Phenolic Compounds and antioxidant potential of mango peels and kernels *(Mangifera indica L.)* on the frying oil stability, lipid profile and activity of some antioxidant serum enzymes in rats

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Abstract: Commercial processing of mango into juice, nectar, pulp puree and jam produces 35–60% waste consisting of peel, kernel which make it worth to investigate on their bioactive phenolic compounds. This study discussed on the total phenolic content (TPC), the quantification of individual phenolics using HPLC for ethanolic extract for mango peel and kernel and evaluation of antioxidant activities of those extracts on the stability of frying oil and serum lipid profile and serum oxidation of rats. Results showed that mango peels and kernels are significantly rich in natural antioxidants such as, carotene ascorbic acid and Anthocyanins and phenolic component such as Pyrogallol acid and chlorogenic acid present in considerably high concentrations. Total polyphenols and Anthocyanins are higher in the kernel than in the peel. Moreover, frying oil samples fortified with ethanolic extract from mango peel and kernel were more protective than oil samples fortified with Butylated hydroxyanizole (BHA) against fatty acids oxidation, peroxide value and Acid number, particularly samples treated with 0.5% of kernel ethanolic extract. The highest decrease in serum cholesterol, triglyceride and LDL-c recorded for groups, which fed on basal diet containing frying oil treated with 0.5% of kernel mango extract, followed by the group treated with 0.5% of peel mango extract. SOD, GPx, MDA and XO of plasma in control group were significantly increased (P<0.05) as compared with groups which fed on frying oil treated with different concentration of peel and kernel ehanolic extracts. The study here in revealed that fruit peels represent an excellent source of high natural antioxidants, which may be applied in pharmaceutical, food and cosmetic industries.
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Keywords: phenolic component, frying oil, antioxidant, mango peel, mango kernels, lipid profile, serum antioxidant.

1. Introduction

Diets rich in fruits and vegetables are gaining increased importance because of their significant role in reducing the risk of certain types of cancer, cardiovascular diseases and other chronic diseases (Joshipura *et al.,* 2001). Fruits and vegetables contain many antioxidant compounds including phenolic compounds, carotenoids, anthocyanins and tocopherols (Naczk & Shahidi, 2006).

Mango (*Mangifera indica L.*) is one of the most important tropical fruits consumed in fresh or processed form globally. In addition, a large number of non-marketable fruits are typically discarded thereby creating massive amounts of bio-waste. Commercial processing of mango into juice, nectar, pulp, puree, fruit leather, and jam produces 35–60% waste consisting of peel, kernel, and cull fruit (Larrauri *et al.,* 1996). Stones and peels are the most important by-products of mango processing, with the peel constituting approximately 40% of the fruit. The edible pulp makes up 33–85% of the fresh fruit, while the peel and the kernel amount to 7–24% and 9–40%, respectively (Wu *et al*., 1993) According to Larrauri *et al.* (1996), byproducts of industrial mango processing may amount to 35–60% of the total fruit weight. Since these wastes are a disposal problem, attempts have been made at efficiently utilizing by-products (Sogi *et al.,* 2013).

Mango waste contains significant amounts of phytochemicals, which makes it suitable to be processed for value-added applications in functional foods and nutraceuticals. Mango peel is rich in pectin, cellulose, hemicellulose, lipids, protein, polyphenols and carotenoids with excellent antioxidant and functional properties (Ajila *et al.,* 2007).

Mango peel and kernel contains various classes of polyphenols, carotenoids, and vitamins with different health-promoting properties, mainly antioxidant activity (Manthey & Perkins-Veazie, 2009). Mango kernels are rich sources of gallic acid, ellagic acid, ferulic acid, cinnamic acids, tanins, vanillin, coumarin, and mangiferrin, all having potential to act as a source of natural antioxidants (Abdalla *et al.,* 2007a). Dried mango peel and kernel products can improve the nutritional, functional and sensory properties, and oxidative stability of oil/oil-rich product (Abdalla *et al.,* 2007b).

