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FORTIFICATION OF EXTRUDED SNACKS USING SOME FRUIT PEELS

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ABSTRACT: By-products from fruit processing industries became one of the main challengeable aspects in the world due to the large quantities produced annually. However, these plant by-products are rich source of valuable compounds such as dietary fiber, antioxidants, protein, carbohydrate and essential oils, *etc*. Mango peels and pumpkin peels are important sources of bioactive compounds including antioxidants and proteins. Physicochemical and phenolic compounds of mango and pumpkin peels powder were determined. Yellow corn grits was fortified with 0.60%, 0.45% and 0.30% of mango peels (MP) and pumpkin peels (PP). Likewise, the effect of fortification on physicochemical and sensory properties of extrude snack foods was studied. The results indicated that the extruded snack foods fortified with 0.60% MP had the highest bulk density and hardness (0.322 g/cm^3 and 26.3 N., respectively). While, the highest expansion ratio (2.8%) was obtained from control sample. Fortification with both mango and pumpkin peels enhanced the antioxidant activity of the final products. Sensory evaluation showed that fortification with 0.30% MP had the best sensory characteristics compared with control sample witch had the lowest sensory scores.

Key words: Mango peels, pumpkin peels, antioxidant compounds, extrude snack foods, fortification.

INTRODUCTION

Fruit and vegetable by-products such as peel, bark, seeds, leaves, *etc*., often contain more bioactive compounds and with higher antioxidant activities than those found in the edible portion. Thereby, many researches are focused on exploiting these unconventional sources for the recovery of valuable molecules **(Can-Cauich *et al*., 2017)**.

Fruits and fruit by-products are important source to get vitamins, minerals, fibers and phenolics. They have therapeutic values in terms of metabolic regulators due to the availability of bioactive components. Their regular consumption could help in the reduction of risk of various chronic diseases such as cancer, alzheimer, cataracts and cardiovascular diseases **(Kaur and Kapoor, 2001; Slavin and Lloyd, 2012)**. Recently, many studies were performed to explore the medicinal use of fruits and their peels **(Chel-Guerrero *et al*., 2018)**. Fruit peels are generally considered waste, yet they have the potential to be used as sources of cheap and readily available bioactive compounds for certain applications in the food and pharmaceutical industries **(Deng *et al*., 2012)**.

Food industry is probably one of the largest sectors from the industrial activities in Egypt. It plays a major role in the supply Egyptian population with their food needs. It was reported that 39% of food waste is produced by the food manufacturing industries in developed countries including Egypt **(Mirabella *et al*., 2014)**. The large amount of waste produced by the food industries causes serious environmental problems and also results in economic losses if not utilized effectively. Additionally, the costs to dry, store and ship food by-products are economically limiting factors. Thus, different research reports have revealed that food industry by-products can be good sources of potentially valuable bioactive compounds. Thus, different research reports have revealed that food industry by-products can

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be good sources of potentially valuable bioactive compounds **(Joshi *et al*., 2006; Van-Dyk., 2013; Jahurul *et al*., 2015)**.

The mango (*Mangifera indica L.*) is the most important member of the Anarcadiaceae family. This fruit is native to southern Asia, especially Burma and eastern India. It spread early into Malaysia, Eastern Asia, and Eastern Africa. Mango peel is a non-edible fruit part usually discarded, even though it has the higher phenolic compounds (PC) content compared to its pulp or seed. It is a rich source of water-soluble phenolic acids (PA), being gallic acid the abundant compound (commonly found as a part of gallotannins) **(Sáyago-Ayerdi *et al*., 2013; Velderrain- Rodríguez *et al*., 2015)**. Recent studies showed that among the other PC found in mango (cv. 'Ataulfo') peel, gallic acid has the highest intestinal permeability in a CaCo-2/HT29 monolayer model, and it also has the highest antiproliferative activity against LS180 human colon cancer cells, which suggest that its addition into functional food products may promote intestinal health **(Pacheco-Ordaz *et al*., 2018; Velderrain-Rodríguez *et al*., 2018)**.

