important to be investigated from not only the point of view of its nutritional value but also as a potential therapeutic agent against a wide range of human disease (Oliveira et al., 2009; Garcia-Alonso et al., 2004).

In the arid and Mediterranean regions, Wild food plants (WFPs) are important food items in traditional diets of local people. They have been employed in traditional and popular medicine and consequently making an important contribution to the health of local communities. Recently, much attention has been focused on conservation and development of WFPs to support their use as an alternative to other agricultural fruits available in the market or as a new ingredient for the food industry (Johns and Eyzaguirre, 2006, 2007). However, no data have been found about the variability of the macro and micronutrients composition and antioxidant properties of the edible fruits of the proposed study species in the region.

Because of the importance of wild plant food sources, it would be beneficial to understand how these plants contribute to human health and nutrition, and to recognize their potential for sustaining populations during future food shortages. Although previous studies have been published on the nutritional value of wild plants (Cook et al., 2000; Nordeide et al., 1994; Salih et al., 1991), the available information of their chemical and nutrient composition is far from exhaustive. Hence, the objective of this work is to assess the nutritional value and antioxidant activity of mature fruits in the three study species *Arbutus pavarii*, *Nitraria retusa* and *Ficus palmata*. The macronutrients and mineral analysis, phenols content, and reducing power and radical scavenging activity on DPPH radicals are measured.

MATERIAL AND METHODS

Study species

***Arbutus pavarii* Pamp. (Ericaceae):** The species is known as "strawberry tree." The evergreen shrubs and trees are 1.5 to 3 (-6) m high. Flowering occurs in late spring and fruits mature in late summer (Jafri and El-Gadi, 1977-1993). The fruit is globose and many-seeded berry, yellow to orange red when fully ripe. The fresh mature fruits are edible, but sometimes processed before consumption. Processed products include alcoholic beverages and non-alcoholic drink, jams, marmalades and jellies. In traditional folk medicine, the fruits are used as antiseptic, diuretic and laxative, beside treatment arterial hypertension. The species is Mediterranean and endemic to Libya in Gebal Al-Akhdar (Green Mountain) escarpment (Plate 1).

***Nitraria retusa* (Forssk.)Asch. (Nitrariaceae):** The species occurs in coastal and inland habitat types. It is commonly found in coastal and inland salt affected sites, edges of salt marshes, and inland desert valley habitats. The species is salt and drought tolerant. Flowering occurs in late spring and fruits mature in summer (Boulos, 2009). The thorny shrubs and trees are up to 3 m high. Drupes are one-seeded fruits, fleshy and red in colour A tasty refreshing juice is extracted from the mature fruits (Salem et al., 2011). Ripe fresh fruits are edible and used in traditional medicine by local inhabitants for having hypoglycemic effects. The species is globally distributed in North Africa, and west Asia to Pakistan.

***Ficus palmata* Forssk. (Moraceae):** The species growth is confined to rock and outcrop sites of the valley habitat types, slopes and cliffs particularly in mountain escarpment. Flowering and fruiting occur during late spring and summer (Boulos, 2009). Shrubs and trees are up to 4 m high. Fruit are fig type with fleshy receptacle and small one-seeded drupelets. Mature fruits are deep purple in colour. The species is globally distributed in tropical Northeast Africa, and west Asia to Northwest India. The species is critically endangered and threatened by habitat disturbance and cutting of its wood. Fully ripe fresh or partially dry fruits are edible

Plate 1. Study species and mature fruits. Upper= *Arbutus pavarii*, fruiting plant branches (left) and mature fruits (right). Middle= *Nitraria retusa*, individual plant (left) and fruiting branch (right), and Lower= *Ficus palmata*, individual plant (left) and fruiting branch (right).

and used by local inhabitants for treatment of constipation. Latex is added to milk to make yoghurt (Plate 1).