Synthetic antioxidant compounds such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are commonly used in

processed foods. It has been reported that these compounds have some side effects and are carcinogenic (Ito *et al.,* 1983). Natural antioxidants present in foods and other biological materials have attracted considerable interest because of their presumed safety and potential nutritional and therapeutic value. The increased interest in natural antioxidants has led to the antioxidant evaluation of many species of fruits, vegetables, herbs, spices and cereals (Liyana-Pathirana & Shahidi, 2005).

During processing of mango, peel and kernel is a major byproduct. As peel is not currently utilized for any commercial purpose, it is discarded as a waste and becoming a source of pollution. It has been reported that mango peel and kernel contains a number of valuable compounds such as polyphenols, carotenoids, enzymes and dietary fibre (Ajila *et al*., 2007) Therefore, the objective of the present study was to evaluate the antioxidant activity of ethanolic extract of mango peel and kernel and estimate the major antioxidants such as polyphenols, carotenoids, and anthocyanin contents. Moreover, assess their impact on antioxidants and some functional properties such as oil frying stability (oil antioxidant) and serum lipid profile and serum antioxidant properties.

2.Material and methods

Material

Market-ripe mangoes (*Mangifera indica*) were purchased from Egyptian local market, Cairo government. Fruits were sorted for maturity and defects, followed by well washing. Peel and kernel stones were removed manually using stainless steel knives. The stones were opened to get kernels. Mango peel were cut into thin strips whereas the kernels were cut cross-section wise into thin thick slices before methanol extraction.

Drying of mango peels and kernels

Mango peel and kernel pieces were spread in single layer for drying. Samples settings under-vacuum drying machine as follows: temperature at 50°C, under-vacuum of 0.3 bar and time for 3 hours. The dehydrated samples were ground using a grinder to be in powder form and packaged in polyethylene bags and stored at 20 °C until analyzed.

Preparation of ethanolic extract

The extraction was carried out for fine powder by ethanol for 3 hrs at 40°C by used magnetic stirrer. The extract was filtration through filter paper. The residual solvent of ethanolic extract was removed using a rotary evaporator.

Determination of ascorbic acid, total carotenoids and total Anthocyanin

Ascorbic acid content were determined according to AOAC, 1991. Total carotenoids were determined as B-carotene equivalent using a standard curve prepared with pure B-carotene (0.5–2.5 lg/mL hexane) as described by Davis *et al.* (2007). Anthocyanin content was expressed as mg cyanidin 3-glucosides equivalent/100 g mango peel and kernel for the triplicate extracts.

Preparation of oxidized frying oil:-

Frying oil (sunflower75% & soybean 25%) available in Egyptian markets was used in current study. Oil was introduced into a separate fryer, The samples were divided into, oil without any antioxidant treatment, oil treating with BHA, oil trating with 0.2% and 0.5% of ethanolic extract from both mango peel and kernel as described by (Nor *et al.,* 2009) with some modified. The initial frying temperature was heated at 180° ± 2 C. Continued to use frying oil to frying potatoes for two hours (2 kilos of potatoes per 1 liter of fresh oil or modified oil), in the end of the frying experiment the oil was filtered, cool and kept in to dark polyethylene packages. All oil samples stored in a freezer until used. All samples in this study determined the acid number and peroxide value according to (AOAC.1990).

Identification of phenolic compound by high performance liquid chromatography (HPLC):-

The phenolic compounds of ethanolic extract of (mango peels and kernls), were determined by HPLC according to the method of Goupy *et al.* (1999) using HPLC Hewllet Packered (series 1050) equipped.

Animals

Forty two adult male albino rats of local species weighing 230-250 grams were used in the present study. All rats were given normal diet and water ad libitum and housed in room maintained at 25±5 ^{o}C and a 12 hrs light-dark cycle. Pure frying oil and frying oil treated with different concentration of ethanol mango peel and kernel extracts added to rat's basal diet.

Rats were divided into seven equal groups:

Group I: (6 rats) sedentary control group (control negative) fed on basal diet (CG).

Group II: (6 rats) fed on basal diet contain 10% untreated with antioxidant frying oil (FO).