Pumpkin (*Cucurbita moschata* L.) belongs to the genus *Cucurbita* and family Cucurbitaceae. Pumpkin fruit is one of the widely grown vegetables incredibly rich in vital antioxidants, and valuable source of carotenoids which have major role in the form of pro-vitamin A. Carotenoids are the primary source of vitamin A for most of people living in developing countries. Pumpkin peels do not present significant contents of carbohydrates, lipids, iron, and potassium; however, this part of the vegetable have substantial amounts of proteins and fibers, in addition to ascorbic acid and calcium, which presented relevant concentrations in comparison with the pulp, a commonly consumed part **(Staichok *et al.*, 2016)**.

Corn (*Zea mays* L.) has a wide range of kernel colours such as white, yellow, orange, purple and black. In addition to its attractive colours, pigmented corn is rich in phytochemicals and many secondary metabolites such as phenolic compounds, carotenoids and flavonoids **(Žilić *et al*., 2012)**. These constituents are regarded as an important source of antioxidants in cereals and exist in free as well as bound form **(Montilla *et al.*, 2011)**. Corn starch is used as food additives to improve health benefits **(Lim *et al*., 2013).** Moreover, corn grits is also rich in these phytochemicals and also used as food additives **(Ng and Wan Rosli, 2013)**.

Extrusion-cooking is a popular food processing technique, classified as high temperature-short time (HTST) process, applicable to the production of a wide range of food and feed products. The thermal and mechanical treatment during the extrusion-cooking may influence starch gelatinization, protein denaturation and inactivation of enzymes, anti-nutritional factors, and microbes. It is one of effective processing methods useful for the transformation of raw materials and/or by-products into nutritionally valuable foodstuffs, due to its versatility, high productivity, relatively low costs, energy efficiency and the propensity to develop functional properties (**Altan *et al*., 2008; Wojtowicz *et al*., 2015; Thakur *et al*., 2017)**. Extruded corn snacks are very popular as a source of gluten-free carbohydrates because of their specific texture and convenience of use, especially for consumers on a celiac disease diet **(Wojtowicz *et al*., 2013)**.

Snack foods are highly consumed, especially by young people. According to studies on consumer trends, more consumers are often replacing the traditional three meals a day with snacks **(Beswa *et al*., 2016)**. One of the technologies more frequently used to produce snack foods is the extrusion, which is a thermal processing that involves the application of high temperatures, high pressure, short time, and shear force on an uncooked mass, such as cereal foods **(Alam *et al*., 2016)**. Extruded snack products are mostly cereal based and developed mainly from corn, wheat, and rice **(Lourenço *et al*., 2016)**. A quality property in snack foods is the specific volume that is a physical parameter and measures the axial and radial expansion. This property basically depends on the viscous and elastic properties of the melted material and is highly influenced by temperature **(Hashimoto and Grossmann, 2003)**. The starch (especially from corn) is one of the biopolymers with greater versatility in food and industrial applications **(López-García *et al*., 2017)**, and is the main ingredient in the manufacture of snack foods.

Thus, the aim of this paper is to study the chemical composition of mango and pumpkin peels and the effect of fortification of corn snack foods with mango and pumpkin peels on its physical and sensorial properties.

MATERIALS AND METHODS

Mango and pumpkin fruits were obtained from local market in the 10th of Ramadan city, Egypt. While, yellow corn grain (corn 101) obtained from Meza Company for corn products in the 10th of Ramadan city.

Mango and pumpkin fruits were washed and peeled then the peels were dried in drying oven at 45°C for 72 hr. Dried peels were crushed in an industrial miller. The powdered samples were packed in pouches until the time of analysis.

Preparation of Snacks Product

Table 1 shows formula of extrude snack food fortified with mango peels (MP) and pumpkin peel (PP) powder. Yellow corn grits was fortified with 0.60%, 0.45% and 0.30% ether MP or PP powders. Vegetables oil (1.0%) and an amount of water (3.0%) was added in all samples.

