World Journal of Dairy & Food Sciences 6 (1): 35-42, 2011
ISSN 1817-308X

Utilization of Mango Peels and Seed Kernels Powders as Sourcesof Phytochemicals in Biscuit

I.S. Ashoush and M.G.E. Gadallah

Department of Food Science, Faculty of Agriculture, Ain Shams University, Cairo, Egypt

Abstract: Mango peels and seed kernels are the major by-products of mango juice industry, they are rich sources of natural bioactive compounds which play an important role in prevention of diseases. In the present study, the effect of mango peels powders (MPP) at different replacing levels (5, 10, 15 and 20%) and mango kernels powders (MKP) at (20, 30, 40 and 50%) on rheological, physical, sensory and antioxidant properties of biscuits were evaluated. The results revealed that MPP had high contents of ash, crude fiber and water holding capacity while, MKP characterized by higher fat and protein than MPP. Farinograph data of wheat flour incorporated with MPP showed an increase in water absorption from 60.4 to 67.6%, while decrease in MKP. The content of phenolics increased from 3.84 to 24.37 mg/g of biscuit incorporated with deferent levels of MPP and MKP. The biscuits incorporated with MPP and MKP exhibited an improvement in their antioxidant properties. Acceptable biscuits with mango flavor were obtained by incorporating up to 10% MPP and with MKP up to 40%. Thus, the results indicated that by incorporating mango peels and kernels powders, it is possible to enhance the nutritional quality and improved antioxidant properties of biscuits.

Key words: Mango peels * Mango seed kernels * Biscuits * Antioxidant activity * Phenolic content * Physicochemical analysis

INTRODUCTION

Mango (*Mangifera indica* L.), which belongs to the family Anacardiaceae, is one of the most cultivated fruit in the world. Several million tons of mango wastes are produced annually from factories. Because mango is a seasonal fruit, about 20% of fruits are processed for products such as puree, nectar, leather, pickles and canned slices, among others, which have worldwide popularity [1]. There are several varieties grown in Egypt, the better known cultivars are alphonso, pairi, zebda, mabroka, balady and succary [2]. The world production of mango fruits more than 35 million tons while, in Egypt, 450 thousand tons of mango fruits were produced in 2009 [3].

During processing of mango, peel is a major by-product. Peel contributes about 15-20% of the fruit [4]. 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 fibre and vitamin C and it also exhibited good antioxidant properties [5-8]. A preliminary study showed that the seed represents from 20% to 60% of the whole fruit weight, depending on the mango variety and the kernel inside the seed which represents from 45% to 75% of the whole seed [9]. Soong *et al.* [10] indicated that mango seed kernel has potent antioxidant activity with relatively high phenolic contents. They referred that mango seed kernel was also shown to be a good source of phytosterols as campesterol, bsitosterol, stigmasterol and also contain tocopherols. Abdalla *et al.* [11] characterized the phenolic compounds in Egyptian mango seed kernels. The components included tannins, gallic acid, coumarin, ellagic acid, vanillin, mangiferin, ferulic acid, cinammic acid and unknown compounds. Schiber *et al.* [12] and Nunez-Selles [13] referred that the antioxidant effect of the mango seed kernel was due to its high content of polyphenols, sesquiterpenoids, phytosterols and microelements like selenium, copper and zinc.

Biscuits are the most popularly consumed bakery items in the world. Some of the reasons for such wide popularity are their ready to eat nature, affordable cost, good nutritional quality, availability in different tastes and longer shelf life [14]. Hassan *et al.* [15] reported that the physicochemical properties of the mango peel fiber

Corresponding Author: I.S. Ashoush, Department of Food Science, Faculty of Agriculture, Ain Shams University, Cairo, Egypt

rich powder make it a suitable by-product to be used in the preparation of a low calorie and high fiber food products, such as bakery products.

The objective of present study was to evaluate the effect of mango by-products, which is found to be rich in phytochemicals, on the physical, chemical, rheological and sensory characteristics of biscuits. Total phenolic content and antioxidant activity in mango peels and seed kernels as well as in prepared biscuits were also determined.

