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Antioxidant activity of roasted and unroasted peanut skin extracts

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Abstract

Roasted and unroasted Peanut skins were extracted by solvents of increasing polarity (EE80%, EE, EA80% and EA). The yields and total phenols content of each extract were ordered as follows: EE80%> EE > EA80% > EA. There were significant differences between roasted and unroasted peanut skins and also between solvents. Total phenols content and scavenging activity were higher in roasted peanut skin than unroasted peanut skin. The main phenol and flavonoid compounds in roasted peanut skin were caffeic acid and hisperidin, respectively. Peanut skins are rich in phenol antioxidants. Ethanol 80% extract was the highest content of total phenols and the highest free radical-scavenging activity. Peanut skin extracts may thus be a potential source of natural antioxidants and retarding oxidation process in sunflower oil during storage at 60ºC for 20 days.

Introduction

Antioxidants are often added to foods to prevent the formation of free radicals, to slow down the oxidation process and help to maintain nutritional quality and shelf-life of foods. Several synthetic antioxidants, namely butylated hydroxyl toluene (BHT), butylated hydroxyl anisole (BHA), propyl gallate (PG), and ethyl protocatechuate (EP) have been used in foods to prevent oxidation. However, the use of synthetic antioxidants in foods are restricted by legislation and discouraged due to their perceived toxicity and carcinogenicity. Therefore, extracts of herbs, vegetables, fruits, cereals, nuts and other plant products rich in phenol, are of increasing interest for the food industry as natural antioxidant ingredients (Win *et al*., 2011).

Peanuts (*Arachis hypogaea* L.) are one of the most widely used legumes in the world. Several phyto chemicals including resveratrol, flavan-3-ols and pro anthocyanidins have been identified in peanuts and evaluated for their potential health benefits. Byproducts of the peanut industry which include peanut plant leaves, roots, hulls, shells and skins have also been identified as rich sources of phytochemicals although currently these plant parts have little economic value. These materials, peanut skins are most commonly used as low cost fillers in animal feed but are known to have an astringent taste and anti nutrient properties. The antioxidant activity of peanut skins has been reported (Nepote *et al*., 2002, 2005; Van Ha *et al*., 2007; Ballard *et al*., 2009; Lewis *et al*., 2013).

Edible parts of the peanut consist of the kernel and the protective skin. This coating is removed from the kernels prior to application in snack products (Van Ha *et al*., 2007). Peanuts skins or testa have long been regarded as being a low economic waste byproduct of the peanut industry. Skins are used as animal feed and are sold inexpensively. Based on world in shell peanut production, 29 million tons of peanuts are produced with an average skin content of 2.6% (Sobolev and Cole, 2004). Dry blanching is the most commonly used practice to separate skins from peanut kernels (Sobolev and Cole, 2004; Didzbalis *et al*., 2004). Blanching temperatures can range from 94°C (Didzbalis *et al*., 2004) to 175°C (Yu *et al*., 2005). During heat treatment, the brown peanut color that is formed increases due to sugar amino acid reactions, Millard browning, with subsequent production of melanoidins (Sobolev and Cole, 2004). The products that are formed, "Millard reaction productions" (MRPS) especially melanoidins, possess antioxidant activity through scavenging oxygen radicals or chelating metals (Yilmaz and Toledo, 2005). Therefore, heat increases the antioxidant capacity of peanut skins. The raw peanut skin color can be attributed to tannins and catechol-type compounds (Sobolev and Cole, 2004).

Peanut skin removal as well as roasting can affect the phenolic composition. Roasting decreases the proanthocyanidin content of monomers, trimers and tetramers by 29-54% in peanut skins (Bolling *et al*., 2010; Tatsuno *et al*., 2012). Yu *et al*. (2006) confirmed that roasting, a common practice in the peanut industry used to remove peanut skins, yields

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comparable total phenolic concentration and potency in skins that are produced in the direct peeling skin method. Roasting was reported to have had the least effect on total phenolics and procyanidin composition (Hwang *et al*., 2001; Yu *et al*., 2006). Peanut skins have been reported as being efficient free radical scavengers and metal chelators making them candidates for the stabilization of foods containing water and transient metal ions (Van Ha *et al*., 2007).

Peanut skins are a waste from blanched processing of peanut kernels. Peanut skins are sometimes used to feed cattle however; their value could be increased if other more valuable uses could be found. The objective of this work was to extract antioxidant components from roasted and unroasted peanut skin using different solvents {ethanol (EE), aqueous ethanol (EE80%), ethyl acetate (EA) and aqueous ethyl acetate (EA80%)}, and to determine the antioxidant activity of these extracts.

Materials and Methods

Chemicals and sample collection

Peanut (*Arachis hypogaea* L.) skins, as byproduct and sunflower oil were obtained from local market, Giza, Egypt. All solvents and chemicals used were of analytical grade.