Chemical Composition

Moisture, ash, crude protein, and crude lipids, of mango and pumpkin peels were determined according to the methods recommended by **AOAC (2005)**, while total carbohydrate content was measured by difference. All analyses were conducted in central lab for soil, Food and Feed Staff (CLSFF), Faculty of Technology and Development, Zagazig University.

Determination of Total Phenolic Content (TPC)

The concentration of total phenols was measured by spectrophotometer (Jenway-UVVIS Spectrophotometer), based on a colourimetric oxidation/reduction reaction, as described by **Skerget *et al.* (2005)**, using Folin– Ciocalteu as oxidizing reagent **(AOAS, 1990)**. 0.5 ml of diluted extract (10 mg in 10 ml solvent); 2.5 ml of Folin-Ciocalteu reagent (diluted 10 times with distilled water) and 2 ml of Na2CO3 (75 g/l) were added. The sample was incubated for 5 min at 50°C then cooled. For the control sample, 0.5 ml of distilled water was used. The absorbance was measured at 760 nm. Quantification of TPC was based on a Gallic acid standard curve generated by preparing 0, 5, 10, 15, 20, 30 mg/l. of Gallic acid. Total phenolic content was expressed as Gallic acid equivalent (GAE) and calculated using the following linear equation based on the calibration curve:

$$y = 0.0068\,x + 0.0206,\ R^2 = 0.9829$$

Where:

(y) is the absorbance and (x) is the concentration (mg GAE g^{-1} extract).

R^2=Correlation Coefficient. All determination was performed in triplicates.

DPPH Radical Scavenging Activity

The free radical scavenging activity of peel extracts was measured by the DPPH according to the method of **Hanato *et al.* (1988)**. One hundred µl of each extracts (10 mg extract/10 ml solvent) was added to 3 ml of 0.1 mM DPPH dissolved in ethyl acetate and ethanol according to the solvent used for extraction. After 30, 60 and 120 min incubation period at room temperature, the absorbance was estimated against a control at 517 nm **(Gulcin *et al.*, 2004)**. Percentage of antioxidant activity of free radical DPPH was calculated as follows:

$$\text{Antioxidant activity (inhibition \%)} = [(A\ control - A\ sample)/A\ control] \times 100$$

Where:

A control is the absorbance of the control reaction and a sample is the absorbance in the presence of plant extract.

Total Carotenoids

The photosynthetic pigments (chlorophyll a, b and carotenoids) were extracted from the dry peels powder for each treatment using pure acetone according to Fadeel's Methods **(Fadeel, 1962)**. The extract was filtered. The optical densities were measured spectrophotometrically using (spectronic -20) spectrophotometer at 662, 644 and 440.5 nm for chlorophylls a, b and caroteonids, respectively. The pigment concentrations were calculated using wettsteins formula **(Wettestein, 1957)**. The concentration of pigments was then calculated in mg/g dry peels powder as follows:

Table 1. Formulations of snack products

Formula	Yellow corn grains (%)	Vegetables oil (%)	Peels powder (%)	Water (%)
Control	96.00	1.0	0	3.0
Extrude snack with 0.60% MP	95.40	1.0	0.60	3.0
Extrude snack with 0.45 %MP	95.55	1.0	0.45	3.0
Extrude snack with 0.30% MP	95.70	1.0	0.30	3.0
Extrude snack with 0.60% PP	95.40	1.0	0.60	3.0
Extrude snack with 0.45% PP	95.55	1.0	0.45	3.0
Extrude snack with 0.30 %PP	95.70	1.0	0.30	3.0

* MP = Mango peels; PP= Pumpkin peels

Extrusion Process

An extruder (US-made model 2013) consisting of mixing unit, milling unit, thermal extruding unit, spicing unit, oven was used. Machine temperature was fixed at 140^{o}C. Production rate was 150 kg/hr. The lower the speed of the machine the less the feed rate.

Dried mango and pumpkin peels were added to yellow corn grits (101) at levels 0.30%, 0.45% and 0.60% to produce extruded snack foods. vegetables oil (1.0%) and water (3.0%) were added in all samples. After production, the product was assembled in plastic bags to maintain moisture in the product.