MATERIALS AND METHODS

Materials: Ripe mango seeds and peels as by-products (waste) were collected after mango pulp processing from zebda variety during the summer season of 2010 from Al-Qahera Company for Agriculture Industry, Al-Obor, Egypt. Commercial soft wheat flour (72% extraction), bakery fat, powdered sugar and skimmed milk powder were purchased from the local market. Food grade dextrose, sodium chloride, sodium bicarbonate and ammonium bicarbonate were used in biscuit processing. Sodium carbonate and methanol were obtained from El-Gomhoreya Co., Cairo, Egypt.1,1-diphenyl-2-picrylhydrazyl radical (DPPH) and Folin-Ciocalteus phenol reagent was purchased from Sigma–Aldrich Inc. (St Louis, MO, USA).

Preparation of Mango Peel and Kernel Powders: Mango peels were washed with tap water to remove any dirt particles. The peels were spread thin in trays and dried at 50°C using a cross flow drier for 18 h to a moisture content around 10%. The dried peels were powdered using a hammer mill and sieved through a 150 mm sieve. The mango seeds were washed, air dried and the kernels were removed manually from seeds. The kernels were chopped and dried at 50°C [16]. The dried material was ground in a hammer mill into a powdery form.

Samples Extraction: The extracts of mango peels powders (MPP), mango kernels powders (MKP) and biscuit samples were obtained as described by Bloor [17]. Half gram from each of MPP, MKP and biscuit samples was extracted with 20 ml of methanol: water (60:40 v/v). The mixture was centrifuged and the supernatant was adjusted to 25 ml. An aliquot of these extracts were used for the quantification of total phenolic and antioxidant activity.

Proximate Analysis of MPP and MKP: MPP and MKP were analyzed for their moisture content, ash, crude fiber, protein and fat, according to the methods described in AOAC [18]. Nitrogen content was estimated by micro-Kjeldahl method and converted to protein by using the factor 6.25. For water (WHC) and oil (OHC) holding capacity determinations, Twenty-five milliliters of distilled water or commercial corn oil were added to 0.5 gm of MPP or MKP, shacked vigorously for 1 min and then centrifuged for 15 min at 10,000g. The residue was weighed and the WHC and OHC were calculated as g water or oil per g of dry sample, respectively [19].

Determination of Total Phenolic Content: Total phenolic content of the extracts was determined colorimetrically, using the Folin-Ciocalteu method, as described by Singleton *et al.* [20]. Aliquots of 0.5 ml of the extract were added to 0.5 ml of Folin-Ciocalteu reagent, followed by addition of 0.5 ml of an aqueous 7.5% solution of sodium carbonate. The mixture was stirred and allowed to stand for 30 min. The absorbance at 765 nm was measured using a model UV/VIS 1201 spectrophotometer (Shimadzu, Kyoto, Japan). A blank sample consisting of water and reagents was used as a reference. The results were expressed as milligrams of gallic acid equivalents per gram powder (mg GAE/g powder) by reference to the gallic acid calibration curve using the following equation:

$$Y = 0.0158 + 0.0917\,X \quad r^2=0.99$$

Measurement of Antioxidant Activity (DPPH Free Radical Scavenge): The ability of the extracts to scavenge $DPPH^{\cdot}$ free radical was determined by the method described by Blois [21]. Aliquots (200 µl) of each of mango peel powder (MPP), mango kernel powder (MKP) and biscuit sample extracts were mixed with 1.0 ml of 0.1 mM $DPPH^{\cdot}$ in methanol. The control samples contained all the reagents except the extract. The reaction mixture was shaken well and allowed to react for 20 min at room temperature. The remaining $DPPH^{\cdot}$ free radical was determined by absorbance measurement at 517 nm against methanol blanks. The percentage scavenging effect was calculated from the decreased in absorbance against control according to the following equation:

$$\text{Scavenging activity \%} = [(Abs_{control} - Abs_{sample})/Abs_{control}] \times 100$$

Rheological Parameters: Farinograph test was carried out to determine the effect of substituting wheat flour with selected levels of mango peel and kernel powders on dough rheology using a farinograph (type 810107, Brabender OHG, Duisburg, Germany) according to the standard AACC [22] method. Parameters measured were water absorption, arrival time, development time, dough stability, mixing tolerance index and degree of softening.

