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Effect of Pomposia (*Syzygium cumini*) Fruit Juice on the Stability of Fried Sunflower Oil

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Abstract: Pomposia fruits (*Syzygium cumini*) is rich sources of phenolic components. The aim of the current investigation was to evaluate the efficiency of pomposia extract as natural antioxidant compared with BHT as with the most commonly used synthetic antioxidant material. Therefore, sunflower oil was mixed with 200, 400, 800 and 1200 ppm of concentrated juice of pomposia were separately heated at 180±5°C, then 500 g of frozen French fries were fried every 30 min. Sunflower oil samples were heated at 180±5°C, frozen French fries were fried every 30 min during a continuous frying period of 12 h. Some physico-chemical properties (refractive index, viscosity, colour, acid value, peroxide value, thiobarbituric acid test and polymer content) of non-fried and fried oil were measured at various heating periods. The results of the current study indicated that mixing sunflower oil with the natural polyphenolic compounds of pomposia extract at level 800 and 1200 ppm oil increased the stability and hence improved the quality of sunflower oil during frying process.

Key words: BHT, frying, quality assurance tests, pomposia fruits (*Syzygium cumini*), sunflower oil

INTRODUCTION

Deep frying is widely used for the preparation of many types of foods. The high temperatures reached during food frying lead to a complex series of reactions that result in hydrolysis, oxidation and polymerization of the oil (Rossell, 2001). During deep fat-frying hydroperoxide, which is the major oxidation product decomposes to secondary products, such as esters, aldehydes, alcohols, ketones, lactones and hydrocarbons. These secondary products adversely affect flavour, aroma, taste, nutritional value and overall quality of foods. Additionally, certain oxidation products are potentially toxic at relatively low concentrations (Min and Boff, 2001; Nawar, 1996). It is believed that the antioxidants protect the fat from oxidation during the time that the oil is exposed to high temperatures (Augustin and Berry, 1983).

To avoid or delay the lipid oxidation in food processing, antioxidants have been used for over 50 years (Cuvelier *et al*., 1994). The antioxidants play an important role in the manufacturing, packaging and storage of fats and fatty foods and have been proven to retard oxidation (Lin *et al*., 1981). The synthetic antioxidants i.e., Butylated Hydroxyanisole (BHA) and Butylated Hydroxytoluene (BHT) are very cost-effective given a high stability. The use of BHT and BHA in food has been decreased due to their suspected action as promoters of carcinogenesis as well for the general consumer rejection of synthetic food additives (Namiki, 1990). Recently, the use of natural antioxidants for frying purposes has increased (Bracco *et al*., 1981). Therefore, the importance of replacing synthetic antioxidants with natural ingredients from oilseeds, spices and other plant materials has greatly increased (Mansour and Khalil, 2000; Shaker, 2006; Farag *et al*., 2006; EL-Anany, 2007).

Fruits and vegetables are rich sources of phenolic components that include simple phenols, flavonoids and anthocyanins. Besides enormous benefits, phenolic components affect the organoleptic qualities of several foods and food products primarily through affecting their color and taste known as astringency (Shahidi and Naczk, 2005). Anthocyanins are natural pigments act as antioxidant displaying orange, red, purple or blue colour in plants and foods (Bridle and Timberlake, 1997; Clifford, 2000). Jamun (*Syzgium cumini L.*) is an evergreen tropical tree in the flowering plant family Myrtaceae, native to India and Indonesia. It is also grown in other areas of Southeast Asia including Malaysia, Myanmar, Pakistan and Afghanistan. The tree was also introduced to Florida, USA in 1911 by the United States Department of Agriculture and is now commonly planted in Suriname (Chowdhury and Ray, 2007).