Physical Properties

Bulk density

The bulk density of the product was calculated using the following equation:

Snacks bulk density (g/cm^3) = Wd/Vd

Park *et al.* (1993).

Where:

Wd = Snacks sample mass (g);

Vd = Snacks sample volume (cm^3).

Expansion ratio

Expansion ratio of the product was calculated using the following relation:

Expansion ratio (%) = de/dd (**Moraru and Kokini, 2003**).

Where:

de = Piece snacks diameter;

dd = Die hole diameter.

Snacks hardness

Snacks hardness was measured by digital force gauge (Shimpo) with an accuracy of 0.1 N. **(Nabih, 2017)**.

Colour Measurement

Colour attributes of the snack foods samples (L*, a* and b*) were performed using Hunter Lab colour analyzer (Hunter Lab Colour Flex EZ, USA) according to **Singh *et al.* (2008)**. The L* value (lightness index scale) ranges from 0 (black) to 100 (white) while, a* value indicates the redness (+a) or greenness (−a*) and the b* value refers to the yellowness (+b) or blueness (−b*). Samples were placed in petri dishes and filled to the top. The petri dish was placed directly on the colourimeter sensor.

Sensory Evaluation

The sensory evaluation of extrude snack food fortified with different proportions of mango and pumpkin peel powder was performed once every month during three months by Staff members of Food Science Department, Faculty of Agriculture, Zagazig University, Egypt. The panelists were subjected to evaluate the samples of each brand for appearance, smell, taste, texture, colour and overall acceptability by using scores from 1 to 10, where (9-10) excellent, (6-8) very good, (4-5) fair and (2-3) not acceptable **(Norfezah *et al*., 2013)**.

Statistical Analysis

The results were reported as mean + standard deviation (SD) (n=3). The average contents of the extracts prepared by the different treatment were statistically investigated using one-way analysis of variance (ANOVA) with Duncan by SPSS for Windows 16.0. A statistical probability (p value) less than 0.05 indicated a statistically significant difference between groups **(Steel and Torrie, 1980)**.

RESULTS AND DISCUSSION

Chemical Composition

Chemical analyses of mango, pumpkin peels and yellow corn grits is represented in Table 2. From the results, it was stated that mango peels had contents of carbohydrate and fat (58.33 and 7.28, respectively) while, pumpkin peels had higher contents of protein (14.42%), ash (9.18%) and crude fiber (19.80%). These results are in agreement with **Ajila *et al.* (2010)** and **Martinez *et al.* (2012)**. Yellow corn grits showed relatively high content of carbohydrate (79.8%) and moisture (11.5%), while it had low content of fat (0.7%) and crude fiber (0.2%). These results are in agreement with **Ullah *et al.,*(2010)**.

Total Phenolic Content

Table 2 exhibits the total phenolic contents of mango, pumpkin peels powder and yellow corn grits expressed as mg Gallic acid/mg. extract of mango peels powder gave the highest amount of phenolic contents (44.6 mg GAE/g extract) followed by corn grits and pumpkin peels extract (31.0 and25.5 mg GAE/g extract, respectively). These results are in agreement with **De la Parra *et al.* (2007)** , **Ramamoorth *et al.* (2007)**, **Drogoudi *et al.* (2008)**, and **Karimi *et al*. (2011)**.

Content of Total Carotenoids

Caroteonid content of pumpkin peel powder was the highest (158.12 mg/g) while the lowest was observed in the yellow corn girts (95.67 mg/g) (Table 2). These results are in agreement with **Egesel *et al.* (2003) and El-Hassaneen *et al*. (2013)**.

Colour Measurements

Table 2 shows the colour measurements of mango, pumpkin peel powder and yellow corn girts. In general, mango peel powder had the highest a value binge 5.63 while, the highest L value was found in corn grits (74.37). These results are in harmony with **Dutta *et al.* (2006)**. and **Manasa *et al*. (2019)** .