Biscuit Processing: Biscuits samples were processed from doughs containing 5, 10, 15 and 20% MPP or 20, 30, 40 and 50% MKP as substituting levels for wheat flour according to the method described by Leelavathi and Haridas Rao [23]. The formula used was as follows: 200 g wheat flour, 60 g sugar, 50 g shortening, 2 g sodium chloride, 0.8 g sodium bicarbonate, 3 g ammonium bicarbonate, 4 g dextrose, 4 g skimmed milk powder and 40 - 42 ml water. The ground powder sugar and fat were creamed in a Hobart mixer (N-50) with a flat beater for 3 min at 61 rpm (speed 1). Sodium bicarbonate, sodium chloride and ammonium bicarbonate were dissolved in water and added. Skimmed milk powder was made into suspension with water and transferred to the cream. The contents were mixed for 6 min at 125 rpm (speed 2) to obtain a homogenized and creamy texture. Sieved flour was added to the cream and mixed for 2 min at 61 rpm (speed 1). The dough pieces were sheeted to a thickness of 3.5 mm, cut using a circular mould (51 mm diameter) and baked at 205°C for 8-9 min. After baking, biscuits were left to cool at room temperature and were wrapped tightly with polypropylene pouches and kept until further analysis.

Evaluation of Biscuits:

Physical Measurements: Diameter (W) of biscuits was measured by laying six biscuits edge-to-edge with the help of a scale. The same set of biscuits was rotated 90° and the diameter was remeasured. Average values were reported in millimeter. Thickness (T) of biscuits was measured by stacking six biscuits on top of one another and taking the average in millimeter. The spread ratio was calculated by dividing diameter (W) by thickness (T).

Moisture Content: Moisture content in biscuit powders was determined according to the method described in AOAC [18].

Color Measurements: Color of biscuit surface samples was determined according to the tristimulus color system described by Francis [24] using spectrophotometer (MOM, 100D, Hungary). Color coordinates X, Y & Z were converted to corresponding Hunter L^*, a^* & b^* color coordinates according to formula given by manufacturer. The chroma (C) represents color saturation or purity was calculated from $C = (a^2+b^2)^{1/2}$ and total color intensity $(a^2+b^2+L^2)^{1/2}$.

Sensory Evaluation: Biscuits incorporated with mango peel and kernel powders were coded with different numbers and submitted to sensory evaluation by ten member trained panels of food science department staff. The panelists were asked to rate each sensory attribute using the control biscuits as the basic for evaluation. Biscuits were evaluated for surface color, surface appearance, texture, taste/flavor, interior color and overall quality on a 9-point hedonic scale [25].

Statistical Analysis: All data were expressed as mean values ± SD. Statistical analysis was performed using one way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with $p \leq 0.05$ being considered statistically significant [26] Statistical analysis was conducted with SAS program [27].

RESULTS AND DISCUSSION

Characteristics of MPP and MKP: The results of proximate analysis, WHC, OHC, total phenolics and scavenging activity of mango peels powders (MPP) and mango kernels powders (MKP) are presented in Table 1. The most important difference between MPP and MKP was the higher in the moisture, protein and fat contents in MKP incomparable with MPP, while a significant lower in ash and crude fiber occurring in MKP. Water holding capacity of MPP was higher than that of MKP being 5.08 and 2.08 g water/g, respectively, indicating that the higher fiber content in MPP hold more water compared to MKP. This observation is agreed with those reported by Ajila *et al.* [5], Abdalla *et al.* [11], Ajila *et al.* [28] and Arogba [29].

MKP characterized by significantly higher amount of phenolics and greater free radical scavenging activity compared to MPP beaning 23.90 and 19.06 mg/g, 95.08 and 93.89%, respectively. It means that the higher phenolic content and more scavenging activity. These findings are in harmony with those obtained by Ribeiro *et al.* [30].

Table 1: Proximate composition (g/100g dry sample), WHC, OHC, total phenolic and scavenging activity of MPP and MKP

Characteristics	MPP	MKP
Moisture (%)	4.92 ± 0.32[b]	6.57 ± 0.31[a]
Ash (%)	3.88 ± 0.59[a]	1.46 ± 0.06[b]
Fat (%)	1.23 ± 0.10[b]	8.15 ± 0.06[a]
Protein (%)	3.6 ± 0.15[b]	7.76 ± 0.30[a]
Crude fiber (%)	9.33 ± 0.61[a]	0.26 ± 0.07[b]
WHC (g H_2O/g)	5.08 ± 0.60[a]	2.08 ± 0.12[b]
OHC (g oil/g)	2.02 ± 0.18[a]	1.74 ± 0.10[a]
Total phenolics (mg GAE/g)	19.06 ± 0.30[b]	23.90 ± 0.33[a]
Scavenging activity (%)	93.89 ± 0.20[b]	95.08 ± 0.10[a]