Jamun also known as pompozia fruits is a good source of phenolic compounds and anthocyanin (Hamed *et al*., 2001; Saraswathy and Chami, 2007). The total anthocyanin content of pompozia fruits was

216 mg/100 mL of extract which is equivalent to 230 mg/100 g fruit on a dry weight basis. Three anthocyanins were identified as glucoglucosides of delphinidin, petunidin and malvidin by HPLC-ESI-MS. The antioxidant capacity of ethanol extract of pomposia was tested using models, such as DPPH•-scavenging, reducing power assay, lipid peroxidation in rat brain, liver, liver mitochondria, testes and human erythrocyte ghosts. The extract showed 78.2% DPPH•-scavenging at 2.5 ppm, while BHA exhibited only 41.6% activity at the same concentration, thus proving it to be a more efficient free radical-scavenger than the widely used BHA. One ppm of the extract was equivalent to 3.5 μM ascorbic acid, as estimated by reducing power assay. The high antioxidant activity and relatively high stability of the pigments make pompozia (*S. cumini*) a potential source of natural colourant as well as antioxidants (Veigas *et al*., 2007).

The antioxidant property of the skin of pomposia fruit may come in part from the antioxidant vitamins, phenolics or tannins and anthocyanins present in the fruit (Banerjee *et al*., 2005). Generally two types of pomposia, the first one called Rajamun is big oblong, deep purple or bluish in colour having pink to grey juice, sweet flesh with small seeds. The second type is known as Kaatha which has small fruits with comparatively big seed and flesh acidic in taste. The fruits are consumed fresh and universally accepted to be very good for medicinal purposes especially for curing diabetes because of its effect on the pancreas (Shrotri *et al*., 1963; Amba Dan, 1973; Joshi, 2001). Utilization of pompozia juice as natural colorant for dairy products and jelly products was carried out by Hamed *et al*. (2001). The fruits and seeds of pomposia are useful in treating diabetes, pharyngitis, splenopathy, urethrorrhea and ringworm infection (Warrier *et al*., 1996).

Therefore, the aim of the current investigation was to evaluate the efficiency of pompozia extract as natural antioxidants during frying process of sunflower oil in comparison with BHT as synthetic antioxidant.

MATERIALS AND METHODS

Source of pomposia: Pomposia (*Syzygium cumini*) was obtained from the farm of Faculty of Agriculture, Cairo University, Giza, Egypt (season July 2008). The fruits were ripened and freshly harvested.

Chemicals: Catechin and BHT were purchased from Sigma (St. Louis, MO, USA). Folin-Cioculteau reagent was obtained from Gerbsaur Chemical Co (Germany).

Sunflower oil: Freshly refined sunflower oil without synthetic antioxidants was obtained from Sila edible oil Co. S.A.E., Kom Osheim, El-Fayoum Governorate Egypt.

Preparation of pomposia (*Syzygium cumini*) juice: The fruits were cleaned, cut into pieces and then pressed by means of the hydraulic laboratory press model C S/N 37000-156 Freds from Carver (WI, USA). The resultant crude juices were centrifuged at 4000 rpm for 30 min the supernatant was concentrated using a freeze-dryer (Labconco corporation Kansas city, Missouri 64132 USA). The concentrated juice was kept in a brown bottle at 5°C until use.

Frying process: A known amount (ca. 4 kg) of each of the sunflower, sunflower oil was separately placed in a stainless steel pan of electric fryer (25 cm depth ×30 cm length ×25 cm width (Univest Co., 6th of October city, Industrial zone No. 3, Giza, Egypt) and considered as a control. Another portion of the oil under study were mixed with different aliquots of concentrated pomposia juice to contain 200, 400, 800 and 1200 ppm of polyphenols. Also, an experiment was conducted where the oil was mixed with BHT at a concentration of 200 ppm to compare the antioxidant efficiency of the phenolic of pomposia juice with the most commonly used synthetic antioxidant material. The aforementioned oils were separately heated at 180±5°C, then 500 g of frozen French fries were fried every 30 min. Oil samples were taken at the beginning and every 2, 4, 8 and 12 h from the commencement of the frying process for chemical analysis and the entire continuous heating period was 12 h. The oil samples were left to cool down then stored at -10°C for chemical analyses.

Determination of chemical composition of pomposia (*Syzygium Cumini*) juice.

Determination of moisture content: A known weight of pomposia juice (5 g) was dried in an oven at 105°C until a constant weight was reached (AOAC, 2000).

Determination of ash content: The ash content of pomposia juice was determined by muffle furnace at 550°C until a constant weight was obtained (AOAC, 2000).

Determination of crude protein: The total nitrogen of pomposia juice was determined by the usual Kjeldahl method (AOAC, 2000). The crude protein were then calculated by multiplying the total nitrogen by a factor of 6.25.

