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Increasing the Sunflower Oil Stability by Using Mango Peels Powder as Source of Natural Antioxidant

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Abstract

Increasing the sunflower oil stability during deep fat frying by using mango peels powder (MPP) as natural source of antioxidants was evaluated. Some physical, physicochemical properties, fatty acid content and phenolics compounds were also determined. The results showed that the mango peels had contains different amount of protein, fat, ash, fiber, carbohydrates and energy value. The mean values of total phenolics, total flavonoides and scavenging activity (DPPH) of mango peels, were 18.93 mg GAE/g, 4.578mg/g DW and 90.46 %, respectively. The highest levels of mango peels phenolics compounds recorded for gallic acid and chlorogenic acid, while the lowest levels recorded for P-coumaric acidand caffeic acid. The values of viscosity, specific gravity and refractive index wereincreased with the elongation of frying days.The highest fatty acids values of control sunflower oil and sunflower oil blended with 2000 MPP after heating and deeping frying for 1and 6 days recorded for linoleic and oleic acid, while, the lowest values recorded for palmitoleic acid and linolenic acid. The lowest increasing in peroxide value, inisidine value, saponification recorded for sunflower oil with 200 ppm BHA blended with sunflower oil with 2000 ppm MPP. While, iodine value and free fatty acid were deceased. In conclusion, addition of mango peels to sunflower oil improvement some physical, physicochemical properties and oil stability during deep-fat frying processing.

Key word: Mango peels powder,Deep-fat frying process andScavenging activity.

Introduction

Several decades ago, there has been increasing attention given to new sources of natural antioxidant phytochemicals as a result of their potential health benefits, in addition to their functional properties in traditionally commercialized products such as preserving color and flavor and hence improving shelf life **(Arun*et al.,* 2015)**.

Generally, synthetic antioxidants such as butylatedhy-droxytoluene (BHT) and butylatedhydroxyanisole (BHA) are used to control oxidation, but these synthetic antioxidants are known to have carcinogenic and toxic effects on humans. Therefore, the importance of replacing synthetic antioxidants with natural ingredients has increasedsignificantly **(Mohdaly *et al.,* 2010)**.

On the other hand, byproducts of food processing are a low-cost raw material for the extraction of healthy compounds such as dietary fiber, natural antioxidants, and natural food additives. Also, fruit and vegetable waste and byproducts are discarded frequently at a cost to the manufacturer. Hence, using of the waste as a source of polyphenols may be of noticeable economic benefit to food processors **(Al-Weshahy and Rao, 2012)**.

Lipid oxidation is one of the most important causes of food quality deterioration; it generates off odors and off flavors, decreases shelf life, alters texture and color, and decreases the nutritional value of food. Countless methods have been introduced to control the rate and extent of lipid oxidation in foods, but the addition of antioxidants is one of the most effective. Antioxidants have become a crucial group of food additives due to their ability to extend the shelf life of foods without any adverse effect on their sensory or nutritional qualities **(Alamed *et al.,* 2009)**.In particular, phenolic compounds isolated from plants are recognized as the most promising group of molecules that help to prevent oxidation and maintain product quality **(Shahidi and Wanasundara, 1997)**.The main by-products of processing mangos (*Mangiferaindica*, L.) are the peel and the seed, which represent approximately 35e60% of the fruit **(Larrauri*et al.,* 1996)**.Volatile and nonvolatile compounds are formed in vegetable oils during deep-fat frying process. Volatile compounds are removed from oil and nonvolatile compounds accumulate in the oil. Nonvolatile compounds

are produced primarily by thermal oxidation and polymerization of unsaturated fatty acids **(Aladedunye and Przybylski, 2013)**.

Mango peel and seed have a great deal of antioxidant activity because they are rich in bioactive compounds such as phenolic compounds (quercetin, quercetinOglycosides, isoquercetrinquerce-tringalactoside, 3,4-dihydroxy benzoic acid, ellagic acid, mangiferin, isomangiferin, homomangiferin, mangiferinhydrybenzoic acid, xanthones), carotenoids, tocopherols and sterols)**(Ribeiro*et al.,* 2008)**.