Sample collection

Mature fruits of *A. pavarii* were collected in 8 October, 2010 from Qandulah, Al-Jabal Al-Akhdar, Libya (N 32° 34' 12.6", E 21° 39' 6.0", elevation 745 m a.s.l). The fruits of *N. retusa* were collected in 28 May, 2010 from Wadi El-Reshrash, Eastern desert, Egypt (N 27° 02' 55.0", E 33° 16' 53.7", elevation 661 m a.s.l). The fruits of *F. palmata* were collected on 3 October, 2010 from the mountains of Abha City, Saudi Arabia (N 18° 11.7' 14.0", E 42° 30.5' 33.0", elevation 2065 m a.s.l). Fruits were collected manually from randomly selected several individual plants of one population and pooled to form a single sample. The collected samples were immediately packed in tight plastic bags and carried in the same day to the laboratories in ice box, where it was preserved in deep freeze at -20°C until analysis. All gathered fruits were in their optimal ripening status and appeared healthy in external appearance. The samples were shipped frozen by air to Faculty of Agriculture Research Park, Cairo University for analysis. Sample analysis was completed within one month of harvest.

Macronutrient analysis

The content of moisture, ash, crude fibers, crude protein, lipid and carbohydrates were determined in accordance with the standard methods of the AOAC (2000). All determinations were run in triplicates (three analyses of the same sample). The results were calculated on the basis of sample fresh weight. Moisture content was determined by drying the fruits at 105°C in an oven until constant weight was obtained; at least for 72 h. Ash content was determined by incineration in muffle furnace at temperature 450±10°C. Fiber estimate was obtained from the loss in weight on ignition of dried residue following the digestion of fat free samples with 1.25% each of sulfuric acid and sodium hydroxide solutions. The crude protein content (N × 5.25) was estimated by the macro-kjeldahl nitrogen assay method using a digestion apparatus combined with the photocolorimetric method described by Baethgen and Alley (1989). The lipid content was determined by n-hexane extraction and measured by soxtherm (Gerhadt, lab instrument). Total hydrolysable carbohydrate was determined calorimetrically according to Dubois et al. (1956). Soluble sugars was extracted by boiling in 80% neutral aqueous ethanol for 6 h, and determined using the phenol-sulfuric acid method according to Dubois et al. (1956). The energy content was estimated by multiplying the percentages of crude protein, crude fat and digestible carbohydrates by their respective Atwater factors, which are 4, 9 and 4, respectively (Udosen, 1995; FAO, 2003). Total amino acids were determined by acid hydrolysis (Block et al., 1958) and measured according to Etsushiro et al. (1981).

Mineral analysis

The mineral ions Na, K, Ca, Mg, Fe, Zn, and Cu were measured after wet-ashing by atomic absorption (Model Varian, spectra AA220). Phosphorus was estimated calorimetrically (UV-visible spectrophotometer), using potassium dihydrogen phosphate standard (AOAC, 2000). Mineral composition is calculated on the basis of fruit fresh weight as mg per 100 g fresh weight.

Antioxidant compounds

Total phenolics: The total phenolics content was determined colorimetrically at 765 nm using Folin-Ciocalteu reagent in combined methanol and acetone extracts of freeze-dried fruits (Perez-Jimenez et al., 2006). The determination was performed according to the Folin-Ciocalteu procedure (Singleton and Rossi, 1965). Total phenolic content was expressed as gallic acid equivalents (GAE).

Tannins: Total tannins were determined by copper acetate gravi-metric method. The method depends on quantitative precipitation of tannin with copper acetate solution, then ignition of copper tannate to copper oxide and weighing the residual copper oxide (Ali et al., 1991). The amount of tannins was calculated as each one gram copper oxide is equivalent to 10305 g tannins.

Anthocyanins. These phenolics pigments were analyzed using the Lees and Francis method (Alarcao-E-Silva et al., 2001). The sample was blended in 100 ml 0.1 N HCl in C_2H_5OH (15 : 85) and the macerate stored overnight at 43°C. The absorbance of an aliquot was measured at 535 nm and converted to anthocyanin contents using the formula proposed by Fuleki and Francis (1968).