Determination of total crude lipids: The crude lipids of pomposia juice was determined according method of Blight and Dyer (1959) using a mixture of chloroform-methanol (2: 1, v/v).

Determination of crude fiber: A known weight of pomposia juice (0.5 g) was digested with sulfuric acid (200 mL, 1.25%) then with sodium hydroxide (200 mL, 1.25%) and washed several times with diethyl ether. The resultant product was dried at 100°C then ashed at 550°C (AOAC, 2000).

Determination of soluble carbohydrates: Soluble carbohydrates were calculated on dry weight basis by difference.

Determination of total polyphenols: Total polyphenols were determined according to the method of Jayaprakasha *et al*. (2003). An aliquot from pomposia juices (0.1 mL) were dissolved in a 10 mL mixture of acetone and water (6:4 v/v). Sample (0.2 mL) was mixed with 1.0 mL of ten-fold diluted Folin-Ciocalteu reagent and 0.8 mL of 75 g L^{-1} sodium carbonate solution. After standing for 30 min at room temperature, the absorbance was measured at 765 nm. The results were expressed as (+) catechin equivalents.

Physico-chemical properties of sunflower oil: These tests were conducted on fresh and fried sunflower oil samples.

Refractive index: Refractive index of oil samples was determined according to the AOAC (2000) method using Abbe-refractometer (NYRL-3-Leica Mark, leica Inc. Bauffalo, NY, USA).

Colour: Lovibond tintometer from Tintometer Limited (Solstice Park, Amesbury, UK) was used to measure the color of the oil samples under investigation, the yellow glass filter was fixed at 30 and the intensity of red glass color was measured (Nielsen, 1998). Relative flow time was measured as an indication of oil viscosity. The relative flow times of the various samples of oils were measured using an Ostwald viscometer according to Joslyn (1950).

Viscosity: Relative flow time was measured as an indication of oil viscosity. The relative flow times of the various samples of oils were measured using an Ostwald viscometer according to Joslyn (1950). An adequate volume (5 mL) of the oil was transferred to the wide arm of the Ostwald tube which was immersed in water bath at 60°C and left for 30 min. The oil was then forced to pass though the capillary tube and the adjoining bulb to the mark. The time necessary for the oil to fall down through a specific distance between the two marks was accurately determined.

Acid value: Acid value was determined according to AOAC (2000) method as follows: a known weight (2 g) of the oil was dissolved in a neutral ethyl alcohol (30 mL). The mixture was boiled on a water bath for 2 min and then titrated with potassium hydroxide solution (0.1 N) in the presence of phenolphthalein as an indicator. Acid value is expressed as mg KOH required to neutralize the acidity in 1 g oil.

Peroxide value: The peroxide value was determined according to AOAC (2000) method. A known weight of the oil sample (5 g) was dissolved in a mixture consisted of glacial acetic acid: cholroform (30 mL, 3: 2, v/v) then freshly prepared saturated potassium iodide solution (1 mL) was added. Distilled water (30 mL) was added then titrated slowly with sodium thiosulphate solution (0.1 N) in the presence of starch solution (1%) as an indicator. Peroxide value is expressed as milliequivalent peroxides/ 1 kg oil.

Thiobarbituric acid value (TBA): The method of Sidwell *et al*. (1954) was conducted to determine the TBA value as follows. A known weight of oil (3 g) was dissolved in a carbon tetrachloride (10 mL) followed by the addition of TBA reagent (10 mL, 0.67% TBA in 50% acetic acid). The mixture was transferred to a separatory funnel and the aqueous layer was drawn into a test tube and immersed in a boiling water bath for 30 min. The absorbance of the developed pink color was then recorded at 530 nm against a blank reagent.

Insoluble polymer content: The insoluble polymers were determined according to the method outlined by Wu and Nawer (1986) as follows: One gram of oil was added to methanol (125 mL) containing 1% H_2SO_4. The mixture was boiled under a reflux condenser for 2 h and cooled to room temperature.

The methanol insolubles were filtered and washed with methanol until no sulphuric acid remained. The washed insoluble polymers were dissolved in a petroleum ether (25 mL) and transferred to a pre-weighed flask. The solvent was then evaporated under a stream of nitrogen and the flask was again weighed.