DPPH Radical Scavenging Activity

The results of DPPH radical-scavenging activities of mango, pumpkin peels powder and yellow corn grits extracts are represented in Fig. 1. The antioxidant activity in mango and pumpkin peels extracts were 93.59% and 75.82%, respectively after 120 min. The highest antioxidant activity was observed with mango peel powder. The antioxidant activity in yellow corn grits extract was 91.40% after 120 min. These results are in agreement with **De la Parra *et al.* (2007) and Kim *et al*. (2010)**.

Physical Characteristics of Extrude Snack Foods

Physical characteristics of extrude snack foods fortified with mango and pumpkin peels powder are shown in Table3. Physical characteristics of extrude snack foods, such as bulk density, expansion ratio and hardness were affected by fortification with mango, pumpkin peel powder. The value of bulk density was the highest (0.322 g/cm^3) in extrude snack foods fortified with 0.60% mango peel powder. Control sample had the highest expansion ratio (2.8%) and the lowest hardness value (15.9 N) while, the snack foods fortified with 0.60% mango peels had the highest hardness value (26.3 N). These results are in agreement with **Brennan *et al.* (2008 a, b)**.

Chemical Characteristic and Colour Values of Extrude Snack Foods

Chemical characteristics of extrude snack foods fortified with mango and pumpkin peels are presented in Table 4. The moisture content value was the highest (5.87%) in extrude snack foods fortified with 0.60% mango peel, while it was less content in extrude snack foods fortified with (0.30%) mango peels powder being 5.40%. As for crude fibre is was less content in unfortified extrude snack foods being 0.20%. While was high content in extrude snack foods fortified with pumpkin peel powder (0.60% and 0.45%) being 0.95%, 0.80%, respectively.

Table 2. Physicochemical characteristics of mango, pumpkin peels powder and yellow corn grits (based on dry weight)

Component	Mango peel powder	Pumpkin peel powder	Yellow corn grits
Chemical composition (%)			
Moisture	10.30 ± 0.3[a]	13.56 ± 0.25[b]	11.5 ± 0.12[c]
Ash	3.95 ± 0.04[b]	9.18 ± 0.80[a]	0.3 ± 0.01[c]
Protein	5.92 ± 0.23[b]	14.42 ± 0.55[a]	7.5 ± 0.1[c]
Fat	7.28 ± 0.21[a]	7.09 ± 0.02[b]	0.7 ± 0.002[c]
Crude fibre	14.22 ± 1.06[b]	19.8 ± 1.50[a]	0.2 ± 0.04[c]
Total carbohydrate	58.33 ± 1.2[b]	35.95 ±0. 6[c]	79.8 ±1.8 [a]
Total phenolic content (mg/g)	44.6 ± 0.10[a]	25.5±0.001[c]	31.0 ±0.01[b]
Carotenoids (mg/g)	105.89 ± 0.14[b]	158.12±0.22[a]	95.67±0.001[c]
Colour			
L*	45.66 ± 0.04[c]	55.06 ± 0.10[b]	74.37 ± 0.2[a]
a*	5.63 ± 0.21[a]	5.12 ± 0.10[c]	5.28 ± 0.15[b]
b*	8.26 ± 0.01[c]	15.42 ± 0.05[b]	35.1 ± 0.5[a]

Each reported value is the mean± SD of three replicates. Means in the same column followed by different letters are significantly different ($p < 0.05$).