Carotenoids: The carotenoid content of fruits was measured in 85% acetone extract of the freeze-dry sample according to Fahmy et al. (1990). The optical density of the extract was measured at 453, 505, 645 and 663 nm. The content of b-carotene was calculated according to the following equation:

$$\beta\text{-carotene} = 0.216 \times A663 - 1.220 \times A645 - 0.304 \times A505 + 0.452 \times A453$$

Vitamin C: Vitamin C was determined following Klein and Perry (1982). Samples were extracted with metaphosphoric acid (1%, 10 ml) for 45 min at room temperature and filtered. The filtrate (1 ml) was mixed with 2,6-dichloroindophenol (9 ml) and the absorbance was measured spectrophotometrically at 515 nm against a blank. The content of vitamin C was calculated on the basis of the calibration curve of authentic L-ascorbic acid.

Total antioxidant capacity: The total antioxidant capacity of plant methanolic extract was assayed following Pan et al. (2007). One ml of the extract was combined with 3 ml reagent solution (0.6 M H_2SO_4, 28 mM sodium phosphate and 4 mM ammonium molybdate). The reaction mixture was incubated at 95°C for 150 min after cooling at room temperature; the absorbance was measured at 695 nm against blank. Readings were taken every 30 min. The antioxidant activity was expressed as absorbance of the sample. The activity of catechol (0.5 mg/ml) was assayed for comparison.

DPPH scavenging activity: The free radical scavenging activity of the fruit extract was assessed by the decolouration of a methanolic solution of 2,2-diphenyl-1-picrylhydrazyl (DPPH) according to Lee et al. (2002) and Oliveira et al. (2009, 2011). The reduction of the DPPH radical was measured by monitoring continuously the decrease of absorption at 517 nm. DPPH scavenging effect was calculated by using the equation:

$$\% \text{ scavenging effect} = [(ADPPH - AS) / ADPPH] \times 100$$

Where AS is the absorbance of the solution when the sample extract was added while ADPPH represents the absorbance of the DPPH. The extract concentration providing 50% inhibition (EC_{50}) was calculated from the graph of scavenging effect percentage against the extract concentration. The antioxidant activity of standard concentration of vitamin E was assayed for comparison.

Hydrogen peroxide scavenging activity: The activity was measured by replacement titration (Zhao et al., 2006). A solution of1 ml of 0.1 mM H_2O_2 and 1 ml of various concentrations (0.2, 0.4, 0.6, 0.8 and 1 mg/ml) of the test fruit extract were mixed, followed by two drops 3% ammonium molybdate, 10 ml 2 M H_2SO_4 and 7 ml 1.8 M KI. The mixed solution was titrated against 5 mM NaS_2O_3 until yellow colour disappeared. The relative activity to scavenge hydrogen peroxide was expressed as percentage of the titer volume change as following:

$$\% \text{ Inhibition} = [(V_{control} - V_{sample}) / V_{control}] \times 100$$

Data analysis

Data were analyzed using SAS procedures and software. Means and standard deviations were obtained. One-way ANOVA and least significant difference were used to compare the mean values.

RESULTS

Macronutrient contents

The chemical composition of the fruits in the three species is given in Table 1. The fruits of *N. retusa* reached the highest values of moisture (76.25%) and ash (1.12%) contents compared to those of *A. pavarii* and *F. palmata*. Alternatively, the fruits attained the lowest values of fiber (2.68%), protein (1.51%), lipids (0.75%),

Table 1. Nutritional composition of the fruits in the three study species.