Statistical analysis: The data of the present work were subjected to analysis of variance and the least significant difference test, in order to compare the mean values of the investigated parameters (Cochran and Cox, 1992).

RESULTS AND DISCUSSION

Chemical composition and mineral contents of pomposia (*Syzygium cumini*) juices (Based on dry basis): The gross chemical composition of pomposia (*Syzygium cumini*) juice are shown in Table 1. The moisture content of crude juice was 79.82%. Analysis of pomposia juice shows that the levels of crude proteins crude lipids, total hydrolysable carbohydrates, crude fibers and ash were 4.66, 1.76, 88.24, nill and 1.85%, respectively based on dry weight basis. These data demonstrate that the main pomposia juice constituent was the total hydrolysable carbohydrates, it was approximately 18.9 time as high as that of the crude protein. Whilst, the crude proteins was about 2.6 and 2.51 times as great as that of crude lipids and ash, respectively. Pomposia juice was nearly free from crude fibers. The total polyphenol content of this juice was 0.49% determined as (+) catechin equivalents.

Influence of pomposia extract on some physico-chemical properties of sunflower oil

Refractive index: The data presented in Table 2 show that the refractive indices increased gradually with increasing the time of frying period. However mixing sunflower oil with 800 and 1200 ppm of pomposia extract or 200 ppm of BHT caused a significant ($p<0.01$) decrease in the refractive indices in fried sunflower oil compared to sunflower oil samples mixed with 200 and 400 ppm of pomposia extract and control sample without antioxidant. It is well known that frying process caused conversion of some of the non-conjugated double bonds into conjugated ones. This reaction led to an increase in the refractive index (Farag *et al*., 2006; EL-Anany, 2007). Data also show that the efficiency of pomposia extract at levels 800 and 1200 in lowering the increase of refractive indices were similar to the efficiency of synthetic antioxidant BHT at level 200 ppm.

Viscosity: The viscosity of frying oils increased as a consequence of oxidation and polymerization reactions (Gutierrez *et al*., 1988). Changes in the viscosity of sunflower oil samples under investigation are shown in Table 2. Generally, viscosity values were gradually and significantly increased with increasing the period of frying. The viscosity of fried oil was used for indicating the extent of the polymerization reaction caused by

Table 1: Chemical composition (%) of pomposia (*Syzygium cumini*) juice (Based on dry basis)

Component	Pomposia juices
Moisture	79.82±1.11^{b}
Crude proteins (N×6.25)	4.66±1.07^{c}
Crude lipids	1.76±0.00^{d}
Crude fiber	Not detected
Ash	1.85±0.08^{d}
Soluble carbohydrates	88.24±0.51^{a}
Total polyphenols	0.49±0.01^{e}
LSD	1.078

Values are expressed as the mean of three determinations; Values followed by different letter are significantly different at ($p<0.01$); Mean values followed by the SD (±); LSD refers to Least Significant Difference test

Table 2: Changes in some physical properties of sunflower oil mixed with different levels of pomposia juice, 200 ppm of BHT and Sunflower oil without antioxidants (control)