Group III: (6 rats) subjected fed on basal diet contain 10% frying oil treat with BHA (FO + BHA).

Group IV: (6 rats) fed on basal diet contain 10% frying oil treated with 0.2% polyphenols extract from mango peel extract (FO+0.2% mango peel).

Group V: (6 rats) fed on basal diet contain 10% frying oil treated with 0.5% polyphenols extract from mango peel extract (FO+0.5% mango peel).

Group VI: (6 rats) fed on basal diet contain 10% frying oil treated with 0.2% polyphenols extract from mango kernel extract (FO+0.2% mango kernel).

Group VII: (6 rats) fed on basal diet contain 10% frying oil treated with 0.5% polyphenols extract from mango kernel extract (FO+0.5% mango kernel).

At the end of the experiment, all animal were fasted for 12 hrs and then blood sample were collected under diethyl ether anesthesia. Blood sample were left to clot and sera separated using cooling centrifugation and stored at -20 ^{o}C until used to biochemical analysis.

Estimation of serum lipid profile

Total serum cholesterol (Cohn *et al.,* 1988), triglycerides (Foster and Dumns, 1973), HDL-c (young, 2001), LDL-c and VLDL-c calculated by the methods described by (FriedWald et al., 1972). Total Lipid was measured by colorimetric method (Zollner and Kirsch., 1962). Lipids react with sulfuric, phosphoric acids and vanillin to form pink colored complex.

Determination of Antioxidants enzymes

Glutathione peroxidase (GPx) was measured with UV method (Paglia and Valentine, 1967). The enzyme reaction is initiated by adding the substrate, hydrogen peroxide at 340 nm. The rate of decrease in the absorbance is directly proportional to the GPx activity in the sample.

Malondialdehyde (MDA): MDA in plasma and tissue was measured by HPLC with fluorescence detection using commercial kit (Immunodiagnostic kit, Germany).

Xanthine oxidase (XO): Skeletal muscle and plasma (XO) were determined by ELISA kit (Cayman's xanthine oxidase, USA), The assay is multi step enzymatic reaction in which xanthine first produce H_2O_2 during oxidation of hypoxanthine, in the presence of horseradish peroxidase , H_2O_2 react with ADHP (10-acetyl-3-7- Dihydroxyphenoxazine) to produce highly fluorescent compound which can be measured at wave length from 520-550 nm.

Superoxide Dismutase (SOD) was measured with colorimetric method (Nishikimi et al., 1972).This assay relies on the ability of the enzyme to inhibit the phenazine methosulphate-mediated reduction of nitroblue tetrazolium dye. The (SOD) determined at 560 nm.

3.Result And Discussion

Phenolic compound

The phenolic compounds (mg/100g) of ethanolic extracts from mango peel and kernel analyze by high-performance liquid chromatography (HPLC) against standard compounds. Data in table (1) showed that Chlorogenic acid was the highest amount of total polyphenols compounds found in both mango peel and kernel. On the other hand, Protocatechouic and Ferulic acid was found only in mango kernel. On the other hand, Caffiec acid was the lowest amount of total polyphenols found only in both peel and kernel. All polyphenols were higher in mango kernel as compared to mango peel. Based on the HPLC analysis, and by comparison with standards, 16 polyphenols could be identified or characterized in mango kernel extract, and 13 polyphenols in mango peel extract. From the above mentioned data it could be concluded that, mango kernels and peel proved a source of phenolics, especially mango kernel. This result is applicable with other study (Pura-vankara *et al.,* 2000).