During processing of mango, peel is a major by-product. Peel contributes about 15-20% of the fruit. As peel is not currently utilized for any commercial purpose, it is discarded as a waste and becoming a source of pollution. Peel has been found to be a good source of phytochemicals, such as polyphenols, carotenoids, vitamin E, dietary fiber and vitamin C and it also exhibited good antioxidant properties **Kim *et al.,*(2010)**.

Some agricultural wastes from the fruit can industry such as mango peels have been found to be a rich source of antioxidants phenolic compounds. The major phenolic compounds of mango peels were gallic acid, syringic acid, gentisyl-protocatechuic, mangiferin, ellagic acid and quercetin that these phenolic compounds could be a good source of natural antioxidant and can used in food, pharmaceutical and cosmetics industry **(Tunchaiyaphum*et al*., 2013)**.

This work was conducted to study the increasing of sunflower oil stability with MPP as source of natural antioxidants.

Materialsand Methods

Materials

The fresh peel of mango (*Mangiferaindica*, L.) was obtained from local market, Menoufia Governorate, transferred frozen and stored at -18°C until analysis and processing.

Chemicals

Folin-Ciocalteu reagent and standard substances including gallic acid, sinapic acid, caffeic acid, chlorogenic acid, *p*-coumaric acid and dihydroxy benzoic acid were purchased from SigmaChemical Company (St. Louis, MO), vanillic acid, ferrulic acid, rutin and quercetin from Fluka St. Gallen, Switzerland. All reagents and standards were prepared using Milli-Q deionized water (Millipore, Bedford, USA). All other chemicals and reagents were of analytical reagent grade and purchased

from Al-Ghomhoria Company for Trading Drugs, Chemicals and Medical Instroments, Egypt.

Methods

Preparation of mango peel powder (MPP)

To prepare MPP, mango peels were washed thoroughly under running tap water, shade dried, and ground to a fine powder using an air mill, high speed mixture (Molunix, Al-Araby, company, Egypt, and then serving as powder seize.

Oil heating process

The intermittent heating processwas done according to the procedure of **Tsuzuki, *et al.,*(2010)**. In this procedure a sunflower oil (750g) and variousoil samples mixed with OWC, were placed in a stainlesssteel pan fryer (50cm diameter and 30cm height) providedwith thermostat to control in the heating temperature,individually to a temperature of 180±5°C. The various oilsamples were heated continuously at 180±5°C for 4 hr.every day, for 5 consecutive days. At certain periods ofheating (4, 8, 12, 16 and 20 hrs), aliquots from the oilsamples were removed and stored at 5°C until analyzed.

Analytical Methods

Moisture, Protein (N x 6.25 Kjeldahl method), fat (hexane solvent, Soxhielt apparatus), fiber and ash were determined according to the method recommended by **A. O. A. C. (2005)**.

Carbohydrates and energy value

Carbohydrate calculated by differences as follows:

% Carbohydrates = 100 - (% moisture + % protein + % fat + % ash + % fiber).

Energy value was estimated by the sum of multiplying protein and carbohydrates by 4.0 and fat by 9.0 according to **FAO (1982)**.

Determination of viscosity

The viscosity of oil samples (50 ml) was measured according to the method of **Quinn and Beuchat (1975)** using Brookfield viscometer, spindle no. 4, speed 30 rpm at room temperature. The viscosity was expressed in centipoises (cps).

Determination of refractive index and specific gravity

Refractive index and specific gravity were determined according to the method described by **(AOCS, 1982)**.

Peroxide value(PV),iodine number(IN), p inisidine value (PAV), free fatty acids (FFA) and saponification value (SV) were determined according to (**AOAC, 2005**).

Determination of total phenolics

The total phenolic content was measured by the Folin-Ciocalteau (F-C) method proposed by **Singleton and Rossi (1965**). For the extraction of phenolic compounds, see section 3.2.4 and 3.2.5.6. A sample of 0.1 ml was mixed with 7.9 ml of water. Then, F-C reagent (0.5 ml) was added and allowed to stand for 5 min. Sodium carbonate (20% w/v; 1.5 ml) was then added to the mixture. After shaking, the mixture was incubated for 90 min. The total phenolic content was determined using a gallic acid standard calibration curve. A stock solution of 5g/l of gallic acid was prepared by dissolving 0.5 g of gallic acid in 100 ml of distilled water. Different concentrations of standards in the range of 50-750 mg/l were prepared by diluting the stock solution in distilled water. The absorbance of all standards was measured at 765 nm using a spectrophotometer (Genova MK3, New Malden, Surrey, UK). The calibration curve was constructed by plotting the absorbance of different standards versus the standard concentration. The concentration of phenolics in the samples were calculated using the calibration curve equation, which had a correlation coefficient greater than 0.995. All samples were analyzed in duplicate and final results were expressed as milligrams of gallic acid equivalents per 100 g of mango peel.