Peanut roasting

Peanuts were roasted in an oven at 166ºC for 7 min. Upon removal from the oven, roasted peanuts were cooled using forced ambient air, and skins were manually removed using gloved hands, collected and stored in sealed commercial bags (Davis *et al*., 2010).

Preparation of peanut skins extracts (PSE)

Roasted and unroasted peanut skins (10g) were extracted separately using organic solvents (100mL) ethanol (EE), aqueous ethanol (EE80%), ethyl acetate (EA) and aqueous ethyl acetate (EA80%) overnight in a shaker at room temperature (22±1ºC) followed by filtration through Whatman No.1 filter paper. The residues were re-extracted under the same conditions. All vessels were wrapped with aluminum foil to prevent light degradation during extraction (Yu *et al*., 2005).

Extraction yield (%)

The combined filtrates were evaporated in a rotary evaporator below 40ºC. The extracts obtained after evaporation of organic solvents were weighted to determine the extract yield and stored at -20°C until further use.

Total phenols

Total phenols (TP) content of peanut skins extracts were calorimetrically determined using the Folin-Ciocalteu method (Gamez-Meza *et al*., 1999).

Radical scavenging activity (RSA) of extracts

The electron donation ability of the obtained extracts was measured by bleaching of the purple colored solution of DPPH according to the method of Hanato *et al*. (1988).

Determination of phenol compounds

Phenol compounds of roasted peanut skin were determined by HPLC according to the method described by Goupy *et al*. (1999) as follow: 5 g of sample were mixed with methanol and centrifuged at 1000 rpm for 10 min and the supernatant was filtered through a 0.2 µm Millipore membrane filter then 1-3 ml was collected in a vial for injection into HPLC (Agilant series 1200) equipped with auto sampling, injector, solvent degasser, UV detector set at 280 nm and quaternary HP pump (series 1100). The column temperature was maintained at 85ºC. Gradient separation was carried out with methanol and acetonitrile as a mobile phase at flow rate of 1mL/min. phenolic acid standard from sigma Co. were dissolved in a mobile phase and injected into HPLC. Retention time and peak area were used for calculation of phenol compounds concentration by the data analysis of Agilant Software.

Determination of flavonoid compounds

Flavonoid compounds of roasted peanut skins were determined by HPLC according to the method described by Mattila *et al*. (2000).

Model system samples for measurement oxidative stability.

The roasted aqueous ethanol (EE80%) extract of Peanut skins was applied to sunflower oil at 200, 400, 600 and 800 ppm, in 250mL beakers each, to examine their antioxidant activity. BHT (200 ppm) was also applied for comparison among control and sunflower oil with extracts. The antioxidant-enriched oil samples were subjected to accelerated oxidation in the dark in an oven at 60°C for 20 days. Aliquot 20 g sample were withdrawn periodically every 5 days for determination of oxidative stability in triplicate.

Measurements of oxidative stability in sunflower oil

Peroxide value (PV) and Conjugated dienes (CD) of the oil samples were determined according to (AOAC, 2005). TBA value was determined according to Allen and Hamilton (1989). Antioxidant

Effectiveness (AE%) was calculated from the equation reported by Adegoke and Gopala Krishna (1998):

AE % = (PV of control – PV of test sample / PV of control) X 100.

Statistical analysis

Statistical analyses were conducted using SPSS software version 16 (SPSS Inc., Chicago, USA). All analyses were performed in triplicate and data reported as means ± standard deviation (SD). Data were subjected to analysis of variance (ANOVA). The confidence limits used in this study were based on 95% ($P < 0.05$).

Results and Discussion

The yield of bio-active extracts with different solvents varied from 6.08 to 12.82% in unroasted peanut skin. meanwhile, it was 6.51 to 14.23% in roasted peanut skin (Table 1). There is a significant difference in yield extract at the 0.05 level between solvents. The highest yield had extracted with ethanol 80% followed by ethanol, ethyl acetate 80% and ethyl acetate, respectively. Variation in the extraction yields of different extracts might be attributed to differences in polarity of solvents. Also, results revealed that yield extract was higher in roasted peanut skin (10.14±3.44%) than unroasted peanut skin (9.17 ±2.92%). Jayaprakasha *et al*. (2001) found that ethyl acetate extract gives more monomers, such as catechin and epicatechin type compounds, than procyanidins in grape seed. However ethyl acetate: water (9:1), (17:3) and (4:1) may extract more polar compounds, such as trimers, tetramers and pentamers. The presence of water increases permeability of seed tissue and thus enables a better mass transport by molecular diffusion. Generally, monomers have lower antioxidant activities than dimers and others. Data also indicated that, the yield of antioxidant extracts of roasted peanut skin was higher than those of unroasted peanut skin. A two-way ANOVA was conducted that examined the effect of solvent and roasting treatment on yield extract. There was a statistically significant interaction between the effects of solvent and roasting treatment on yield extract, F (3, 16) = 92.846, p = 0.000. These results agreed with El-Shourbagy and El-Zahar (2014), where they found that the highest yield of peanut skin extract when extracted with ethanol 80% followed by hexane and ethyl acetate. Also, Nepote *et al*. (2005) showed that the best method for extraction of the antioxidant compounds from peanut skins with ethanolic solvent at laboratory level was using 70% (v/v) ethanol in water, non-crushed peanut skins, by shaking for 10 min and in three stages and the maximum yield was recorded for phenolic compounds when extracted at the optimum conditions.