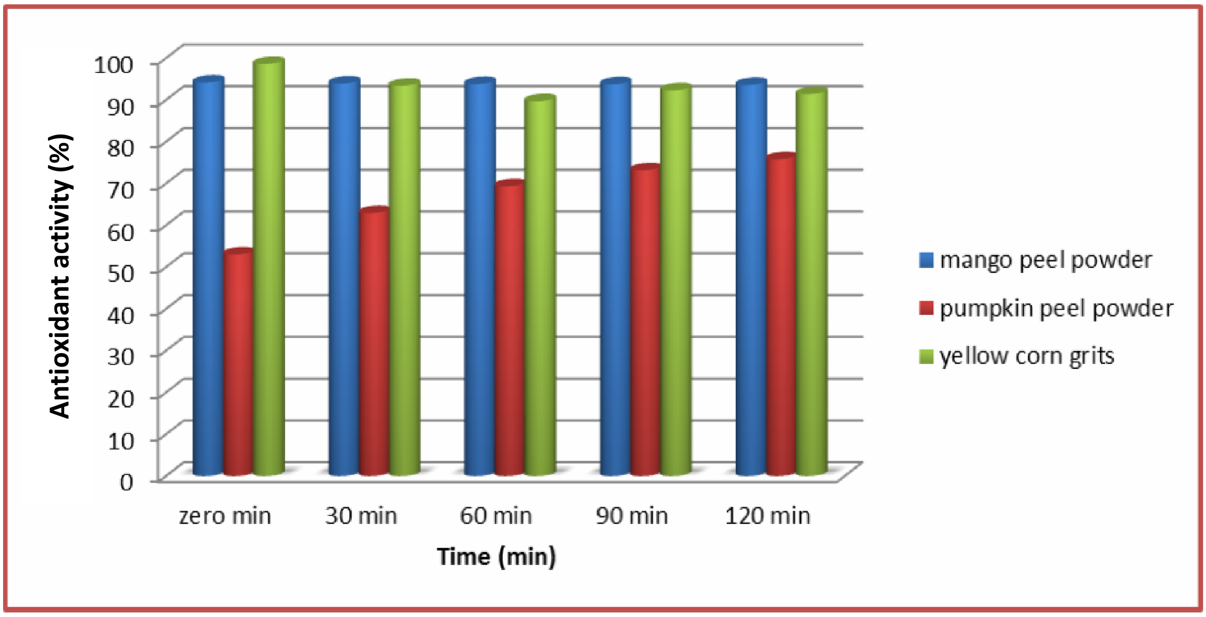

Fig. 1. The antioxidant activity of mango, pumpkin peels powder and yellow corn grits extract

Table 3. Bulk density, expansion ratio and hardness of the snacks

Product	Bulk density (g/cm^3)	Expansion ratio (%)	Hardness (N)
Control Snacks	0.280 ± 0.002^{c}	2.8 ± 0.08^{a}	15.9 ± 0.01^{d}
Snacks with 0.3% MP	0.318 ± 0.004^{b}	2.7 ± 0.07a	21.5 ± 0.06^{b}
Snacks with 0.45% MP	0.320 ± 0.005^{a}	2.5 ± 0.02^{c}	25.0 ± 0.11^{a}
Snacks with 0.6% MP	0.322 ± 0.008^{a}	2.4 ± 0.01^{b}	26.3 ± 0.21^{a}
Snacks with 0.3% PP	0.310 ± 0.004^{b}	2.7 ± 0.07^{a}	16.9 ± 0.02^{c}
Snacks with 0.45% PP	0.290 ± 0.003^{c}	2.6 ± 0.04^{b}	17.8 ± 0.03^{c}
Snacks with 0.6% PP	0.255 ± 0.001^{d}	2.4 ± 0.01^{d}	19.6 ± 0.05^{b}

MP = Mango peels; PP= Pumpkin peels, Each reported value is the mean± SD of three replicates. Means in the same column followed by different letters are significantly different ($p < 0.05$).

Table 4. Chemical characteristics and colour values of fortified extrude snack foods