Determination of total flavonoids

Total flavonols in the extracts were estimated using the method of **Kumaran and Karunakaran(2007**). To 2.0 ml of methanolic extract sample, 2.0ml of 2% $AlCl_3$ in ethanol and 3.0mL (50g/l) sodium acetate solutions were added. The absorption at 440nm was read after 2.5h. at 20°C. Extract samples were evaluated at a final concentration of 0. 1mg/ml. Total flavonoid content was calculated as quercetin (mg/g) using the following equation based on the calibration curve: $y = 0.0255 x$, $R2 = 0.9812$, where x was the absorbance and y was the quercetin equivalent (mg/g).

Determination of DPPH Radical Scavenging Activity

The antioxidant activity of MPP, based on the scavenging activity of the stable DPPH free radical, was determined by the method described by **Lee *et al.*, (2004)** as follows: Known volumes (0.2-0.7ml)

of potato peel extract were individually added to test tubes then completed to a known volume (1.0 ml) by DW. 1.0 ml of DPPH solution (0.2 mlmolin ethanol) was added to each tube then mixed well and incubated at room temperature for 30 min. Control was prepared by the same procedure without potato peel extract. Ascorbic acid solution (0.03%, w/v) was used as a positive control. The absorbance (A) of the solution was measured at 517 nm using Jenway 6300spectrophotometer. Inhibition of DPPH free radical in percent (I%) was calculated from the following equation: $I\% = [(A - A)/A] \times 100$

Identification of phenolics compounds from MPP

MPP (10 g) dissolved in 45 ml of water was loaded into the reactor. To prevent plugging, glass wool (10 mm thick) was placed at both ends of the extraction vessel. In a typical experiment, distilled water was first degassed and then delivered with the HPLC pump at a constant flow rate (2 ml/min) to the preheating section. Then, it was passed through the extraction vessel preloaded with the potato peel. The pressure of the system was adjusted to 6 MPa by using the back-pressure regulator. The temperature of the system was monitored by a temperature controller (Omega Engineering, Stamford, CT). After the extraction cell, the extract passed through a cooling system using cold water to prevent degradation. The extraction was carried out for 120 min and the samples were collected in vials every 30 min. Extractions were carried out at temperatures of 100-240°C, at a constant pressure of 6 MPa and using a constant flow rate of 2 ml/min. The residue left after each extraction was re-extracted with 10 ml of methanol and extracted for 1 hr. All extractions were performed in duplicates. The extracts were stored at 4°C for further analysis of total phenolics by using the F-C method and of individual phenolic composition by using HPLC system (Varian, Palo Alto, CA) equipped with a 401 model autosampler, pumps, and a UV model 1305 detector. The column used was Luna RP-18 (150 mm x 4.6 mm i.d. x 5 µm) with a Phenomenex security guard column C18 (4 mm x 3 mm) (Phenomenex, Irvine, CA). The HPLC methodology adapted from **Pellati*et al.*, (2005)** was modified for the quantification of phenolic compounds from potato peel.

Determination of fatty acid

Fatty acid methyl esters for GC analyses were obtained using methanolic hydrogen chloride according to the method described by

Miguel *et al.,* (2014). Unsaturated fatty acids double-bond positions were determined by GC-MS mass spectra of their dimethyl disulphide adducts. The samples containing the fatty acid methyl esters were dissolved in 0.2 ml of dimethyl disulfide and 0.05 ml of the solution of iodine in diethyl ether (60 mg/ml) was added. After 24 h at room temperature, the mixture was extracted three times with 2 ml of *n*-pentane/ ether (1:1). The *n*-pentane/ether fraction was washed with 5% sodium thiosulphate solution and evaporated to dryness. The product was dissolved in *n*-pentane. GC analyses were performed using a twin FID Perkin Elmer Autosystem XL gas chromatograph (Perkin Elmer, Shelton, USA), a data handling system and a vaporising injector port into which two columns of different polarities were installed: a DB-1 fused-silica column (30 m × 0.25 mm *i.d.*, film thickness 0.25 mm) and a DB-17HT fused-silica column (30 m × 0.25 mm *i.d.*, film thickness 0.15 μm). The oven temperature was programmed for 170–270°C at 5°C/min and then held isothermally for 5 min; injector and detector temperatures were 300°C; carrier gas, H_2at a flow of 30 cm/second. The samples were injected using the split-sampling technique with a ratio of 1:50. Percentage composition of the samples was computed using the normalisation method from the GC peak areas without correction factors. The data shown are mean values of two injections of each sample.