Data are the mean ± SD, n = 3, Mean values in the same raw bearing the same superscript do not differ significantly ($p \leq 0.05$)

Table 2: Effect of MPP and MKP on farinograph parameters of biscuit dough

Treatments		WA* (%)	AT (min)	DDT (min)	DS (min)	MTI (BU)	D of S (BU)
Control		60.4	1.5	2.5	3.5	70	90
MPP (%)	5	64.3	1.5	3.0	6.0	35	60
	10	67.6	1.5	11.0	21.5	20	80
MKP (%)	20	58.7	1.0	1.5	2.0	100	135
	30	57.8	1.0	1.0	1.5	110	140

WA: water absorption, AT: arrival time, DDT: dough development time, DS: dough stability, MTI: mixing tolerance index, D of S: degree of softening, BU: Brabender unit, * Expressed on 14 % moisture basis, Average of two values

Effect of MPP and MKP on Rheological Parameters: Farinograph parameters were determined for wheat flour and wheat flour substituted with 5, 10% of MPP and 20, 30% of MKP and the results are presented in Table 2. Incorporating of MPP in dough increased the water absorption from 60.4% for control to 67.6% for dough contained 10% MPP. This increment may be due to the high content of dietary fiber in mango peel which substantiated by the chemical composition of MPP (Table 1). Sudhakar and Maini [31] reported that mango peel is rich in pectin which is a soluble dietary fiber and it had water holding capacity more than cellulose. The increase in water absorption in MPP incorporated wheat flour is mainly due to the interaction between water and hydroxyl groups of polysaccharides through hydrogen bonding [32, 33, 34]. The dough development time and dough stability increased from 2.5 to 11.0 min and from 3.5 to 21.5 min, respectively with 10% incorporation of MPP, this may be due to high content of dietary fibers especially pectin which act as a food hydrocolloid in MPP, while the dough development time and dough stability decreased when using MKP due to their high content of lipids.

Physical Measurements of Biscuits: The effect of replacing 5, 10, 15 and 20% of wheat flour with MPP and replacing 20, 30, 40 and 50% of wheat flour with MKP on physical properties of biscuits was studied and the data are presented in Table 3. The results showed that all selected MPP and MKP treatments caused significant increase in biscuit diameter as compared with 50.33 mm for control except 20% of MPP. The highest diameter (55.83 mm) was found by MKP at 30% without significant difference with 20 and 30% MKP. Incorporation of 20% MPP in biscuit given less diameter value (50.16 mm) without significant difference with control. It was also clear that using MPP up to 15% and MKP at all levels in biscuit preparations resulted in significant increase in thickness when compared with 8.16 mm for control. The higher thickness (9.67 mm) was recorded by MPP at 10% and MKP at 20%. The decrease in diameter and thickness of biscuits with addition of 20% MPP may be due to dilution of gluten. This observation is agreement with those obtained by Ajila *et al.* [35].

Concerning to spread ratio, it was observed that replacing of 50% wheat flour by MKP recorded the highest value 6.41 followed by 6.27 for MPP at 20% which had no significant difference with control. Results also showed that no significant difference was found in spread ratio between biscuit containing 15% MPP and biscuit containing 30 and 40% MKP.

Color of Biscuits: All treatments with MPP and MKP significantly affected the lightness (L^*), redness (a^*), yellowness (b^*), chroma and total intensity of biscuit surface color (Table 4). The L^* value decreased with

Table 3: Influence of MPP and MKP on the physical measurements of biscuits

Treatments		Diameter W (mm)	Thickness T (mm)	Spread ratio W/T
Control		50.33 ± 1.24^{d}	8.16 ± 0.01^{f}	6.18 ± 0.15^{b}
MPP (%)				
	5	53.25 ± 1.48^{b}	9.17 ± 0.02^{c}	5.81 ± 0.16^{d}
	10	53.25 ± 1.48^{b}	9.67 ± 0.13^{a}	5.51 ± 0.14^{f}
	15	51.67 ± 0.65^{c}	8.66 ± 0.11^{d}	5.97 ± 0.11^{c}
	20	50.16 ± 0.72^{d}	8.00 ± 0.13^{g}	6.27 ± 0.16^{b}
MKP (%)				
	20	54.83 ± 1.33^{a}	9.67 ± 0.02^{a}	5.67 ± 0.14^{e}
	30	55.83 ± 1.26^{a}	9.33 ± 0.09^{b}	6.09 ± 0.16^{c}
	40	55.58 ± 1.16^{a}	9.17 ± 0.03^{c}	6.06 ± 0.12^{c}
	50	53.33 ± 1.30^{b}	8.33 ± 0.18^{e}	6.41 ± 0.23^{a}