Variable	Control	Snacks					
		0.60% MP	**0.45% MP**	**0.30% MP**	**0.60%PP**	**0.45%PP**	**0.30% PP**
Chemical composition							
Moisture (%)	5.86±0.14^{a}	5.87±0.14^{a}	5.43±0.13^{d}	5.40±0.13^{d}	5.82±0.13^{a}	5.67±0.14^{b}	5.55±0.13^{c}
Ash (%)	2.87±0.02^{b}	2.82±0.02^{b}	0.64±0.01^{d}	0.64±0.01^{d}	2.82±0.02^{b}	3.19±0.01^{a}	2.37±0.02^{c}
Protein (%)	7.4±0.30^{d}	7.78±0.29^{a}	7.72±0.30^{b}	7.67±0.28^{c}	7.95±0.30^{a}	7.88±0.29^{a}	7.62±0.30^{c}
Fat (%)	1.77±0.08^{a}	0.82±0.04^{d}	1.50±0.06^{a}	1.34±0.07^{b}	1.49±0.06^{b}	1.25±0.06^{c}	1.20±0.07^{c}
Crude fibre (%)	0.2 ±0.03^{d}	0.59±0.03^{a}	0.39±0.04^{c}	0.36±0.03^{c}	0.95±0.07^{a}	0.80±0.03^{a}	0.45±0.06^{b}
Carbohydrate (%)	81.9±0.43^{c}	82.12 ±0.48^{b}	84.32 ±0.46^{a}	84.59 ± 0.48^{a}	80.97±0.42^{d}	81.21±0.2^{d}	82.81± 0.42^{b}
Total phenolic content (mg/g)	25.3±0.01^{c}	42.7±0.16^{a}	35.2±0.11^{a}	29.4±0.08^{b}	20.2±0.001^{c}	17.9±0.002^{d}	14.9±0.004^{d}
Carotenoids (mg/l)	165.43±0.0^{d}	188.56±1.43^{a}	179.34±1.04^{a}	167.90±0.13^{c}	189.12±1.8^{a}	176.54±0.24^{b}	166.31±0.09^{d}
Colour value							
L*	59.4±0.001^{d}	79.02± 0.9^{a}	75.14±0. 7^{a}	70.8±0.003^{c}	76.8±0.3^{a}	72.3±0.05^{b}	67.9±0.002^{d}
a*	0.82±0.001^{d}	1.3±0.23^{c}	2.51±0.6^{a}	1.9±0.44^{b}	1.03±0.04^{d}	1.6±0.35^{b}	1.28±0.12^{c}
b*	24.1±0.5^{d}	29.43±1.3^{b}	36.1±1.76^{a}	30.8±1.45^{a}	27.9±0.89^{c}	27.7±0.87^{c}	27.7±0.87^{c}

MP = Mango peels; PP= Pumpkin peels, Each reported value is the mean± SD of three replicates. Means in the same column followed by different letters are significantly different ($p < 0.05$).

Extract of extrude snack foods fortified with (0.60%) mango peel gave the highest amount of phenolic contents (42.7 mg GAE/g extract) while, the lowest content was obtained from the snack foods fortified with (0.30%) pumpkin peel (14.9 mg GAE/g extract).

Carotenoids composition of the fortified extrude snack foods are shown in Table 4. Total carotenoids content was the highest in extrude snack foods fortified with 0.60% pumpkin peel (189.12 mg/l) while the lowest content was observed in control sample (165.43 mg/l).

Lightness (L value) was decreased from 59.4 in unfortified extrude snack foods (control) to 79.02 in extrude snack foods fortified with 0.60% mango peel. Redness (a value) was increased to 2.51 in extrude snack foods fortified with 0.45% mango peel powder as compared to that observed in unfortified extrude snack foods (0.82). On the other hand, the yellowness (b value) was increased from 24.1 in unfortified extrude snack foods to 36.1 in extrude snack foods fortified with 0.45% mango peel powder (Table 4). These results agree with **Altan *et al*. (2008) and Que *et al*. (2008)**.

Antioxidant Activity of Extruded Snack Foods

The results of DPPH radical-scavenging activities of extruded snack foods fortified with mango peels and pumpkin peels powder are represented in Fig. 2. The antioxidant activity in extrude snack foods fortified with 0.60% mango peel powder extract was the highest being 98% after 120 min, while it was the lowest in control sample extract (82% after 120 min.). A gradual increase in antioxidant activity was noticed as the percent of both mango and pumpkin peels fortification increased.