	Pomposia juice (ppm)					
Frying period (h)	200	400	800	1200	BHT 200 ppm	Control
Refractive index						
0	1.4725±0.0000^{a}	1.4725±0.0000^{a}	1.4725±0.0000^{a}	1.4725±0.0000^{a}	1.4725±0.0000^{a}	1.4725±0.0000^{a}
2	1.4726±0.0000^{a}	1.4725±0.0000^{a}	1.4725±0.0000^{a}	1.4725±0.0000^{a}	1.4726±0.0000^{a}	1.4726±0.0000^{a}
4	1.4733±0.0000^{a}	1.4729±0.0000^{a}	1.4728±0.0000^{a}	1.4728±0.0000^{a}	1.4732±0.0000^{a}	1.4734±0.0000^{a}
8	1.4739±0.0000^{a}	1.4737±0.0000^{a}	1.4737±0.0000^{a}	1.4737±0.0000^{a}	1.4738±0.00^{a}	1.4748±0.00^{a}
12	1.4749±0.0000^{b}	1.4748±0.0000^{b}	1.4740±0.0000^{a}	1.4741±0.0000^{a}	1.4746±0.0000^{a}	1.4910±0.0000^{c}
LSD	0.01633					
Viscosity (min)						
0	83.50±0.10^{f}	83.50±0.10^{f}	83.50±0.10^{f}	83.50±0.10^{f}	83.50±0.10^{f}	83.50±0.10^{f}
2	90.00±0.00^{d}	85.00±1.00^{f}	84.00±1.00^{f}	84.00±2.00^{f}	84.00±0.00^{f}	94.00±1.00^{c}
4	95.10±0.17^{c}	86.00±0.00^{ef}	84.83±0.58^{f}	84.67±0.29^{f}	85.00±1.00^{f}	100.00±1.00^{b}
8	100.00±1.00^{b}	89.00±1.00^{de}	85.17±1.04^{f}	85.13±1.03^{f}	85.20±1.00^{f}	106.00±0.00^{a}
12	107.00±1.00^{a}	90.00±0.00^{d}	86.20±1.05^{ef}	86.00±0.00^{ef}	86.30±0.04^{ef}	108.00±0.04^{a}
LSD	2.811					
Color (Red slide)						
0	2.40±0.06^{j}	2.40±0.06^{j}	2.40±0.06^{j}	2.40±0.06^{j}	2.40±0.06^{j}	2.40±0.06^{j}
2	4.50±0.00^{hi}	4.00±0.00^{hi}	3.00±2.00^{ij}	3.00±0.00^{ij}	3.60±0.50^{ij}	5.00±1.00^{gh}
4	7.50±0.50^{e}	6.00±1.00^{fg}	3.50±0.50^{ij}	3.40±0.50^{ij}	4.00±0.40^{hi}	10.00±0.00^{c}
8	10.00±0.00^{c}	9.00±1.00^{cd}	4.50±0.50^{hi}	4.50±0.50^{hi}	4.50±0.00^{hi}	12.00±0.58^{b}
12	13.00±0.00^{ab}	12.00±1.00^{b}	8.00±1.00^{de}	7.00±0.00^{ef}	7.50±0.50^{e}	14.00±0.00^{a}
LSD	1.332					

Values are expressed as the mean of three determinations; Values followed by different letter are significantly different at ($p<0.01$); Mean values followed by the SD (±); LSD refers to Least Significant Difference test

oxidation of unsaturated fatty acids. These polymeric materials are mainly responsible for the increase in viscosity in cooking oils (Berger, 1984; Gutierrez *et al*., 1988). In this respect Al-Harbi and Al-Kabtani (1993) reported that the increase in viscosity of frying oils was due to polymerization which resulted in the formation of higher molecular weight compounds (carbon-to-carbon and/or carbon-to-oxygen-to-carbon bridges) between fatty acids. Viscosity value of sunflower oil without antioxidant at the end of frying period was about 1.00, 1.21, 1.25, 1.25 and 1.25 times as high as that for sunflower oil mixed with 200, 400, 800 and 1200 ppm of pomposia extract and 200 ppm of BHT, respectively. The lowest value of viscosity at the end of frying period was for sunflower oil sample treated with 1200 ppm of pomposia extract. No significant ($p>0.01$) differences were observed between sunflower oil treated with 800 and 1200 ppm of pomposia extract and that sample treated with 200 ppm of synthetic antioxidant BHT. The addition of antioxidants compounds of pomposia extract significantly lowered the viscosity of fried sunflower oil by retarding polymerization reactions during frying. One would also report that mixing sunflower oil with 800 or 1200 ppm of pomposia extract led to decrease the changes of viscosity values during frying process. It means that the highest level of polyphenols mixed with oil induced the lowest change on oil viscosity.