Statistical analysis

Data were recorded as means and analyzed by (SPSS) (Ver.10.1). One–way analysis of variance (ANOVA) and Duncan comparisons were tested to signify differences between variable treatments of MPP **(SAS 1988)**.

Results and discussion

Chemical composition of MPP

Data presented in Table (1) show the chemical composition of MPP.It is clear to mention that the mango peels had contains different amount of protein, fat, ash, fiber, carbohydrates and energy value as wet weight. The values were 2.34, 2.25, 2.27, 5.44, 16.60% (W/W) & 96.01 kcal/100g and 2.29, 0.12, 1.55, 2.45, 12.44% & 60.0 kcal/100g, respectively. These results are in agreement with **Romelle*et al.,*(2016),** they reported that lipid, protein, ash, crude fiber and carbohydrates contents in mango peels were respectively from 3.36 ± 0.37 to 12.61 ±

0.63%, from 2.80 ± 0.17 to 18.96 ± 0.92%, from 1.39 ± 0.14 to 12.45 ± 0.38%, from 11.81 ± 0.06 to 26.31 ± 0.01% and from 32.16 ± 1.22 to 63.80 ± 0.16%.

Total phenolics, total flavonoids and scavenging activity content of mango peels

Data tabulated in Table (2) show the total phenolics, total flavonoids and scavenging activity contents of MPP. It is clear to mention that the mean values of total phenolics, total flavonoids and scavenging activity (DPPH) of MPP, were 18.93 mg GAE/g, 4.578mg/g DW and 90.46 %, respectively. The results are in agreement with **Han *et al.,* (2007)**, they reported that mango peels contain the highest total phenolics content being, 24.06 %. In humans, phenolic compounds have been reported to exhibit a wide range of biological effects including anti-bacterial, anti-inflammatory and antioxidant properties.**Also, Jayaprakasha and Patil, (2007)**, reported that the MPP contained more polyphenols and flavonoids than flesh and exhibited good antioxidant activity by effectively scavenging various free radicals, such as DPPH radicals, hydroxyl radicals and alkyl radicals. In addition, it has been demonstrated that the MPP is a potential anti-proliferative agent. The antioxidant and anti-proliferative activities of MPP might be due to the synergistic actions of their content the effect bioactive compounds categories.

Identification of phenolics compounds of mango peels

Data given in Table (3) show the identification of phenolics compounds of MPP.The obtained results indicated that the highest levels of MPP phenolics compounds recorded for gallic acid and chlorogenic acid, the values were 79.16 and 9.48 mg /100 g, respectively.On the other hand, the lowest levels of mango peels phenolics compounds recorded for P-coumaric acidand caffeic acid, the values were 0.46 and 0.83 mg/100g mg /100 g, respectively, while, syringicacid and vanillic acid did not detect at this conditions. These results are in agreement with **El-Gammal, (2012)** found that the MPP contained 9 compounds of phenolic compounds, the most abundant one being salicylic comprised about 6015.28 ppm concerning to the derivatives with the chlorogenic and benzoic being 2485.44 ppm and 2390.23 ppm, respectively while the lowest compounds were protocatchoic, vannillic, gallic, catechin and catechol being 37.49, 132.68, 137.30 and 189.58 ppm,

respectively.Also,**Arshad*et al.,*(2015)**, reported that in the MPP samples, gallic acid was predominant, followed by protocatechuic acid, chlorogenic acid, caffeic acid and *p*-coumaric acid. Comparatively, a higher level of phenolics and significant antioxidant capacity in mango peel indicated that it might be useful as a functional food and value-added ingredient to promote human health.