The total phenol contents (TPC) of the extracts are shown in Table 1. There is a significant difference in total phenols at the 0.05 level between solvents. EE(80%) and EE had higher total phenolic contents than EAE(80%) and EAE. Nepote *et al*. (2005) showed that the best solvents to extract a high yield of total phenolic and antioxidant compounds were 50 and 70% (v/v) ethanol in water. However, when considering the evaporation time and cost, the preferred solvent mixture was 70% (v/v) ethanol in water because the evaporation time is lower. El-Shourbagy and El-Zahar (2014) reported that EE80% extract of peanut skin had the highest content in total phenols followed by ethyl acetate and hexane extracts. Also, results revealed that total phenols content was higher in roasted peanut skin (100.46±5.80 mg/kg)

Table 1. Chemical characteristics for different solvents extracts of peanut skins [a]

Characteristics		Yield extract (%)	Total phenols (mg/kg)	Antioxidant activity (DPPH) scavenging (%)
Unroasted Peanut skin	EE*	10.92±0.10[a]	96.11±0.10[a]	80.24±0.97[ae]
	EE (80%)*	12.82±0.16[b]	102.32±0.03[b]	85.07±0.86[b]
	EAE*	6.08±0.02[c]	90.03±0.02[c]	74.74±0.88[c]
	EAE (80%)*	6.88±0.04[d]	93.89±0.03[d]	77.60±1.25[d]
Roasted Peanut skin	EE*	12.51±0.03[e]	99.45±0.04[e]	81.15±0.70[e]
	EE (80%)*	14.23±0.06[f]	109.54±0.03[f]	88.51±0.24[f]
	EAE*	6.51±0.06g	94.51±0.04g	75.47±1.04[c]
	EAE (80%)*	7.33±0.03h	98.34±0.01h	79.28±0.16[a]
Treatment	Unroasted	9.17 ±2.92	95.59 ±4.65	79.41 ±4.06
	Roasted	10.14±3.44	100.46±5.80	81.10±4.98

*EE = ethanol extract, EE (80%) aqueous ethanol (80%) extract, EAE= ethyl acetate extract and EAE (80%) aqueous ethyl acetate (80%) extract

[a]Values are the mean of three independents ± standard deviation. Different lower case letters in the same column indicate significant differences by ANOVA (P<0.05)

than unroasted peanut skin (95.59 ±4.65 mg/kg). A two-way ANOVA was conducted that examined the effect of solvent and roasting treatment on total phenol content. There was a statistically significant interaction between the effects of solvent and roasting treatment on total phenol content, F (3, 16) = 1945.3, p = 0.000. Davis *et al*. (2010) mentioned that at least partially attributable to moisture loss upon roasting, as raw skins were not dried prior to testing. However, peanut skins were only 11% moisture, which suggests the initial heating at 166ºC for 7 min liberated phenolic compounds previously bound within the skin matrix. Further roasting decreased phenolic content of the skin, such that at 21.5 min and 77 min. Hence, higher roast intensities seem to degrade phenolics within the skin but these values were still greater than that of raw skin.

The higher TPC of peanut skin may be attributed to the presence of phenolic compounds such as proanthocyanidins (Yvonne *et al*., 2007). Nepote *et al*. (2005) reported that TPC in peanut skin was 118 mg/g dry skin. Yu *et al*. (2005) also found that one gram dry peanut skin contained 90-125 mg of total phenols and the skin removal methods (direct peeling, blanching, and roasting) and types of solvents used for extraction significantly affected the total phenols.

Results in Table 1, indicated that all extracts exhibited antioxidant activity. There is a significant difference in antioxidant activity (DPPH) scavenging at the 0.05 level between solvents. The extracts that contained high amount of TPC showed high scavenging activity. The EE(80%) and EE extracts showed higher scavenging activity than those of EAE(80%) and EAE extracts. Results showed that roasted peanut skins extracts had higher scavenging activity than unroasted peanut skins. A two-way ANOVA was conducted that examined the effect of solvent and roasting treatment on scavenging activity. There was a statistically significant interaction between the effects of solvent and roasting treatment on scavenging activity, F (3, 16) =3.236, p = 0.050. These results also, agreed with El-Shourbagy and El-Zahar (2014) where, ethanol extract showed slightly better antioxidant characteristics compared with ethyl acetate and hexane extracts. Also, Nepote *et al*. (2005) reported that the best solvents to extract a high yield of total phenolic and antioxidant compounds were 50 and 70% (v/v) ethanol in water.