Colour: The colour of the fried potatoes and potato chips is one of the most significant quality factors of acceptance for fried products. Frying process caused a significant increase of darkness which was measured as red slid by using a Lovibond tintometer. The results present in Table 2 show that the values of red glass slides for fried sunflower oil were gradually and significantly increased with the increasing the period of frying. It was observed that the colour index (reflecting an over-all chemical degradation and polymerization) increased with frying time. Darkening of the oil during deep-fat frying is due to the polymer formation of unsaturated carbonyl compounds and non-polar compounds of foodstuff solubilized in the oil (Gutierrez *et al*., 1988). Mixing sunflower oil with 800 and 1200 ppm of pomposia extract caused a significant ($p<0.01$) decrease in colour values compared with control sample. Sunflower oil sample mixed with 1200 ppm of concentrated pomposia extract had significantly ($p<0.01$) the lowest value at the end of frying period, this reduction may due to the antioxidative effects of pomposia extract in lowering degradation of unsaturated fatty acids and formation of polymers during frying process. In this respect, several studies indicated high correlations between darkening of the colour of fried oils and the degradative processes such as formation of hydroperoxides, conjugated dienoic acids, ketones, hydroxides, etc. (Nawar, 1996; Fritch, 1981; Orthoefer, 1988; Gutierrez *et al*., 1988; White, 1991; Orthoefer *et al*., 1996).

Acid value: Deterioration of frying oils is generally followed by changes in Free Fatty Acid (FFA) level, color of the used oil, or an increase in polarity of the oil (Paradis and Nawar, 1981; Tan *et al*., 1985; Orthoefer, 1988; White, 1991; Melton *et al*., 1994; Orthoefer *et al*., 1996). Normally, frying oils undergo extensive degradation and complex chemical transformations when heated. The presence of air and water introduced as steam during the frying process can accelerate the deterioration of frying oil (Clark and Serbia, 1991). Changes in acid value of sunflower oil samples under investigation are shown in Table 3. The acid value of non-fried sunflower was 0.12 mg KOH g^{-1}. Generally, the values of free fatty acids of sunflower oil samples increased significantly ($p<0.01$) with increasing the period of frying. Mixing sunflower oil samples with different levels of pomposia extract or 200 ppm of BHT caused a good depression in acid values during frying periods. Data also show that the acid values of sunflower oil mixed with pomposia extract at levels 200, 400, 800 and 1200 ppm and with 200 ppm of BHT at the end of frying process were approximately 1.31, 1.38, 1.68, 1.86 and 1.72 times lower than that of sunflower oil without antioxidant. Sunflower oil mixed with 1200 pppm of pomposia extract and significantly the lowest acid value at the end of frying period. In the same time, there was no significant difference between sunflower oil treated with synthetic antioxidant (BHT) at 200 ppm and that treated with 800 ppm of pomposia extract. The obtained results indicate that polyphenolic compounds lowered the hydrolytic rancidity. One has to point out that the increase in acid value stems from two sources. The basic source is the fatty acids produced from the hydrolysis of ester linkages in the oil moiety due to the presence of moisture either from the water in the food and from the surrounding atmosphere. The minor route comes from the organic acids produced from the secondary oxidation products. In this regard Farag *et al*. (2003, 2006), Shaker (2006) and EL-Anany (2007) observed that polyphenolic compounds of fruits and leaves possessed antihydrolytic effects.

Peroxide Value (PV): Oil oxidation can be determined by oxygen depletion, peroxide value, volatile compounds, conjugated diene content and flavour score (Dunlap *et al*., 1995; Min and Schweizer, 1983).

Table 3: Changes in some chemical properties of sunflower oil mixed with different levels of pomposia juice, 200ppm of BHT and Sunflower oil without antioxidants (control)