Nutritional parameter	*Arbutus pavarii*	*Nitraria retusa*	*Ficus palmata*
Moisture (%)	68.06 ± 1.65 [a]	76.25 ± 2.68 [b]	67.82 ± 2.07 [a]
Ash (%)	0.75 ± 0.09 [a]	1.12 ± 0.18 [b]	0.89 ± 0.08 [a]
Fibers (%)	5.28 ± 0.57 [a]	2.68 ± 0.50 [b]	2.88 ± 0.47 [b]
Protein (%)	2.23 ± 0.41 [a]	1.51 ± 0.46 [b]	2.17 ± 0.37 [a]
Lipid (%)	1.33 ± 0.14 [a]	0.75 ± 0.15 [b]	1.12 ± 0.11 [a]
Hydrolysable carbohydrates (%)	25.55 ± 2.25 [a]	14.78 ± 2.05 [b]	20.35 ± 1.63 [c]
Soluble carbohydrates (%)	15.65 ± 0.60 [a]	9.96 ± 1.65 [b]	11.98 ± 1.88 [b]
Total carbohydrates (%)	41.18 ± 1.79 [a]	24.74 ± 3.37 [b]	28.74 ± 4.97 [c]
Total free amino acids (%)	1.61 ± 0.40 [a]	0.87 ± 0.23 [b]	1.31 ± 0.24 [a]
Energy (Kcal/ 100 g fresh wt)	790.00 ± 19.92 [a]	490.33 ± 64.36 [b]	565.67 ± 75.18 [b]

Values in every row with the same letters are non significantly different at level 0.001.

hydrolysable carbohydrates (14.78%), soluble carbohydrates (9.96%), total carbohydrates (24.74%) and total free amino acids (0.87%) compared to the fruits of *A. pavarii* and *F. palmata*, while these macronutrient contents attained the highest values in *A. pavarii* fruits. The total carbohydrates were the most abundant macronutrients in the three species, where the highest value (41.18%) was found in *A. pavarii*. The energy content of the fruits reached the highest value 790 kcal in *A. pavarii* and the lowest value 490.33 kcal in *N. retusa*.

Mineral composition

The fruits of the three species contained relatively high quantities of potassium, calcium, magnesium, sodium; and considerable amounts of many other nutritionally essential elements, including: phosphorus, iron, zinc and copper (Table 2). The fruits of *A. pavarii* attained the highest concentrations of most of the macro- and micro-nutrients. For example, there was more than a threefold difference between the highest (86.33 mg/ 100 g FW) in *A. pavarii* and the lowest calcium concentration (28.67 mg/ 100 g FW) in *N. retusa*. Similarly, fruits of *A. pavarii* reached the highest contents of potassium (349.33 mg/ 100 g FW) and phosphorus (35.67 mg/ 100 g FW). Meanwhile, fruits of *N. retusa* contained 2.27 and 1.62 times higher sodium concentration than those of *A. pavarii* and *F. palmata*, respectively.

Antioxidant properties

The content of active constituents known to have high antioxidant activity (Table 3) showed significant variations in total phenolic compounds from 10.31 to 16.46 mg/ g, and tannins content ranged from 1.71 to 3.12 mg/ g in *N. retusa* and *A. pavarii*, respectively. Anthocyanins showed slight amounts within narrow range of variations among species that ranged from 0.16 to 0.28 mg/ g in *F. palmata* and *A. pavarii*, respectively. Carotenoids content amounted to 30.67 mg/ g in *A. pavarii*, 18.33 mg/ g in *N. retusa*, and 9.67 mg/ g in *F. palmata*. The content of vitamin C demonstrated wide range of variations among species with vales 85.00 mg/ 100 g in *A. pavarii*, 37.00 mg/ 100 g in *F. palmata*, and 25.33 mg/ 100 g in *N. retusa*.

The antioxidant activity of the edible fruits of the study species demonstrates a concentration dependent increase (Figure 1a). The absorbance of metabolic extracts after incubation time range from 30 to 150 min ranged from 0.16 to 0.25 in *N. retusa*, and 0.29 to 0.45 in *A. pavarii*, while *F. palmata* attained an intermediate values ranged from 0.22 to 0.37.

The DPPH free radical scavenging activity increased with concentration (Figure 1b), that reached at concentration 1 mg/ ml up to 70% in *A. pavarii*, 40% in *F. palmata*, and 15% in *N. retusa*. The hydrogen peroxide scavenging activity (Figure 1c) also demonstrated concentration dependent increase. The extract of *A. pavarii* was more effective than the other two species with value more than 60% at 1 mg/ ml concentration, 45% for *F. palmata*, and 73% for *N. retusa*.