Phenol compounds are the most active antioxidant derivatives in plants. They are known to act as antioxidants not only because of their ability to donate hydrogen or electrons but also because they are stable radical intermediates. Generally, the outer layers of plant such as peel, shell, and hull contain large amount of poly phenol compounds to protect inner materials (Lee *et al*., 2006). Duh *et al*. (1992) identified luteolin and flavonoid in methanol extract which has a strong antioxidant activity.

Extraction of phenol compounds usually involves the use of a weakly acidified alcoholic solvent, followed by concentration under vacuum, purification, and separation of the compounds (Mazza and Minati, 1993). Nepote *et al*. (2002) reported peanut skins to have a range of 144.1 to 158.6 mg/g of total phenols as well as various compounds including carbohydrates. Total phenols are increased during the roasting process. Roasting results in phenol complexes being formed from the Millard reaction, contributing to higher absorbance readings (Yu *et al*., 2005). The solvents used for extraction can also affect total phenol concentration. Ethanol and methanol have been shown to be the most effective in extracting phenols from peanut skins than water. Yu *et al*. (2005) reported that 80% ethanol as being the most effective. Nepote *et al*. (2002) extracted peanut skins with methanol, ethanol, acetone and water. It was reported that the highest total phenol levels were detected in the methanol (158.8 mg/g) and ethanol (144.1 mg/g) extracts, respectively.

Extraction procedures affect the yield of antioxidant compounds. To achieve an optimized extraction of phenol compounds, polar solvents such as aqueous methanol, ethanol or acetone are used for extraction purposes. Skins that are extracted with methanol have been reported to contain 165.5 mg/g total phenolics, while the content of total phenols was lower when using other solvents (Van Ha *et al*., 2007). Ballard *et al*. (2009) reported that fewer phenolic compounds were extracted at higher concentrations of ethanol, which affects the phenolic compounds extracted in peanut skin extract ability to scavenge peroxyl radicals. Out of all of the phenolic antioxidants, proanthocyanidins and catechins make up the bulk in peanut skins by 25.19% (Van Ha *et al*., 2007).

Win *et al*. (2011) mentioned that roasted kernel flour (RKF) showed higher TPC compared to that of raw kernel. Similar result was reported by Talcott *et al*. (2005). The authors showed that phenol contents of 'Georgia Green' cultivar increased from 0.913 mg/g (raw kernels) to 0.949 mg/g (roasted kernels), when the kernels were roasted at 170°C for 10 min. Naturally occurring poly phenols serve as primary sources of antioxidants. During food processing (heating or boiling), certain chemical reactions may occur among the food components and lead to generate secondary antioxidants compounds such as Millard Reaction Products (MRPs) (Dittrich *et*

al., 2003). In peanut roasting, soluble proteins and amino acids are changed as a result of moisture losses and form Millard derivatives, including pyrroles and furans which may contribute to the increased in total phenolic compounds of roasted samples (Yanagimoto *et al*., 2002).

Plant phenols include simple phenolic acids, stilbenes, flavonoids and other group of poly phenol compounds. Flavonoids can be divided into six major groups including flavones, flavonols, flavanones, anthocyanidins, catechins and isoflavones based on the presence of heterocyclic C ring (Ross and Kasum, 2002). Phenolic acids (p-hydroxybenzoic, chlorogenic, ferulic, caffeic, p-coumaric, gallic), flavonoids (epicatechin, quercetin, daidzein, kaempferol and luteolin) and stilbene (resveratrol) were selected for analysis based on the fact that they are commonly found in oil seeds such as peanuts (Win *et al*., 2011).

Phenols and flavonoid analyses were only conducted with the sample of roasted peanut skin due to higher in yield extraction and total phenols content and radical-scavenging activity than unroasted peanut skins. Individual phenolic composition of peanut skin was analyzed by HPLC and the results presented in Table 2. Results revealed that caffeic acid that the predominant compound (2266 ppm), E- vanillic acid (680 ppm), 3-Hydroxytyrosol (427 ppm) and benzoic acid (423 ppm). p-coumaric acid was 14.72 ppm, this agreed with Win *et al*. (2011). The amount of p-hydroxybenzoic acid was (137 ppm).