Data are the mean ± SD, n = 3, Mean values in the same column bearing the same superscript do not differ significantly ($p \leq 0.05$)

Table 4: Influence of MPP and MKP with different levels on the color of biscuits

Treatment		L^*	a^*	b^*	Chroma	Total Intensity
Control		62.48 ± 1.90^{a}	8.97 ± 0.93^{a}	31.64 ± 0.39^{bc}	32.90 ± 0.43^{a}	70.62 ± 1.70^{a}
MPP (%)						
	5	59.22 ± 1.07^{b}	3.89 ± 1.44^{c}	32.76 ± 0.69^{ab}	32.99 ± 0.78^{a}	67.80 ± 0.91^{b}
	10	54.54 ± 1.36^{c}	4.75 ± 1.07^{c}	33.69 ± 2.20^{a}	34.04 ± 2.17^{a}	64.30 ± 1.86^{c}
	15	51.22 ± 0.27^{d}	2.44 ± 0.31^{d}	32.40 ± 0.51^{abc}	32.49 ± 0.50^{ab}	60.66 ± 0.39^{d}
	20	49.36 ± 1.01^{e}	3.41 ± 1.30^{cd}	31.17 ± 0.84^{c}	31.37 ± 0.73^{b}	58.49 ± 1.17^{e}
MKP (%)						
	20	55.12 ± 1.58^{c}	6.96 ± 1.32^{b}	25.86 ± 0.54^{d}	26.80 ± 0.84^{c}	61.15 ± 0.60^{d}
	30	54.95 ± 0.95^{c}	6.41 ± 1.28^{b}	24.43 ± 2.63^{de}	25.30 ± 2.39^{cd}	60.68 ± 2.06^{d}
	40	52.61 ± 1.03^{d}	7.23 ± 0.92^{b}	24.24 ± 0.68^{e}	25.31 ± 0.76^{cd}	58.38 ± 0.69^{e}
	50	51.89 ± 1.52^{d}	7.09 ± 0.99^{b}	23.22 ± 0.44^{e}	24.29 ± 0.67^{d}	57.30 ± 1.19^{e}

Data are the mean ± SD, n = 6, Mean values in the same column bearing the same superscript do not differ significantly ($p \leq 0.05$). L*, lightness, a*, redness, b*, yellowness

Table 5: Sensory attributes of biscuits incorporated with MPP and MKP

Treatments		Surface color (9)	Surface appearance (9)	Interior color (9)	Texture (9)	Taste/ flavor (9)	Overall quality (9)
Control		8.9 ± 0.32^{a}	8.9 ± 0.32^{a}	8.7 ± 0.48^{a}	8.7 ± 0.48^{a}	8.9 ± 0.32^{a}	8.7 ± 0.48^{a}
MPP (%)							
	5	8.3 ± 0.67^{ab}	8.0 ± 0.67^{b}	8.2 ± 0.63^{ab}	8.1 ± 0.74^{a}	8.4 ± 0.52^{a}	8.2 ± 0.63^{ab}
	10	7.1 ± 0.99^{cd}	7.3 ± 1.42^{bc}	7.0 ± 1.49^{cde}	6.8 ± 1.69^{cd}	7.0 ± 1.41^{c}	7.0 ± 1.41^{c}
	15	6.0 ± 1.15^{ef}	6.4 ± 1.07^{d}	5.9 ± 1.52^{ef}	5.8 ± 1.40^{de}	5.8 ± 1.32^{d}	6.0 ± 1.49^{de}
	20	5.6 ± 0.97^{f}	5.8 ± 0.92^{d}	5.2 ± 1.23^{f}	5.3 ± 1.16^{e}	5.3 ± 1.16^{d}	5.4 ± 1.17^{e}
MKP (%)							
	20	7.5 ± 0.85^{bc}	7.6 ± 0.52^{bc}	7.4 ± 1.07^{bc}	8.0 ± 1.05^{ab}	8.0 ± 0.94^{ab}	7.7 ± 1.12^{abc}
	30	6.8 ± 1.03^{cde}	7.4 ± 0.97^{bc}	7.2 ± 1.03^{bcd}	7.0 ± 1.05^{bc}	7.1 ± 1.20^{bc}	7.3 ± 1.01^{bc}
	40	6.6 ± 1.07^{de}	6.7 ± 1.06^{cd}	6.6 ± 1.26^{cde}	6.3 ± 1.06^{cde}	6.8 ± 0.92^{c}	6.8 ± 1.03^{cd}
	50	5.7 ± 0.82^{f}	5.9 ± 0.99^{d}	6.1 ± 1.29^{def}	5.3 ± 1.36^{e}	5.4 ± 0.84^{d}	5.5 ± 1.18^{e}