DISCUSSION

Hitherto, the wild fruits are not regularly consumed by local residents, only the older generation in the region, particularly in the countryside. The present study highlighted the nutritional value and importance of using wild plant fruits, even if not all wild plant fruits are consumed by the local community. Nutrient information would be critical to the success of efforts to promote the wider use of indigenous plant food sources as part of a broader biodiversity resource based development program with regard to the nutritional benefits of the many wild plant foods that exist in their environment. The fruits are also rich in vitamin C, which makes them promising sources of bioactive compounds. The intake of these fruits may positively influence the health of users.

Furthermore, the commercialization of *A. pavarii*, *F.*

Table 2. Minerals composition of the fruits in the three study species.

Mineral (mg/100 g FW)	*Arbutus pavarii*	*Nitraria retusa*	*Ficus palmata*
Sodium	12.33 ± 2.52 [a]	28.00 ± 2.65 [b]	17.33 ± 2.08 [c]
Potassium	349.33 ± 6.66 [a]	263.33 ± 6.11 [b]	208.67 ± 7.09 [c]
Calcium	86.33 ± 2.52 [a]	28.67 ± 1.53 [b]	65.00 ± 3.61 [c]
Magnesium	28.67 ± 1.15 [a]	23.00 ± 2.65 [b]	37.67 ± 5.03 [c]
Iron	2.57 ± 0.42 [a]	1.23 ± 0.31 [b]	3.13 ± 0.35 [a]
Zinc	1.31 ± 0.16 [a]	0.14 ± 0.04 [b]	0.14 ± 0.03 [b]
Copper	0.24 ± 0.05 [a]	0.15 ± 0.03 [b]	0.37 ± 0.06 [c]
Phosphorus	35.67 ± 2.08 [a]	12.33 ± 1.53 [b]	32.67 ± 4.04 [a]

Values in every row with the same letters are non significantly different at level 0.001.

Table 3. Phenolic compounds content of the fruits of the three study species.

Compounds	*Arbutus pavarii*	*Nitraria retusa*	*Ficus palmata*
Total phenolic compounds (mg/g)	16.46 ± 1.47 [a]	10.31 ± 1.16 [b]	12.72 ± 0.61 [c]
Tannins (mg/g)	3.12 ± 0.96 [a]	1.71 ± 0.48 [b]	2.27 ± 0.15 [c]
Anthocyanins (mg/g)	0.28 ± 0.07 [a]	0.25 ± 0.05 [b]	0.16 ± 0.06 [b]
Carotenoids (mg/ g)	30.67 ± 1.53 [a]	18.33 ± 2.52 [b]	9.67 ± 1.53 [c]
Vitamin C (mg/100 g)	85.00 ± 3.61 [a]	25.33 ± 3.06 [b]	37.00 ± 2.65 [c]

Values in every row with the same letters are non significantly different at level 0.001.

palmata and *N. retusa* fruit-derived products may also be of application for the pharmaceutical and food industries. This is possible when considering these fruits as a possible source of bioactive compounds, in order to achieve higher and viable yields.

The results in the current study revealed that fruits of target species are good source of nutrients, minerals and antioxidants. These findings may explain their uses in folk medicine and promote their utilization as health food supplement. The phytochemical analysis of active constituents showed that, the three species contained more than 10 mg/g total phenolic compounds, and substantial content of tannins, anthocyanins, carotenoids and vitamin C which are known to possess high antioxidant activity (Xu and Chang, 2008). Many of these phenolic compounds exhibit wide range of biological effects (Simonetti et al., 2011). As reported by Kumari and Kakkar (2008), the synthetic antioxidants were found to be harmful to health while most of the natural antioxidants from plant sources proved to be safer for health and possess better biological activities.

The moisture contents of studied fruits are higher than the reported values in some important wild edible fruits (e.g. *Balanites aegyptica* – 45.66%, *Ziziphus spina-christi* – 52.41%, *Vangueria infaustra* – 4.16%, *Vitex mombassae* – 12.11%) in other arid and semi-arid regions (Nour et al., 1985; Rathore, 2009; Emamanuel et al., 2011; Feyssa et al., 2011). The moisture content of *A. pavarii* is similar to those values of other strawberry-tree fruits (Özcan and Haciseferoğullari, 2007; Barros et al., 2010).