Table (1): Phenolic compound present in ethanolic extract using High- performance liquid chromatography (HPLC) (mg/100g):-

Phenolic compound	*Mango peels*	*Mango kernel*
Gallic acid	152.20 ± 0.14	**351.18**± 0.65
Mangiferin	**196.15**± 0.24	**515.36**± 0.75
Catechol	**80.15**	**203.47** ± 0.36
Pyrogallol	**ND**	**1337.9**± 0.31
Protocatechouic	**ND**	**431.60**
Caffeine	**22.3**	**12.44**
Caffiec	**3.5**	**7.23**
Chlorogenic acid	456.85 ± 0.55	**1190.77**
Sinapic acid	22.31 ± 1.02	**18.64**
Ferulic acid	0.28 ± 0.03	**33.80**
Salicylic	**ND**	**80.37**
Kaempferol	2.68 ± 0.60	**4.02**
Catechin	**160.22**	**752.34**
Cinnamic	**3.32**	**214.90**
Quercetin	1.34 ± 0.06	**40.33**
Myricetin	26.13 ± 0.18	**102.75**
Total	1121.43 ± 1.98	**5297.1**

The current results also agree with Lakshminarayana *et al.* (1979), who confirmed that total polyphenols are higher in the kernel than in the peel at all stages of mango fruit development. The average of total phenolic component obtained in this study was close to the value of total phenolic obtained in the recent studies which determine total phenolic (TPC) of leaves, peels, stem bark, and kernel of different mango varieties, and total flavonoid contents (TPC) in ranged from 630.89 to 11600.80 mg GAE/100g dry weight (Choudhary and Swarnkar, 2011 and Badmus *et al.,* 2012)

Total carotenoids

From the data illustrated in table (2) it was observed that the dried mango peel contained intermediate amounts of carotenoids, whereas the kernel had negligible amounts. The peel colour of Egyptian mangoes was green and yellow; therefore, it contained high carotenoids. The total carotenoids content in dried green and ripe peel have been reported to range from 9.69 to 16.06 mg/100 g (Aziz *et al.,* 2012). In the present study, the carotenoids values were applicable in the peel compared to those

reported previously. Whereas, the mango kernel colour of (*Mangifera indica*) mangoes was white, therefore, it contained low carotenoids. The previous openion is agree with the Sogi *et al.,* 2013 study.

Total ascorbic acid

The ascorbic acid content was approximately 76.62 mg/100 g in dried peel powder while 70.11 mg/100 g in kernel (Table 2). There was no statistical significant difference were observed between mango kernel and peels. The ascorbic acid values obtained in the present study were within the ranges of the reported values in the literature (Ajila *et al.,* 2007, Aziz *et al.,* 2012 and Sogi *et al.,* 2013).

Table (2): The total amount of carotenoids, ascorbic acid and *Anthocyanins in dried mango peel and kernel (mg/100g)*

Mango	Total carotene	Ascorbic acid	*Anthocyanins*
Peels	11.9 ± 0.24 [a]	76.62 ± 10.31 [a]	320 ± 10.31 [b]
kernel	1.02 ± 0.03 [b]	72.11 ± 9.55 [a]	415 ± 12.11 [a]

Values are expressed as mean ± SD. Significance at $p<0.05$

Values which don't share the same letter in each column are significantly different.

Total Anthocyanins

Anthocyanins are a group of phenolic compounds in the plant kingdom and they exhibit good antioxidant properties (Takeoka & Dao, 2002). As can be seen from Table 2, the anthocyanin content in ripe mango peel 320 ± 10.31mg/100 g in dried peels and 415± 12.11 mg/100 g in dried kernel. The amount of Anthocyanins in kernel is higher than in peel, even statistical significant has been observed between them. This results is completely agree with previous study that confirmed that the total Anthocyanins in peels ranged 203 to 326 mg/100 g in dried peels (Ajila *et al.,* 2007).

Peroxide value and acid number for frying oil

High frying temperature of oil decreases the oxidative stability and flavor quality of oil. Antioxidant decreases the frying oil oxidation, but the effectiveness of antioxidant decreases with high frying temperature Choe and Min (2007*).*The antioxidant activity of mango peel and kernel has reported in the previous part of this study. However, the information on the relationship between oil antioxidant activity and phenolic content extracted from mango peel and kernel is not available.