	Pomposia juice (ppm)					
Frying period (h)	200	400	800	1200	BHT 200 ppm	Control
Acid value (mg KOH/g oil)						
0	0.12±0.02^{t}	0.12±0.02^{t}	0.12±0.02^{t}	0.12±0.02^{t}	0.12±0.02^{t}	0.12±0.02^{t}
2	0.34±0.01^{p}	0.31±0.01^{pq}	0.26±0.01^{rs}	0.23±0.01^{s}	0.28±0.01^{or}	0.39±0.01^{o}
4	0.62±0.02^{L}	0.57±0.02^{L}	0.45±0.01^{mn}	0.42±0.01^{no}	0.46±0.01^{m}	0.64±0.01^{k}
8	0.91±0.01^{fg}	0.88±0.01^{gh}	0.76±0.01^{i}	0.66±0.01^{k}	0.71±0.01^{d}	0.98±0.01^{d}
12	1.23±0.00^{b}	1.17±0.01^{c}	0.96±0.02^{de}	0.87±0.03^{h}	0.94±0.01^{ef}	1.62±0.01^{a}
LSD	0.03072					
Peroxide value (meq. Peroxides/Kg oil)						
0	1.71±0.01^{m}	1.71±0.01^{m}	1.71±0.01^{m}	1.71±0.01^{m}	1.71±0.01^{m}	1.71±0.01^{m}
2	4.02±0.08^{jK}	3.72±0.01^{k}	3.68±0.00^{k}	2.88±0.00^{L}	3.74±0.04^{k}	4.02±0.01^{jk}
4	6.46±0.25^{f}	6.21±0.09^{f}	5.25±0.13^{hi}	4.72±0.03^{ij}	5.16±0.12^{hi}	6.21±0.02^{f}
8	9.31±0.18^{d}	9.01±0.50^{d}	8.75±0.21^{d}	7.36±0.25^{e}	8.52±0.01^{d}	11.32±0.58^{c}
12	12.47±0.00^{b}	12.40±0.12^{b}	11.65±0.52^{c}	10.75±1.07^{c}	11.21±0.43^{c}	15.00± 0.27^{a}
LSD	0.6444					
Thiobarbituric acid value (Absorbance at 530 nm)						
0	0.02±0.00^{k}	0.02±0.00^{k}	0.02±0.00^{k}	0.02±0.00^{k}	0.02±0.00^{k}	0.02±0.00^{k}
2	0.10±0.01^{jk}	0.10±0.00^{jk}	0.09±0.02^{jk}	0.06±0.41^{jk}	0.06±0.00^{jk}	0.21±0.00^{ij}
4	0.48±0.05^{fgh}	0.42±0.00^{gh}	0.35±0.01^{ghi}	0.29±0.05^{hi}	0.37±0.00^{chi}	0.75±0.00^{bcd}
8	0.79±0.01^{bcd}	0.70±0.01^{cde}	0.63±0.00^{def}	0.52±0.02^{efg}	0.64±0.00^{def}	0.91±0.01^{ab}
12	0.84±0.01^{abc}	0.79±0.00^{bcd}	0.70±0.00^{cde}	0.66±0.10^{cdef}	0.73±0.05^{bcd}	0.98±0.01^{a}
LSD	0.1683					
Insoluble polymer content (%)						
0	0.24±0.01^{t}	0.24±0.01^{t}	0.24±0.01^{t}	0.24±0.01^{t}	0.24±0.01^{t}	0.24±0.01^{t}
2	0.86±0.01^{o}	0.82±0.00^{p}	0.65±0.01^{q}	0.46±0.00^{s}	0.52±0.02^{r}	0.99±0.00^{m}
4	1.54±0.02^{i}	1.49±0.01^{j}	1.00±0.00^{m}	0.84±0.00^{pp}	0.95±0.01^{n}	1.68±0.01^{h}
8	1.93±0.00^{e}	1.88±0.00^{f}	1.55±0.01^{i}	1.39±0.01^{L}	1.46±0.00^{k}	2.19±0.01^{c}
12	2.23±0.02^{b}	2.08±0.02^{d}	1.80±0.02^{g}	1.66±0.00^{h}	1.78±0.02^{g}	2.64±0.00^{a}
LSD	0.02379					

Values are expressed as the mean of three determinations; Values followed by different letter are significantly different at ($p<0.01$); Mean values followed by the SD (±); LSD refers to Least Significant Difference test

Hydroperoxides are the primary products of lipid oxidation; therefore, determination of peroxides can be used as oxidation index for the early stages of lipid oxidation (Barthel and Grosch, 1974; Nawar, 1996). Changes in peroxide values of sunflower oil samples under investigation during frying period are shown in Table 3.

In General, the peroxide values of sunflower oil increased significantly ($p<0.01$) during frying and were strongly correlated with prolonging the frying period. The peroxide value of sunflower oil without antioxidant at the end of frying period was about 1.20, 1.21, 1.28, 1.39 and 1.33 times as high as that for sunflower oil mixed with 200, 400, 800 and 1200 ppm of pomposia extract and 200 ppm of BHT, respectively. The lowest value of P.V. at the end of frying period is for sunflower oil sample treated with 1200 ppm of pomposia extract. No significant ($p>0.01$ differences were observed between sunflower oil treated with 800 and 1200 ppm of pomposia extract and that sample treated with 200 ppm of synthetic antioxidant BHT. The obtained results indicate high antioxidative effect of polyphenolic compounds present in pomposia extract in reducing the formation of hydroperoxides during frying process, this effect was entirely dependent upon their concentration.