Data are the mean ± SD, n = 10, Mean values in the same column bearing the same superscript do not differ significantly ($p \leq 0.05$)

the increase in the levels of MPP and MKP. Control biscuit had the highest brightness compared to MPP and MKP enriched biscuits. No specific trend was seen in the change in a^*value upon addition of MPP and MKP. The change in b^* value, which indicates the yellowness, gradually decreased with the increase in MPP and MKP level. These finding may be due to that mango peels and kernels contain polyphenol oxidase and peroxidase activities and they are rich in polyphenols, which are substrates for these enzymes [36]. Therefore, due to the enzymatic browning, brightness and yellowness of the biscuits may be decreased as reported by Ajila *et al.* [35].

Sensory Evaluation of Biscuits: Sensory evaluation studies showed that the surface color and appearance of biscuits containing up to 10% of MPP and up to 40% of MKP were as acceptable as those of control biscuits (Table 5). It was noticed that incorporation of 20% MPP in biscuits caused relatively dark color, the increase in darkness was reflected on L^* values (Table 4) which may

Table 6: Moisture content, total phenolics and antioxidant activity in biscuits enriched with different levels of MPP and MKP

Treatments	Moisture content %	Total phenolic (mg GAE/g)	Scavenging activity %
Control	4.98 ± 0.43^{c}	1.59 ± 0.05^{i}	26.13 ± 0.05^{h}
MPP (%)			
5	5.01 ± 0.18^{c}	3.84 ± 0.563^{h}	61.74 ± 0.08^{g}
10	6.02 ± 0.41^{b}	4.67 ± 0.39^{g}	79.89 ± 0.05^{e}
15	6.73 ± 0.07^{a}	7.01 ± 0.45^{f}	85.88 ± 0.06^{c}
20	6.98 ± 0.24^{a}	9.45 ± 0.70^{e}	88.84 ± 0.31^{b}
MKP (%)			
20	3.78 ± 0.21^{d}	13.08 ± 0.18^{d}	65.77 ± 0.11^{e}
30	4.83 ± 0.39^{c}	19.98 ± 0.52^{c}	84.72 ± 0.08^{d}
40	5.88 ± 0.83^{b}	23.59 ± 0.28^{b}	88.96 ± 0.05^{b}
50	7.08 ± 0.07^{a}	24.37 ± 0.35^{a}	91.57 ± 0.11^{a}

Data are the mean ± SD, n = 3, Mean values in the same column bearing the same superscript do not differ significantly ($P \leq 0.05$)

be due to the enzymatic browning. Recently, Aziah and Komathi [37] reported that mango peel flour imparts a dark brown color to crackers; this might have given the panelists an impression of over-baked product, thus affecting their likings. Results also showed that biscuits had acceptable texture with increased levels of MPP up to 10% and MKP up to 40% as compared to the control. The high replacement levels of MPP resulted in harder biscuits and due to greater water absorption capacity. These obtained results are harmony with those of Smith [38]. The taste and flavor of biscuits were improved with incorporation of MPP and MKP as these biscuits had typical pleasant mango flavor. However, at levels of 20% of MPP and 50% of MKP the biscuits had a slight bitter taste which may be due to high polyphenols content. Also, the presence of tannins in MKP enhanced the biscuit coloration and could explain the relatively lower flavor scores compared with control. These data are in agreement with Arogba [29] and Ajila *et al*. [35].

Regarding to overall quality, it could be observed that biscuits incorporated with MPP up to 10% and with MKP up to 40% showed higher scores compared to control. The lower score values of mango peels crackers could be due to the unattractive color and the unpleasant taste. It could be concluded that biscuits with acceptable overall quality can be prepared by substituted 10% and 40% of wheat flour with MPP and MKP, respectively [37].