Table 2. Phenolic and flavonoid compounds of roasted peanut skins

Phenolic compounds	ppm	Flavonoid compounds	ppm
Gallic	11.46	Narengin	49.92
Pyrogallol	99.14	Rutin	147.05
3-Hydroxy tyrosol	427.14	Hisperidin	1948.73
4-Amino-benzoic	10.24	Rosmarinic	159.66
Protocatchuic	91.52	Quercetrin	33.82
Chlorogenic	88.99	Quercetin	14.08
Catechol	116.18	Narenginin	0.65
Epicatechein	285.63	Kaempferol	2.04
Catechein	359.60	Hespertin	27.89
Caffeine	66.60	Apegnin	5.54
P-OH-benzoic	137.14		
Caffeic	2266.66		
Vanillic	439.70		
Ferulic	76.09		
Iso-Ferulic	100.79		
E- vanillic	680.21		
Resveratrol	65.62		
Ellagic	205.47		
Alpha-Coumaric	23.65		
Benzoic	423.50		
3,4,5-methoxy-cinnamic	16.45		
coumarin	191.57		
Salycilic	6.39		
P-Coumaric	14.72		
Cinnamic	178.33		

Resveratrol is one of the major stilbene phytoalexins that are produced by different parts of the peanuts. Substantial amounts of resveratrol was found in the leaves, roots, and shells of peanuts but the levels noted to be lower in developing seed and seed coats of peanuts (Chung *et al*., 2003). In this study, peanut skin was found to contain amount of resveratrol (65.62 ppm). In edible peanuts from the United States, resveratrol was found at levels of 0.02-1.79 µg/g (ppm) and in peanut products around 0.018-7.873 µg/g (ppm) (Nepote *et al*., 2004). Comparing with those amounts, peanut skins from Egypt had higher content of resveratrol than peanuts and peanut products from USA.

As flavonoids, hisperidin was the predominant compound (1948 ppm), followed by rosmarinic (159 ppm) and rutin (147 ppm) (Table 2). Quercetin was reported to be the major flavonoid in peanut seed (Win *et al*., 2008). In the present study, quercetin (14.08 ppm) in peanut skin. The amount of quercetin detected in our study was quite lower than that reported by Win *et al*. (2011). Also, kaempferol was detected (2.04 ppm).

Antioxidant activity of roasted peanut skins extracts in sunflower oil.

The PV was used to evaluate the oxidative stability of sunflower oil. Therefore, the extracts will have antioxidant activity when the sunflower oil develops a lower PV along time. Only roasted peanut skins aqueous ethanol (80%) extract were used due to their highest content of total phenols and the highest radical-scavenging activity.

The PV of control sunflower oil and sunflower oil with 200, 400, 600, 800 ppm extracts and BHT (0.02% w/w) which, subjected to accelerated oxidation condition at 60°C are shown in Figure 1(A). PV of control sample increased during storage up to 20 days. The others samples enriched with BHT and extracts of peanut skins had the lower PV values than the control sample during storage under accelerated conditions at 60°C. The results obtained in this work reflected the impact of these extracts,

as natural antioxidants, in retarding of oxidation. The PV in control sample was higher than those in oil with different concentration of PSE or BHT. The higher the concentrations of PSE, the lower the PV. Nepote, *et al*. (2002) reported similar antioxidant activity of extracts from non defatted peanut skins in sunflower oil. Also, El-Shourbagy and El-Zahar (2014) found that peanut skin extract retard oxidation and the higher concentrations of peanut skin extract, the lower the PV. Taha *et al*. (2012) concluded that roasted peanut skin extracts can be used safely in the edible oil industry to delay its oxidation.

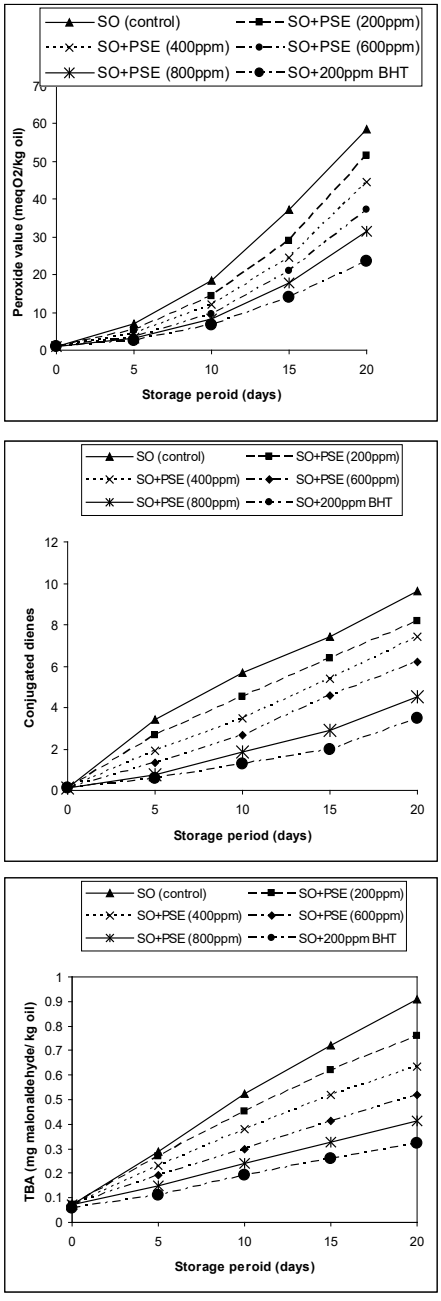

Figure 1. Antioxidant activity of roasted peanut skins extracts in sunflower oil during storage at 60ºC for 20 days. A: Peroxide value, B: Conjugated diene and C: Thiobarbituric acid (TBA) value.