The data in table (3) showed that the high level of acid numbers and Peroxide value existing were (2.1 mg KOH/ g oil and 33.2 Meq/kg, respectively) for frying oil without antioxidant. Our result convergent with result of El-Noamany, (2000) who found that the general average of acid number was ranged from 1.80 and 2.18 mg KOH/g oil and peroxide value was ranged from 27.6 and 35.20 meq/kg for frying oil. While samples treatment with antioxidant (BHA) and polyphenole extract from (mango peel and kernel) shown decreased in acid numbers and peroxide value, even significant statistical was observed between them.

Table (3): Effect of polyphenole extract from mango peel and kernel on peroxide value and acid number:-

Samples	***Peroxide value (Meq/kg)***	***Acid number (mgKOH/g oil)***
Frying oil (Sunflower 75% and soybean 25%) free from antioxidant.	**33.2 [d]**	**2.1 [d]**
Frying oil (Sunflower75% and soybean 25%) fortified with (BHA). Butylated hydroxyanizole	**27.13 [c]**	**2.0 [c]**
Frying oil (Sunflower75% and soybean 25%) add 0.2% polyphenole extract from mango peels.	**19.36 [c]**	**1.7 [b]**
Frying oil (Sunflower75% and soybean 25%) add 0.5% polyphenole extract from mango peels.	**15.24 [bc]**	**1.6 [ab]**
Frying oil (Sunflower75% and soybean 25%) add 0.2% polyphenole extract from mango kernel.	**16.89 [b]**	**1.5 [a]**
Frying oil (Sunflower75% and soybean 25%) add 0.5% polyphenole extract from mango kernel.	**11.52 [a]**	**1.5 [a]**

Significance at $p<0.05$

Values which don't share the same letter in each column are significantly different.

Ethanolic extracts (0.5%) of mango kernel and peel have high antioxidant potentials were evaluated in frying oil at 180 °C for 2 hrs than frying oil with BHA in tests such as acid number and peroxide value. The result is in agreement with result of ***Rosana et al.*** ***(2011)*** revealed that an ethyl acetate fraction rich in phenolics and antioxidant activity proved to be an efficient source of natural antioxidants for use against soybean oil oxidation during frying.

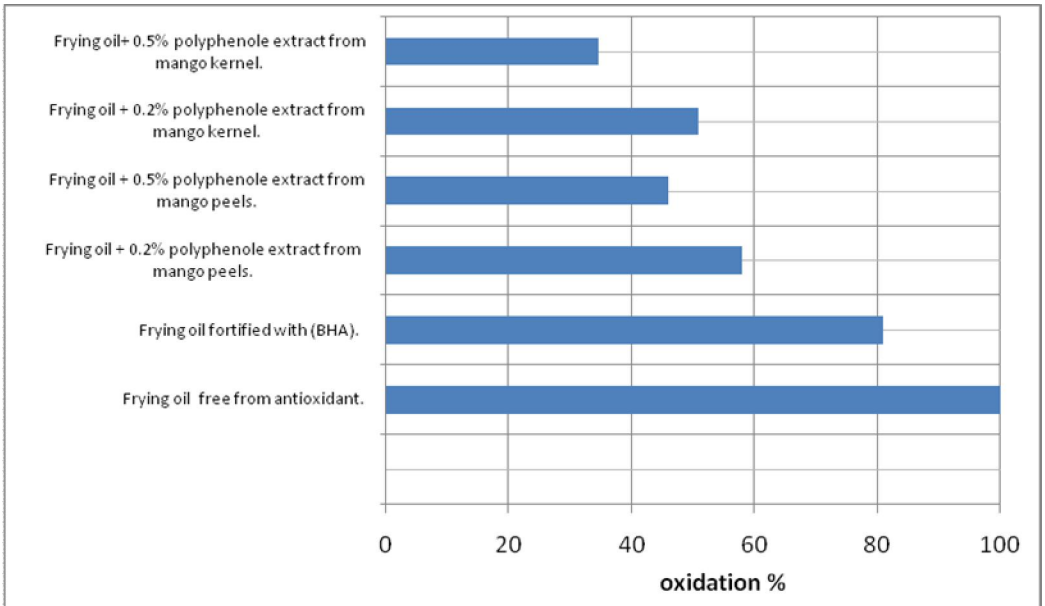

figure 1: the extent of oxidation (%) in the samples of the oil after frying for 2 hours at 180 ° C

In figure 1 the extent of oxidation changes (%) in samples of frying oil is shown. The degree of oxidation of the control samples (free from antioxidant) is regarded as 100%. The results indicated that frying oil samples fortified with ethanolic extract from mango peel and kernel were more protective than oil samples fortified with Butylated hydroxyanizole (BHA) against fatty acids oxidation. In this experiment the most effective, as antioxidant was oil fortified with 0.5% of kernel ethanolic extract followed by oil samples fortified with 0.5% of peel ethanolic extract.