The three species fruits under investigation attained lower values of ash contents than those found in other wild edible fruits of strawberry, blackthorn and rose (Özcan and Haciseferoğullari, 2007; Barros et al., 2010). Concerning fiber content, the fruits of the three species are in agreement with the other fruits falling in mid to higher range of fiber (2.0 to 12.3%) reported for 20 promising wild edible fruits in arid regions (Rathore, 2009; Feyssa et al., 2011; Lulekal et al., 2011).

Fruits of the three studied species contained high content of carbohydrates (24.74 to 41.18%) which are higher than best known source of carbohydrates in some important commercially fruits (that is, apple - 13.4%, banana – 27.2%, fresh dates – 33.8%) (Gopalan et al., 1985). Relatively high carbohydrates and food energy value of *A. pavarii* coincide with the reported values of other wild edible strawberry fruits (Özcan and Haciseferoğullari, 2007; Serçe et al., 2010). While, the three studied fruits had a lower range of protein contents compared to other wild edible fruits ranging from 4.9% (*Balanites aegyptica*) and 23.2% (*Prosopis cineraria*) in other arid region (Rathore, 2009). Similarly, lipid contents were less abundant in the studied species, and lower than those reported for the Turkish strawberry (2.1%), (Özcan and Haciseferoğullari, 2007) and Indian fig (4.71%) (Saklani and Chandra, 2011).

The three species fruits contained large quantities of many essential minerals and trace elements including magnesium, sodium and phosphorus. Mineral concentrations in the three fruits are much higher than the literature values of Turkish strawberry and Indian fig