Conjugated diene (CD)

The specific extinctions, in term of conjugated diene (CD) at 232 nm are considered important parameter for the investigation of primary oxidative deterioration of the oils (Yoon *et al*., 1985) and thus a good indicator of the antioxidant effectiveness of the antioxidants of PSE. Figure 1(B) showed the increase in the content of conjugated diene (CD) during storage time for 20 days at 60ºC. The highest increase in CD was observed for control as compared to those other concentrations of PSE. Formation of CD was lower in sunflower oil with high concentrations of PSE than those of low concentrations of PSE added to sunflower oil. Sunflower oil with BHT was the most effective in retarding formation CD and the highest antioxidant.

Peroxide value and conjugated diene at 232 nm showed the same tendency, indicating a very strong correlation between these two methods (Almeida-Doria and Regitano-D'arce, 2000; Anwar *et al*., 2006).

Thiobarbituric acid (TBA) value

Effect of different concentrations of PSE on the TBA values of sunflower oil during heating at 60ºC for 20 days is given in Figure 1(C). It is well known that TBA values are taken as an index to evaluate the advance of oxidation changes occurred in oil and fats. The addition of PSE as natural antioxidants to sunflower oil retarded the oxidative changes during heating at 60ºC for 20 days. This means that the formation of malonaldehyde, which affects the formation of pink color intensity from the reaction of TBA material with malonaldehyde, took place at a relatively lower rate in sunflower oil with BHT and PSE. Phenol compounds act as hydrogen or electron donors to the reaction mixture and therefore the formation of hydro peroxides is decreased. The slow formation of conjugated dienes and consequently the secondary products by extracts and their major compounds indicated that these materials may be acted as hydrogen donors to proxy radicals. Thus, retarding the auto-oxidation of linoleic acid by chain radical termination has been reported by Mohdali, (2010); Ozkanli and Kaya, (2007); Farag *et al*. (1989).

Results, revealed, again, the same trend as for PV and CD. The TBA values of sunflower oil with different concentrations of PSE increased with heating time. Control sample had the highest TBA values, while sunflower oil with BHT (200 ppm) and sunflower oil with PSE (800 ppm) gave the lowest TBA values. These results agreed with El-Shourbagy and El-Zahar (2014) where, the addition of peanut skin extract as natural antioxidants to ghee retarded

Table 3. The antioxidant effectiveness (AE %) of roasted peanut skin extract (RPSE) on sunflower oil during storage at 60ºC for 20 days

Storage period (Days)	Antioxidant effectiveness (AE) (%) [a]				
	Roasted peanut skin extract (RPSE)				BHT
	200 ppm	400 ppm	600 ppm	800 ppm	200 ppm
5	23.97±1.01	36.66±1.55	49.29±0.03	56.34±0.41	64.86±2.74
10	23.25±1.18	34.05±0.08	47.57±0.91	55.67±0.70	63.78±0.42
15	22.37±0.18	33.69±0.04	43.13±0.11	51.75±0.44	62.26±0.52
20	11.64±0.13	23.80±0.00	36.30±0.00	45.89±0.16	59.41±0.20

(a) AE % = (PV of control – PV of test sample / PV of control) X 100

the oxidative changes during accelerated storage.

Results in Table 3 revealed that the AE of RPSE were a concentration dependent BHT then, 800, 600, 400 and 200 ppm. A two-way ANOVA was conducted that examined the effect of storage time and concentration of RPSE on Antioxidant effectiveness. There was a statistically significant interaction between the effects of storage time and concentration of RPSE on Antioxidant effectiveness, F (12, 40) =12.360, p = .000. Similar results were found when black tea was used (Barbary, 2000).

Conclusion

Peanut skins are an important waste product of the peanut processing. They are rich in antioxidants. Ethanol 80% extract was the highest content of total phenols and the highest free radical-scavenging activity. Total phenols content is higher in roasted peanut skin than unroasted peanut skin. Peanut skin extracts may thus be a potential source of natural antioxidants and retarding oxidation process in sunflower oil.

References

Adegoke, G.O. and Gopala krishan, A.G. 1998. Extraction and identification of antioxidants from the spice *Aframomum danielli*. *Journal of the American Oil Chemists Society* 75(8): 1047-1052.