Bioactive Compounds in MPP and MKP Incorporated Biscuits: The moisture content in biscuits increased from 4.98 in control sample to 6.98% when MPP incorporated at 20% level (Table 6) while, lower moisture content was observed when MKP incorporated up to 40%, further increasing in moisture content was noticed to 7% in biscuits containing 50% MKP being statically equal to that of biscuit incorporated with 20% MPP. The increases in moisture content of biscuit containing MPP may be due to increased water absorption of dietary fiber present in MPP with higher percentage when compared to MKP [29, 35, 37]. The results in Table 6 showed that increasing incorporation levels of MPP and MKP gradually increased the content of phenolics contents in enriched biscuits from 3.84 to 9.45 and 13.08 to 24.37 mg GAE/g biscuit respectively. Even though there was some loss in the phenolic content during processing, there was an increase in phenolic content in biscuits by the incorporation of MPP and MKP. These findings are in agreement with those obtained by Ajila *et al.* [28] and Ajila *et al.* [35].

Also, all the level of MPP and MKP incorporated in biscuits showed an excellent ability in radical scavenging activity (61.74 - 91.57%), while it was only 26.13% in the case of the control (Table 6). Thus, the incorporation of MPP and MKP into biscuits increases health benefits by increasing antioxidant properties as reported by Ajila *et al.* [5] and Ribeiro *et al.* [30].

CONCLUSION

Based on the above results, it could be concluded that the mango peels and seed kernels powders could be used as a potential source for functional food ingredients and, in addition, it could be further processed into therapeutic functional food products.

REFERENCES

1. Loelillet, D., 1994. The European mango market: A promising tropical fruit. Fruit, 49: 332-334.
2. El-Soukkary, F.A.H., M.A. EL-Sahn and H.M.A. Mohamed, 2000. Physico-chemical and nutritional evaluation of mango seed kernel and its utilization for pan bread supplementation. Zagazig J. Agric. and Res., 27: 1319-1342.