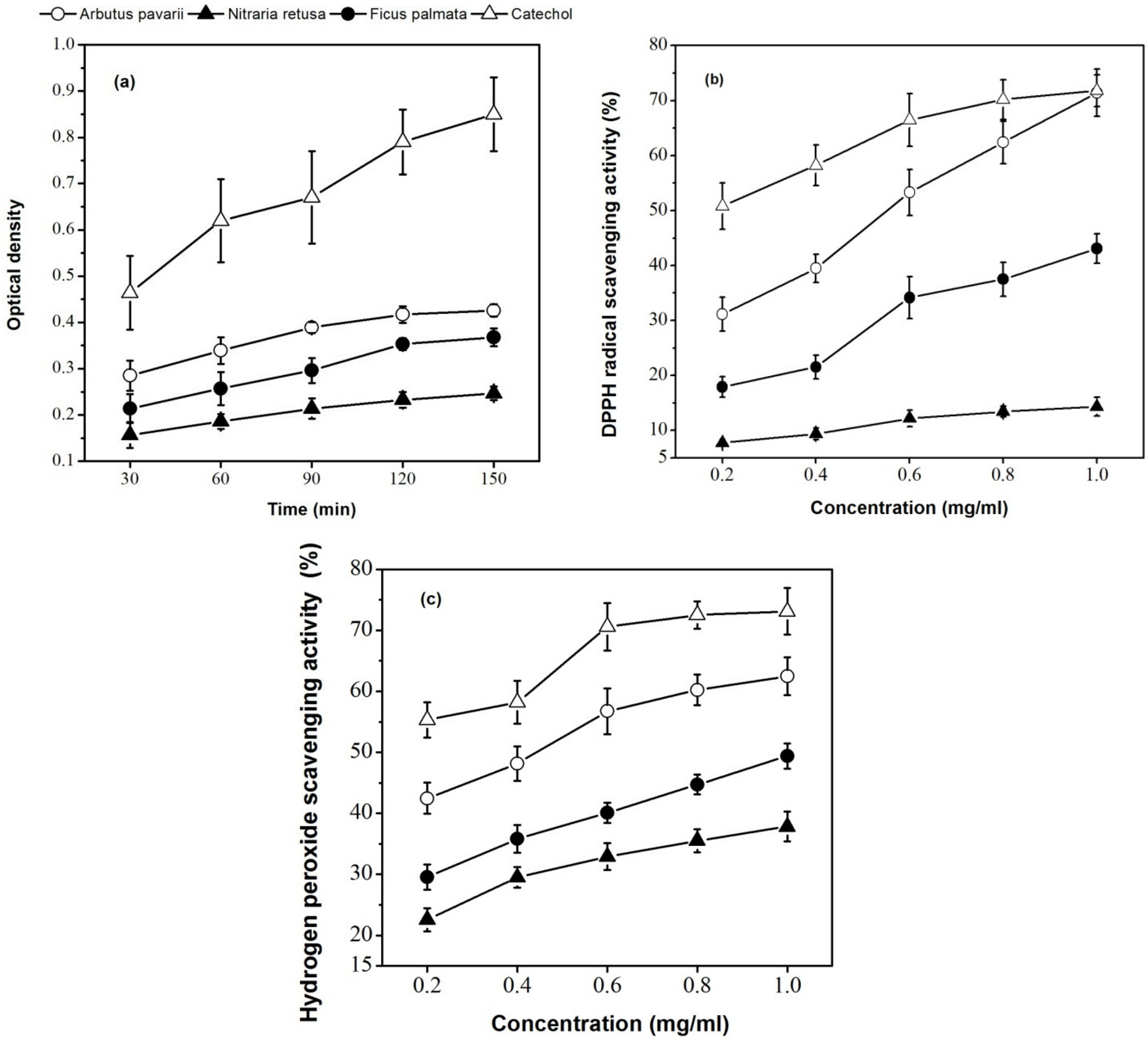

Figure 1. (a) Total antioxidant capacity of methanol extract, (b) DPPH free radical scavenging activity, and (c) Hydrogen peroxide scavenging activity.

tree fruits (Cavaco et al., 2007; Barros et al., 2010; Serçe et al., 2010; Saklani and Chandra, 2011). For example, the concentrations of potassium and calcium were found many folds higher in *A. pavarii* fruits than those of *A. andrachne* and *A. unedo*. The presence of such potassium and calcium rich edible fruits in the countries of the Middle East is important due to the high incidence of potassium and calcium deficiency rickets among the local populations (Pettifor, 2008; Fuleihan, 2009). Sodium, which is important for regulating blood pressure and fluids balance, was present in considerable quantities in the three species.

The results revealed that fruits of the three species can be good sources of natural antioxidants, such as phenolic compounds, vitamin C and tannins. Vitamin C contents of the three fruits in the present study are higher than the common fruits such as apricot, orange, banana, apple and mango (Gopalan et al., 1985; Souci et al., 2008). This vitamin is water soluble, non-enzymatic natural antioxidant, which is widely used as an alternative to synthetic antioxidant (Fasakin et al., 2010). Phenolic compounds in many plant materials have been shown to have strong antioxidant capacity and activity (Rice-Evans et al., 1995; Wu et al., 2004; Sun and Ho, 2005; Hinneburg et al., 2006; Tulipani et al., 2008).

In accordance with this, the antioxidant capacity assessed by DPPH scavenging activity percentage, hydrogen peroxide scavenging activity and total anti-oxidant activity, was highest for *A. pavarii*. Serçe et al. (2010) reported that strawberry tree fruits are rich in antioxidant compounds, such as ascorbic acid (vitamin C). Compared to the study of Al-Ismail et al. (2007), the scavenging activity of DPPH showed strong to moderate capacity. Considering the ecology of wild fruit plants, the variation in nutritional composition, energy and antioxidants among species, one cannot ignore the role of different environmental factors and climatic conditions (Connor et al., 2002; Tura et al., 2007).

It can be concluded that, the chemical composition, antioxidant contents and energy values of the Middle East wild edible tree fruits clearly indicate that they provide key nutrients such as carbohydrates, macro- and micro-minerals and vitamins. The high nutritional quality and unique tastes of these edible fruits are likely to be lost if they are not managed and conserved in the harsh arid environment.

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