Lipid profile

Groups of rat fed on treating oil with ethanolic extract from mango peel and kernel led to significant decrease in the mean value of serum cholesterol and triglyceride as compared to the control group. The best results in serum cholesterol observed for group fed on basal diet with frying oil treated with 0.5% of ethanol kernel extract, because this treatment showed non-significant differences in serum cholesterol and triglyceride as compared to the control group. The current results were completely agreed with Ikeda 2008 who reported that, polyphenols preparations significantly lowered serum and liver cholesterol concentrations. All groups fed on frying oil that treated with mango peel and kernel extract tended to have total cholesterol, triglyceride and LDL-c lower than group fed in frying oil not treated with antioxidant even lower than group fed in frying oil treated with antioxidant (BHA).

Significant difference in HDL-c, has been observed between control group and group fed on frying oil not treated with antioxidant and group fed in frying oil treated with antioxidant (BHA) (Table 4). Data showed that high-density lipoprotein of rats which fed on basal diet contains frying oil treated with 0.5% of mango kernel extract increased significantly at $p<0.05$, as compared to control group and other treated groups. In general, the four treated groups with different mango waste extracts decreased serum cholesterol, triglyceride and LDL-c and increase HDL-c in normal rats. The highest decrease in serum cholesterol, triglyceride and LDL-c recorded for groups, which fed on basal diet containing frying oil treated with 0.5% of kernel mango extract, followed by the group treated with 0.5% of peel mango extract. The results of the current study was completely agreed with other studies that reported Mango waste (peel and kernel was found to improve blood lipid profiles in animal models, as it significantly reduced plasma total cholesterol, triglycerides, and LDL-C associated with a concomitant increase in HDL-C levels and decreased in atherogenic index in rats (Muruganandan, 2005).

Table (4): Effect of frying oil and frying oil treatment with polyphenols extract from (broccoli, red beet and kiwi) on TG, CHL, LDL-c and HDL-c in rats.

Group	CHL mg/dl	TG mg/dl	LDL-C (mg/dl)	HDL-C (mg/dl)
(Control)	116.03 ^{ab} ± 17.20	68.69 ^{a} ±49.26	61.95 ^{a} ± 5.231	47.17 ^{b} ± 2.978
(FO)	177.23 ^{d} ± 26.67	122.45 ^{d} ±13.39	131.32 ^{e} ± 2.909	33.55 ^{d} ± 4.8
(FO+ BHA)	127.06 ^{c} ± 38.14	120.92 ^{d} ±10.33	126.72 ^{e} ± 25.33	39.16 ^{c} ± 3.5
(FO+ 0.2% of mango peel extract)	124.64 ± 42.18	117.10 ^{d} ± 14.13	111.18 ^{d} ± 20.320	40. 33 ^{bc} ± 2.229
(FO+ 0.5% of mango peel extract)	122.05 ^{ab} ± 25.33	87.69 ^{bc} ±1.46	100. 33 ^{c} ± 6.736	47.54 ^{b} ± 2.251
(FO+ 0.2% of mango kernel extract)	124.38 ^{bc} ±19.44	84.39 ^{bc} ±13.30	98.23 ^{c} ± 3.686	52.36 ^{ab} ± 1.722
(FO+ 0.5% of mango kernel extract)	108.34 ^{a} ± 10.73	72.12 ^{ab} ±6.12	70.06 ^{b} ± 2.26	58. 33 ^{a} ± 1.169

a, b, c = Means with the same letter are not significantly different (P> 0.05)
Each value is the mean of 3 replicates ± SD