Physical characterization of crude sunflower oil sample

Data tabulated in Table (4) show thephysical characterization of crude sunflower oil sample. Data indicated that the viscosity value increased with elongation of deep-fat frying period. The lowest value recorded for the fresh sunflower oil before frying, while the highest value recorded for sunflower oil after 4 days of frying, which recorded 73.48 and 93.52 centipoise, respectively.

On the other hand, specific gravity and refractive index recorded the highest values with sunflower oil after 4 days of frying; the values were 0.925 and 1.480, respectively. While, the lowest values recorded for sunflower oil before frying, the values were 0.914 and 1.477, respectively. These values are fairly close to **Hammond *et al.*, (2005)**, who reported that that specific gravity (SG) of sunflower and soybean oil were 0.722 and 0.725, respectively, while the mixture of oils "A" was 0.866.

Fatty of acid composition of sunflower oil after heating and deep-fat frying for 6 days

Data from Table (5) showed the fatty of acid composition of sunflower oil after heating and deep-fat frying for 6 days. It is clear to notice that the highest fatty acids values of control sunflower oil after heating for 1day recorded for linoleic and oleic acid, the values were 54.47 and 28.39 %, respectively. The lowest values recorded for palmitoleic acid and linolenic acid, which were 0.15 and 1.3%, respectively. While, the highest values of control sunflower oil after heating for 6 days recorded for linoleic and oleic acid, the values were 52.53 and 29.51 %, respectively. While the lowest values recorded for palmitoleic acid and linolenic acid, which were 0.12 and 1.46%, respectively.

On the other hand, the highest values of sunflower oil with 2000 ppm MPP after heating for1day recorded for linoleic and oleic acid, the values were 52.50 and 32.75 %, respectively. The lowest values

recorded for palmitoleic acid and linolenic acid, which were 0.14 and 1.34%, respectively. After 6 days of heating, the highest values of sunflower oil with 2000 ppm mango peels recorded for linoleic and oleic acid, the values were 52.78 and 31.79 %, respectively. The lowest values recorded for palmitoleic acid and linolenic acid, which were 0.16 and 1.47%, respectively.

In the case of deep-fat frying,the highest values of sunflower oil with 2000 ppm mango peels after heating recorded for linoleic and oleic acid, the values were 53.19 and 32.08 % and 50.30 and 32.7%, respectively while, the lowest values recorded for palmitoleic acid and linolenic acid, which were 0.14 and 1.38% and 0.14 and 1.37%, respectively. On the other hand, the highest values of sunflower oil with 2000 ppm MPP after deep-fat frying for 1and 6 days recorded for linoleic and oleic acid, the values were 52.69 and 33.01 % and 49.41 and 34.14%, respectively. While the lowest values recorded for palmitoleic acid and linolenic acid, which were (0.0 & 1.33%) and (0.18 & 1.50%), respectively. These results were in agreement with those obtained by **Zhang *et al.*, (2012)** reported that the chemical reactions occurring during deep-fat frying roughly involved hydrolysis, oxidation, isomerisation, and polymerisation which resulted in the generation of FFA, low-molecular alcohol, aldehyde, ketone, acid, lactone, and hydrocarbon, diglyceride and monoglyceride, cyclic and epoxy compounds, transisomers, triacylglycerol monomer, dimer, and oligomer.

Stability of sunflower oil with different antioxidants during deep-fat frying process

Data tabulated in Table (6) show thestability of sunflower oil before and after frying with MPP as natural antioxidants.It is clear to notice that at zero day of frying period the PV of control sunflower oil, sunflower oil with 200 ppm BHA, and sunflower oil with 2000 ppm MPP were 22.63, 20.25, and 20.0 meq/kg oil, respectively.After 6 days of frying period, the PV for all tested sunflower oil increased by different rats. The lowest increased in PV recorded for sunflower oil with 200 ppm BHA and sunflower oil with 2000 ppm MPP, which recorded 30.25 and 32.25 meq/kg oil, respectively.

In case of inisidine value, the obtained results showed that at zero day of frying period the inisidine value ranged from 1.78 -2.10. While,

after 6 days of frying period, the inisidine values for all tested sunflower oil were increased by different rats. The lowest increased in inisidine values recorded for sunflower oil with 200 ppm BHA and sunflower oil with 2000 ppm mango peels, which recorded 3.06 and 3.66, respectively.