Thiobarbituric acid value (TBA): There are two stages of oil oxidation, i.e., the first stage is the formation of hydroperoxides and the second one is the decomposition of hydroperoxides to produce secondary oxidation products which could be react with TBA reagent to produce coloured compounds which absorb usually at 530 nm (Orthoefer and Cooper, 1996). The results of TBA test (Table 3) indicate that sunflower oil without antioxidant at the end of frying period had significantly ($p<0.01$) high TBA value was 0.98 as absorbance at 530 nm. Addition various levels of pomposia extract caused significant ($p<0.01$) lowering effect in the amount of TBA reacting substances. This decreasing increased with the increasing the concentration of pomposia extract. Sunflower oil mixed with 800 and 1200 of pomposia extract had significantly the lowest TBA value at the end of frying period were 0.70 and 0.66 as absorbance at 530 nm. Here again, the results of TBA value of sunflower oil indicted the powerful antioxidant activity of polyphenolic compounds present in pomposia extract. The obtained results show also that the natural polyphenolic compounds of pomposia extract at level 800 exhibited antioxidant effect similar to the effect of synthetic antioxidant BHT at level 200 ppm. These findings demonstrate that mixing sunflower with 800 and 1200 of

pomposia extract decreased oil oxidation and the formation rate of TBA reacting substances. This means that mixing sunflower oil with natural polyphenolic compounds of pomposia improved its quality during frying process.

Insoluble polymer content: The results present in Table 3 show the changes in polymer content of sunflower oil samples under investigation during frying period. In General, the Insoluble polymer content values of sunflower oil increased significantly ($p<0.01$) during frying and were strongly correlated with prolonging the frying period. During frying, oils are hydrolysed to form FFA and mono and diglycerides and these compounds accumulate in the frying oil with repeated use. In addition, oils also oxidize to form hydroperoxide, conjugated dienoic acids, epoxides, hydroxides, aldehydes and ketones. These compounds may undergo fission into smaller fragments or may remain in the triglyceride molecule and cross-link with each other, leading to dimeric and higher polymeric triglycerides (Innawonga *et al*., 2004).

Fried sunflower oil without antioxidant had significantly the highest level of polymer at the end of frying period was 2.64%, mixing sunflower oil with various level of with pomposia extract at levels 200, 400, 800 and 1200 ppm or with 200 ppm of BHT induced significant ($p<0.01$) decreased in the polymer content. This reduction increased with the increasing the concentration of pomposia extract. Fried sunflower oil mixed 1200 ppm of pomposia extract had significantly the lowest level of polymer was 1.66% followed by those samples mixed with 200 ppm of BHT and 800ppm of pomposia extract ranged from 1.78-1.80%, respectively. One would recommend adding pomposia extract at level 800 or 1200 ppm to oils to act as polymerization inhibitor.

Several studies indicated the effect of frying process on the physico-chemical and sensory properties of fried oil. In this respect Clark and Serbia (1991), White (1991) and Tyagi and Vasishtha (1996) reported that frying oils used continuously or repeatedly at high temperatures in the presence of oxygen and water from the food being fried, are subject to thermal oxidation, polymerization and hydrolysis and the resultant decomposition products adversely affect flavour and colour. Deterioration of frying oils is generally followed by changes in Free Fatty Acid (FFA) level, colour of the used oil, or an increase in polarity of the oil (Paradis and Nawar, 1981; Tan *et al*., 1985; Orthoefer, 1988; White, 1991; Melton *et al*., 1994; Orthoefer *et al*., 1996).

The presence of air and water introduced as steam during the frying process can accelerate the deterioration of frying oil (Clark and Serbia, 1991). The results of the current study are in harmony state with the data of previous researches.

CONCLUSION

The experiments on fried sunflower oil quality indicated that the phenolic compounds of pomposia extract at levels 800 and 1200 ppm induced powerful antioxidant effect which was almost equal to the synthetic antioxidant (BHT) at level 200 ppm.

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