The triglyceride lowering property of mangiferin could also indirectly contribute to the overall antihyperglycemic activity through the glucose–fatty acid cycle mechanism (Barreto *et al.,* 2008). According to Moreno *et al.* (2006), an ethanol-based mango peel extract inhibited pancreatic lipase and lipoprotein lipase in vitro, suggesting that they may affect both fat absorption and the uptake of fatty acids. The inhibition of stimulated lipolysis suggested that the cells took up the active components of the extract. In addition, the mango peel extract increased fecal fat excretion and reduced serum glucose and insulin levels and downregulated some obesity-related genes (LPL, hormone-sensitive lipase, fatty acid synthase, resistin) in liver and epididymal fat of Wistar rats.

Serum oxidation

As shown in (Table 5), SOD, GPx, MDA and XO of plasma in control group were significantly increased (P<0.05) as compared with groups which fed on frying oil treated with different concentration of peel and kernel ehanolic extracts. The plasma SOD, GPx, MDA and XO were significantly lower with group fed on basal diet containing frying oil treated with high doses of kernel extract, as compared with control group and group fed on basal diet with none treated frying oil or treated with artificial antioxidant. Groups of rats that fed on diet containing frying oil treated with kernel extract tended to have all oxidant parameters lower than rats fed on peel extract at the same concentration. It may be due the mango kernel have more antioxidant component much higher than mango peel as shown in tables 1 and 2.

Table (5): Effect of frying oil and frying oil treatment with poly phenol extracts of (mango peel and kernel) on SOD, GPx, MDA and XO activity in rats.

Group	SOD U/ml	GPx (mU/ml)	MDA Umol/l	XO uU/ml
(CG)	15.22 ^{ab} ± 2.16	3.51 ^{c} ± 0.52	10.1 ^{a} ±1.3	6.2 ^{ab} ±0.9
(FO)	19.82 ^{c} ± 4.19	4.71 ^{d} ± 0.51	14.2 ^{d} ±2.1	9.3 ^{c} ±1.2
(FO+ BHA)	20.31 ^{c} ± 8.20	4.65 ^{d} ± 0.34	12.1 ^{c} ±3.2	8.6 ^{d} ±1.4 *P>0.05*
(FO+ 0.2% of mango peel extract)	16.21 ^{ab} ± 6.81	3.82 ^{c} ± 0.53	12.1 ^{c} ±3.7	8.1 ^{d} ±1.6
(FO+ 0.5% of mango peel extract)	15.22 ^{ab} ± 3.11	3.01 ^{b} ±0.73	10.5 ^{a} ±1.3	*6.3* ^{ab} ±1.9
(FO+ 0.2% of mango kernel extract)	14.12 ^{a} ± 8.11	2.98 ^{ab} ± 0.62	11.02 ^{b} ±2.2	6.2 ^{ab} ±0.7
(FO+ 0.5% of mango kernel extract)	13.15 ^{a} ± 6.35	2.29 ^{a} ± 0.21	9.5 ^{a} ±1.3	5.7 ^{a} ±2.3

It should be noted that, with the increasing of mango peel and kernel extract the level of serum oxidation has been decreased. There was no significant difference in the plasma SOD, GPx, MDA and XO concentration in groups fed on basal diet containing frying oil treated with 0.5% of kernel extract and control group that fed on basal diet without any frying oil. Also, no significant changes in SOD and **GPx** concentration in group fed on none treated frying oil with antioxidant and group treated frying oil with **BHA** antioxidant.

Conclusions

Due to the presence of both carotenoids and polyphenols, mangos represent a rich source of antioxidants. Some of them have been shown to be of nutritional importance with respect to disease prevention. Losses during processing of mango fruits should, therefore, be minimized. The development of methods for the recovery of polyphenols from mango peels and kernls. Considering the large amounts available, mango peel and kernel waste may be a promising source not only of pectin but also of polyphenols. The latter might be used as natural antioxidants or as bioactive ingredients of functional foods.

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