Also, data in Table (6) indicated that at zero day of frying period the iodine value ranged from 137.26 -138.11g I_2/ 100 g oil. While, after 6 days of deep-fat frying period, the iodine values for all tested sunflower oil were decreased by different rats. The highest decreased in iodine values recorded for sunflower oil with 2000 ppm mango peels and sunflower oil with 200 ppm BHA, which recorded 132.72 and 132.93, respectively.

On the other hand, FFA content at zero day of frying sunflower oil ranged from 0.20-0.21 % oleic acid. While, after 6 days of frying period, the FFA values for all tested sunflower oil were slightly decreased by different rats. The highest decreased in FFA values recorded for sunflower oil with 200 ppm BHA, and sunflower oil with 2000 ppm MPP, which recorded 0.18 and 0.19 % oleic acid, respectively.

In case of saponification value, it could be notice that the saponification value content at zero day of frying sunflower oil ranged from 192.03-192.50 mg koH/g oil.

After 6 days of frying period, the saponification values for all tested sunflower oil increased by different rats. The lowest increased in saponification value recorded for sunflower oil with 200 ppm BHA and sunflower oil with 2000 ppm MPP, which recorded 194.45 and 194.80 mg KoH/g oil, respectively. These results are in agreement with **Bensmira*et al*. (2007),** who noticed that the PV of control sample increased with extending heating time reached to22.57meq/Kg oil after 96 hours. Addition of antioxidants retarded the oxidation process in all treated oil samples while PV of treated samples was lower than those of the control one.

Table (1): Chemical composition of mango peels

Characteristics	Value	
	(WW)	(DW)
Moisture (%)	71.10	----
Protein (%)	2.34	8.14
Fat (%)	2.25	7.80
Ash (%)	2.27	7.97
Fiber (%)	5.44	18.89
Carbohydrates (%)	16.60	57.23
Energy value (Kcal/100g)	96.01	331.68

W/W= Weight wet D/W= Dry weight

Table (2): Total phenolics, total flavonoides and scavenging activity content of potato and mango peels

Samples types	Total phenolic (mg G.A.E./g)	Total flavonoides (mg/g DW)	DPPH (Scavenging activity%)
Mango peels	18.93 ± 19.61	4.578 ± 0.15	90.46±0.75

Values expressed are means ± SD of triplicate measurements.

GAE = Gallic acid equivalent.

Table (3): Identification of phenolics compounds of mango peels

Phenoles	Mg/100g
Chlorogenic acid	9.48± 0.051
Caffeic acid	0.49 ± 0.10
Protocatechuic acid	7.86 ± 0.011
Gallic acid	79.16 ± 0.08
Syringic acid	ND
P-Coumaric acid	0.32 ± 0.02
Ferulic acid	0.69 ± 2.14
Vanillic acid	ND

ND= Not detected

Values expressed are means ± SD of triplicate measurements.

Table (4): Physical characterization of crude sunflower oil sample

Properties	Deep-fat frying period				
	0	1	2	3	4
Viscosity(Centipoise)	73.48	77.08	82.35	87.28	93.52
Specific Gravity	0.914	0.916	0.919	0.921	0.925
Refractive Index	1.477	1.478	1.479	1.479	1.480

Table (5): Fatty of acid composition of sunflower oil before (day 1) and after heating and after deep-frying process at the end of the experiment(day 6), in the presence or the absence of mango peels

Fatty acids (%)	Sunflower oil control		Sunflower oil+ MPP (2000ppm)	
	1	24	0	24
Heating				
Palmitoleic C16:0	0.15	0.12	0.14	0.16
PalmiticC16:1	7.20	7.67	6.92	7.03
Linoleic C18:0	54.47	52.53	52.50	52.78
Oleic C18:1	28.39	29.51	32.75	31.79
LinolenicC18:2	1.30	1.46	1.34	1.47
Stearic C18:3	3.86	4.12	3.36	3.53
Deep-frying				
Palmitoleic C16:0	0.14	0.14	0.0	0.18
Palmitic C16:1	6.43	7.14	6.60	6.84
Linoleic C18:0	53.19	50.30	52.69	49.41
Oleic C18:1	32.08	32.75	33.01	34.14
Linolenic C18:2	1.38	1.37	1.33	1.50
Stearic C18:3	3.46	3.89	3.31	3.75