Allen, J. C. and Hamilton, R. T. 1989. Rancidity in Foods. 2nd ed. London and New York: El Sevier Applied Science.

Almeida-Doria, R.F. and Regitano- D' Arce, M.A. 2000. Antioxidant activity of rosemary and oregano methanol extracts in soybean oil under thermal oxidation. *Ciencia e Tecnologia de Alimentos* 20(2): 101-113.

Anwar, F., Jamil, A., Iqbal, S. and Sheikh, M.A. 2006. Antioxidant activity of various plant extracts under ambient and accelerated storage of sunflower oil. *Grasas y Aceites* 57(29): 189-197.

AOAC. 2005. Official Methods of Analysis. 15th ed. Washington, D.C.: Association of Official Analytical Chemists.

Ballard, T., Mallikarjunan, P., Zhou, K. and O'Keefe, S. 2009. Optimizing the extraction of phenolic antioxidants from peanut skins using response surface methodology. *Journal of Agricultural and Food Chemistry* 57(8): 3064-3072.

Barbary, O. M. 2000. Antioxidative Effectiveness of used black tea on sunflower during heating. *Journal of Agricultural Sciences Mansoura University* 25(1): 297-304.

Chung, L. M., Park, M. R., Chun, J. C. and Yun, S. J. 2003. Resveratrol accumulation and resveratrol synthesis gene expression in response to a biotic stresses and hormones in peanut plants. *Plant Science* 164(1): 103-109.

Davis, J. P., Dean, L. L., Price, K. M. and Sanders, T. H. 2010. Roast effects on the hydrophilic and lipophilic antioxidant capacities of peanut flours, blanched peanut seed and peanut skins. *Food Chemistry* 119(2): 539–547.

Didzbalis, J., Ritter, K. A., Trail, A.C. and Plog, F.J. 2004. Identification of fruity/fermented odorants in high-temperature-cured roasted peanuts. *Journal of Agricultural and Food Chemistry* 52(15): 4828– 4833.

Dittrich, R. , El-Massry, F., Kunz, K., Rinaldi, F., Peich, C. C., Beckmann, M. W. and Pischetstrieder, M. 2003. Millard reaction products inhibit oxidation of human low- density lipoproteins in vitro. *Journal of Agricultural and Food Chemistry* 51(13): 3900-3904.

Duh, P.D., Yeh, D.B. and Yen, G.C. 1992. Extraction and identification of an antioxidative component from peanut hulls. *Journal of the American Oil Chemists Society* 69(8): 814–818.

El-Shourbagy, G. A. and El-Zahar, K. M. 2014. Oxidative stability of ghee as affected by natural antioxidants extracted from food processing wastes. *Annals of Agricultural Science* 59(2): 213–220.

Farag, R. S., Badel, A. Z. M. and El-Baraty, G. S. A. 1989. Influence of thyme and clove essential oils on cotton seed oil oxidation. *Journal of the American Oil Chemists Society* 66(6): 800–804.

Gamez-Meza, N., Nriega-Rodiguez, T. A., Medira-Jularz, L. A., Ortega-Gracia, J., Cazarazez-Casanova, R. and Angulo-Guerrero, O. 1999. Antioxidant activity in soybean oil of extracts from Thompson grape bagasse. *Journal of the American Oil Chemists' Society* 76(12): 1445-1447.

Goupy, P., Hugues, M., Biovin, P. and Amiot, M. J. 1999. Antioxidant composition and activity of barley (*Hordeum vulgare*) and malt extracts and of isolated phenolic compounds. *Journal of the Science of Food and Agriculture* 79(12): 1625-1634.

Hanato, T., Kagawa, H., Yasuhara, T. and Okuda, T. 1988. Two new flavonoids and other constituents in licorice root: their relative astringency and radical scavenging effects. *Chemical and pharmaceutical bulletin* 36(6): 2090–2097.

Hwang, J.Y., Shue, Y.S. and Chang, H. M. 2001. Antioxidant activity of roasted and defatted kernels. *Food Research International* 34(7): 639-647.

Jayaprakasha, G. K., Singh, R. P. and Sakariah, K. K. 2001. Antioxidant activity of grape seed (Vitis vinifera L.) extracts on peroxidation models in vitro. *Food Chemistry* 73(3): 285–290.

Jianmei, Y., Ahmedna, M. and Goktepe, I. 2005. Effects of processing methods and extraction solvents on concentration and antioxidant activity of peanut skin phenolics. *Food Chemistry* 90(1): 199–206.

Kris-Etherton, P. M., Hu, F. B., Ros, E. and Sabaté, J. 2008. The role of tree nuts and peanuts in the prevention of coronary heart disease: multiple potential mechanisms. *Journal of Nutrition* 138(9): 1746S-1751S.