3. FAO 2009. Annual production of mango fruits in Egypt, at the web page: http://www.fao.org/faostat/.
4. Beerh, O.P., B. Raghuramaiah, G.V. Krishnamurthy and N. Giridhar, 1976. Utilization of mango waste: recovery of juice from waste pulp and peel. J. Food Sci. and Tech., 13: 138-141.
5. Ajila, C.M., S.G. Bhat and U.J.S. Prasada Rao, 2007. Valuable components of raw and ripe peels from two Indian mango varieties. Food Chemistry, 102: 1006-1011.
6. Block, G. and L. Langseth, 1994. Antioxidant, vitamins and disease prevention. Food Technol., 48: 80-84.
7. Hertog, M.G.L., E.J.M. Feskens, P.C.H. Hallman, M.B. Katan and D. Kromhout, 1993. Dietary antioxidant flavonoids and risk of coronary heart disease: The Zutphen Elderly Study. Lancet, 342: 1007-1014.
8. Kim, H.J.Y., H. Moon, D. Kim, M. Lee, H. Cho, Y.S. Choi, A. Kim, Mosaddik and S.K. Cho, 2010. Antioxidant and antiproliferative activities of mango (*Mangifera indica* L.) flesh and peel. Food Chem., 121: 429-436.
9. Maisuthisakul, P. and M.H. Gordon, 2009. Antioxidant and tyrosinase inhibitory activity of mango seed kernel by product. Food Chemistry, 117: 332–341.
10. Soong, Y.Y., P.J. Barlow and C.O. Perera, 2004. A cocktail of phytonutrients: identification of polyphenols, phytosterols and tocopherols from mango (*Mangifera indica* L.) seed kernel. In IFT annual meeting, July 12-16, Las Vegas.
11. Abdalla, A.E.M., S.M. Darwish, E.H.E. Ayad and R.M. El-Hamahmy, 2007. Egyptian mango by-product 1. Compositional quality of mango seed kernel. Food Chemistry, 103: 1134-1140.
12. Schiber, A., N. Berardini and R. Carle, 2003. Identification of flavonol and xanthol glycosides from mango peels by HPLC. J. Agricultural and Food Chemistry, 51: 5006-5011.
13. Nunez-Selles, 2005. Antioxidant therapy: myth or reality? Journal Brazilian Chemical Society, 16(4): 699-710.
14. Gandhi, A.P., N. Kotawaliwale, J. Kawalkar, D.C. Srivastava, V.S. Parihar and P. Raghu Nadh, 2001. Effect of incorporation of defatted soy flour on the quality of sweet biscuits. J. Food Sci. and Technol., 38: 502-503.
15. Hassan, F.A.A., A. Ismail, A. Abdul Hamid, S. Azlan and H. Al-sheraji, 2011. Characterization of fiber-rich powder and antioxidant capacity of Mangifera pajang K. fruit peels. Food Chemistry, 126: 283-288.
16. Augustin, M.A. and E.T. Ling, 1987. Composition of mango seed kernel. Pertanika, 10: 53-59.
17. Bloor, S., 2001. Overview of methods for analysis and identification of flavonoids. Methods in Enzymology, 335: 3-14.
18. A.O.A.C., 1995. “Official Methods of Analysis” Association Official Analytical Chemists of the 16 th Ed. International, Washington, D.C., U.S.A.
19. Larrauri, J.A., P. Rupe´rez, B. Borroto and F. Saura-Calixto, 1996. Mango peels as a new tropical fibre: preparation and characterization. Lebensmittel-Wissenschaft und Technologie, 29: 729-733.
20. Singleton, V.L., R. Orthofer and R.M. Lamuela-Ravento´s, 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods in Enzymology, 299: 152-178.
21. Blois, M.S., 1958. Antioxidant determinations by the use of a stable free radical. Nature, 181: 1199-1200.
22. A.A.C.C., 2000. Approved Methods of the American Association of Cereal Chemists. Published by American Association of Cereal Chemists. 10th Ed. St. Paul, Minnesota, U.S.A.
23. Leelavathi, K. and P. Haridas Rao, 1993. Development of high fiber biscuits using wheat bran. J. Food Sci. and Technol., 30: 187-191.
24. Francis, F.J., 1983. Colorimetry of Foods. In: M. Peleg and E.B. Bagly. Physical Properties of Foods. pp: 105-123. The AVI Publishing Company Inc. Westport, Connecticut, USA.
25. Hooda, S. and S. Jood, 2005. Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chemistry, 90: 427-435.
26. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th Ed. Iowa State University Press, Ames, Iowa.
27. SAS, 1996. SAS/ Stat Users Guide: Statistics, System for Windows, version 4.10 (release 8.01 TS level 01M0), SAS Inst., Inc. Cary, North Carolina, USA.
28. Ajila, C.M., M. Aalami, K. Leelavathi and U.J.S. Prasada Rao, 2010. Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations. Innovative Food Science and Emerging Technologies, 11: 219-224.

29. Arogba, S.S., 1999. The performance of processed mango (*Mangifera indica*) kernel flour in a model food system. Bioresources Technol., 70: 277-281.
30. Ribeiro, S.M.R., L.C.A. Barbosa, J.H. Queiroz, M. Knödler and A. Schieber, 2008. Phenolic compounds and antioxidant capacity of Brazilian mango (*Mangifera indica* L.) varieties. Food Chemistry, 110: 620-626.
31. Sudhakar, D.V. and S.B. Maini, 2000. Isolation and characterization of mango peel pectins. Journal of Food Processing and Preservation, 24: 209-227.
32. Chaplin, M.F., 2003. Fiber and water binding, Proceedings of the Nutrition Society, 62: 223-227.
33. Dikeman, C.L. and J.G.C. Fahey, 2006. Viscosity as related to dietary fibre: a review. Critical Reviews in Food Science and Nutrition, 46: 649-663.
34. Rosell, C.M., J.A. Rojas and D.B. Benedito, 2001. Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocolloids, 15: 75-81.
35. Ajila, C.M., K. Leelavathi and U.J.S. Prasada Rao, 2008. Improvement of dietary fiber content and antioxidant properties in soft dough biscuit with the incorporation of mango peel powder. J. Cereal Sci., 48: 319-326.
36. Saby John, K., S.G. Bhat and U.J.S. Prasada Rao, 2003. Biochemical characterization of sap (latex) of a few Indian mango varieties. Phytochemistry, 62: 13-19.
37. Aziah, N.A.A. and C.A. Komathi, 2009. Acceptability attributes of crackers made from different types of composite flour. International Food Research J., 16: 479-482.
38. Smith, W.H., 1972. Hard Semi-sweet Biscuits. In: Biscuits, Crackers and Cookies: Technology, Production and Management, vol. 1. Applied Science Publishers Ltd., London, pp: 466-473.