Table (6): Stability of sunflower oil before and after frying with different antioxidants

Properties	Frying days	SFO control	SFO+ 200 ppmBHA	SFO+2000 ppm mango peels
Peroxide value (ml.eqv./kg oil)	0	22.63±2.25^{a}	20.25 ±1.71^{c}	20.00 ±1.47^{c}
	6	42.13 ±3.75^{a}	30.25 ±0.65^{b}	32.25 ±1.94^{d}
Anisidine value	0	2.10 ±0.17^{a}	2.10 ±0.17^{a}	1.78 ±0.14^{b}
	6	3.78 ±0.34^{a}	3.06 ±0.14^{b}	3.66 ±0.27^{a}
Iodine values (g I_2/ 100 g oil)	0	138.11 ±0.55^{a}	137.26 ±0.55^{a}	137.79 ±1.35^{a}
	6	135.57 ±6.99^{a}	132.93 ±3.88^{b}	132.72 ±2.45^{b}
FFA content (% oleic acid equivalent)	0	0.21 ±0.02^{a}	0.20 ±0.01^{a}	0.20 ±0.00^{a}
	6	0.40 ±0.01^{a}	0.28 ±0.01^{b}	0.33 ±0.01^{b}
Saponification Value (mg KOG/g oil)	0	192.15±0.01^{a}	192.05±0.01^{a}	192.03±0.01^{a}
	6	196.60±0.21^{a}	194.45±0.24^{c}	194.80±0.25^{c}

SFO= sunflower oil BHT= Butylatedhydroxy anisole FFA= Free fatty acids

Means under the same column bearing different superscript letters are significantly different at ($p \leq 0.05$).

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زيادة درجة الثبات لزيت عباد الشمس باستخدام قشور المانجو كأحد أنواع مضادات الأكسدة الطبيعية

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تم تقييم درجة الثباتلزيت عباد الشمس أثناء عمليات القلي العميق (الغزير) باستخدام قشور المانجو. كما تم تقدير بعض الخواصالطبيعيةوالكيموحيوية، ومحتوى الأحماض الدهنية والمركباتالفينوليةفى زيت عباد الشمس. وأظهرت النتائج أن قشور المانجو تحتوي على كميات مختلفة من البروتين والدهون والرماد والألياف والكربوهيدرات وقيم الطاقة,حيث كان متوسط القيمللفينولات الكلية، والفلافونيدات الكلية والنشاط المضادات للأكسدة (DPPH) لقشور المانجو ١٨,٩٣ ملجم /جم حمض جاليك، ٤،٥٧٨ ملجم / جممادة جافة, ٩٠,٤٦٪، على التوالي .كما سجلت أعلى مستويات لقشور المانجو من المركباتالفينوليةلحمض الجاليكوحمض الكلوروجينيك، بينما سجل أقلالمستويات مع حمض ف كيوماريكوحمضالكافيك.لوحظ أن قيم كل مناللزوجة، الوزن النوعي ومعامل الانكسار تزداد مع زيادة عدد مرات القلي .أعلى قيم للأحماض الدهنية فى زيت عباد الشمس الكنترول وزيت عباد الشمس المضاف إليه ٢٠٠٠ جزء في المليون قشور المانجو بعد التسخين والقلي العميق لمدة ١,٦أيام سجلت مع حمضاللينوليك وحمض الأوليك، في حين أن أقل القيم مسجلت مع حمضالبالمتيوليك وحمض اللينولينيك.أقل زيادة في قيم كل من رقم البيروكسيد، والأنسيدين، التصبن سجلت مع زيت عباد الشمس المضاف إليه٢٠٠ جزء في المليونبيوتيلاتيدهيدروكسيأنيسول (BHA)وزيت عباد الشمس المضاف إليه ٢٠٠٠ جزء في المليون قشور المانجو, بينما حدث أعلى انخفاض فالرقماليودى والأحماض الدهنية الحرة. خلاصة القول,أن إضافة قشور المانجو لزيت عباد الشمس أدى إلى تحسين بعض الخواص الطبيعية والكيموطبيعيةودرجة الثبات للزيت أثناء عمليات القلى الغزير.

الكلمات الدالة:مسحوق قشور المانجو, النشاط التأكسدى, عمليات القلى الغزير.