Lee, S., Jeong, S., Kim, S., Park, H., Nam, K. C. and Ahn, D. U. 2006. Effect of far-infrared radiation and heat treatment on the antioxidant activity of water extracts from peanut hulls. *Food Chemistry* 94(4): 489–493.

Lewis, W.E., Harris, G.K., Sanders, T.H., White, B. L. and Dean, L.L. 2013. Antioxidant and Anti-Inflammatory Effects of Peanut Skin Extracts. Food and Nutrition Sciences 4(8A): 22-32.

Mattila, P., Astola, J. and Kumpulanien, J., 2000. Determination of flavonoids in plant material by HPLC with diode-array and electro array detections. *Journal of Agricultural and Food Chemistry* 48(12): 5834–5841.

Mazza, G. and Minati, E. 1993. Anthocyanins in Fruits, Vegetables, and Grains. Boca Raton, FL:CRC Press.

Mohdali, A. A. 2010. Evaluation of some food processing by-products as sources for natural antioxidants. Berlin, Germany: Berlin University, PhD thesis.

Nepote, V., Grosso, N. and Guzman, C. 2002. Extraction of antioxidant components from peanut skins. *Grasas y Aceites* 53(4): 391– 395.

Nepote, V., Grosso, N. R. and Guzman, C. A. 2004. Radical scavenging activity of extracts of argentine peanut skins (*Arachis hypogaea*) in relation to its trans-resveratrol content. *Journal of the Argentine Chemical Society* 92(4-6): 41– 49.

Nepote, V., Grosso, N. R. and Guzman, C. A. 2005. Optimization of extraction of phenolic antioxidants from peanut skins. *Journal of the Science of Food and Agriculture* 85(1): 33-38.

Ozkanli, O. and Kaya, A. 2007. Storage stability of butter oils produced from sheep's non-pasteurized and pasteurized milk. *Food Chemistry* 100(3): 1026–1031.

Ross, J. A. and Kasum, C. M. 2002. Dietary flavonoids, bioavailability, metabolic effects and safety. *Annual Review of Nutrition* 22(1): 19-34.

Sobolev, V. S. and Cole, R. J. 2004. Note on utilization of peanut seed testa. *Journal of the Science of Food and Agriculture* 84(1): 105–111.

Taha, F. S., Wagdy, S. M. and Singer, F. A. 2012. Comparison between Antioxidant Activities of Phenolic Extracts from Different Parts of Peanut. *Life Science Journal* 9(2): 207-215.

Talcott, S.T., Passeretti, S., Duncan, C.E. and Gorbet, D.W. 2005. Polyphenolic content and sensory properties of normal and high oleic acid peanuts. *Food Chemistry* 90(3): 379-388.

Tatsuno, T., Jinno, M., Kawabata, T., Hasegawa, T., Yahagi, N., Takano, F. and Ohta, T. 2010. Anti- inflammatory and Anti-melanogenic Proanthocyanidin Oligomers from Peanut Skin. *Biological and Pharmaceutical Bulletin* 35(6):909-916.

Van Ha, H., Pokorny, J. and Sakurai, H. 2007. Peanut skin antioxidants. *Journal of Food Lipids* 14(3): 298-314.

Win, M. M., Hamid, A. A., Baharin, B. S., Anwar, F., Sabu, M. C. and Pak-Dek, M. S. 2011. Phenolic compounds and antioxidant activity of peanut's skin, hull, raw kernel and roasted kernel flour. *Pakistan Journal of Botany* 43(3): 1635-1642.

Yanagimoto, K., Lee, K., Ochi, H. and Shibamoto, T. 2002. Antioxidative activity of heterocyclic compounds found in coffee volatiles produced by the Maillard reaction. *Journal of Agricultural and Food Chemistry* 50(19): 5480-5484.

Yilmaz, Y. and Toledo, R. 2005. Antioxidant activity of water soluble Maillard reaction products. *Food Chemistry* 93(2): 273–278.

Yoon, S. H., Kim, S. K., Shin, M. G. and Kim, K. H. 1985. Comparative study of physical methods for lipid oxidation measurement in oils. *Journal of the American Oil Chemists Society* 62(10): 1487- 1489.

Yu, J., Ahmedna, M. and Goktepe, I. 2005. Effects of processing methods and extraction solvents on concentration and antioxidant activity of peanut skin phenolics. *Food Chemistry* 90(1-2): 199-206.

Yu, J., Ahmedna, M., Goktepe, I. and Dai, J. 2006. Peanut skin procyanidins: Composition and antioxidant activities as affected by processing. *Journal of Food Composition and Analysis* 19(4): 364-371.

Yvonne, C., Walker, L., Vogler, B. and Verghese, M. 2007. Changes in the phytochemical composition and profile of raw, boiled and roasted peanuts. *Journal of Agricultural and Food Chemistry* 55(22): 9266-9273.