Sensory Evaluation of Fortified Extrude Snack Foods

The effect of mango and pumpkin peels fortification on sensory characteristics (appearance, colour, smell, taste, texture and overall acceptability) of extrude snack foods is shown in Table 5. All examined sensory characteristics of control sample and extrude snack foods fortified with 0.30% mango peels powder were superior (significantly different $p < 0.05$) to extrude snack foods fortified with 0.60% and 0.45% mango and pumpkin peels powder. Extrude snack foods fortified with 0.30% mango peel had the highest scores of appearance, colour, smell, taste, texture and overall acceptability being 9.8, 9.3, 9.7, 8.5, 8.5, 9.2, respectively. Control samples had the least score of sensory evaluation. The result of sensory evaluation indicated that 0.30% mango peel powder can be successfully used in fortification of extrude snack foods.

Conclusion

From obtained results, it could be concluded that 0.30% - 0.60% mango peels powder can be successfully used in fortification of extrude snack foods corn grits.

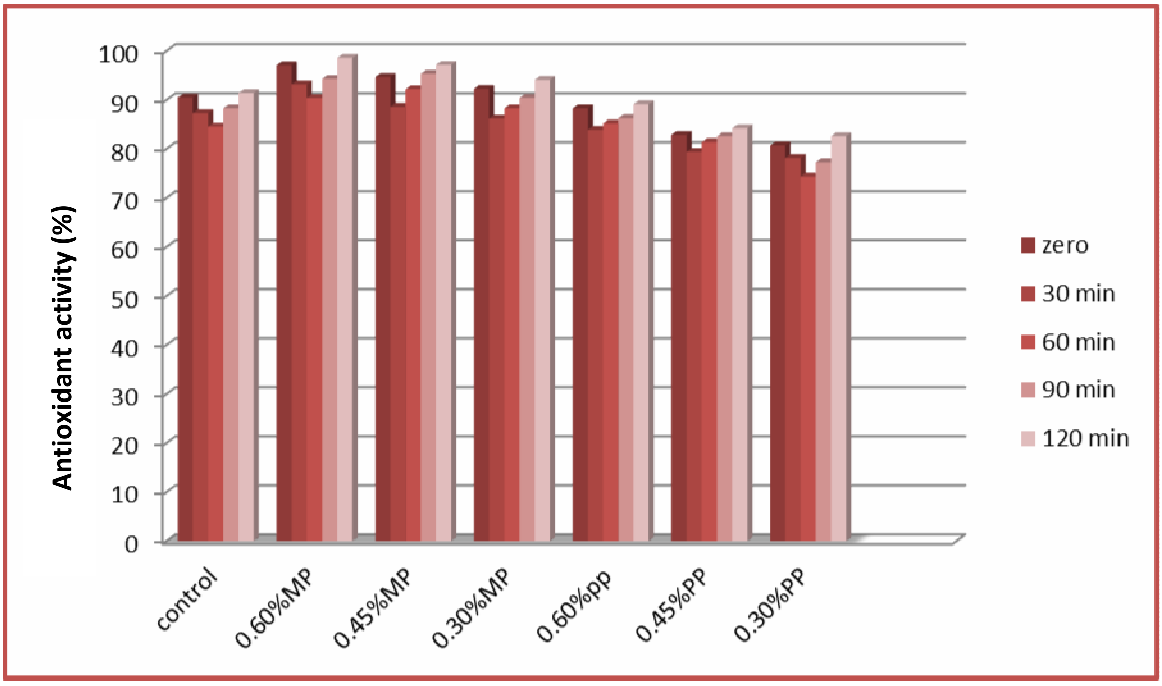

Fig. 2. Antioxidant activity of extruded snack foods fortified with mango peels (MP) and pumpkin peels (PP)

Table 5. Sensory evaluation of extrude fortified snack foods

Product	Appearance	Colour	Smell	Taste	Texture	Overall acceptability
Snacks with 0.60% MP	9.5^{a}	8.6^{b}	8.9^{b}	8.5^{b}	8.4^{c}	8.8^{b}
Snacks with 0.45% MP	9.2^{a}	8.9^{b}	8.5^{b}	8.2^{c}	8.2^{c}	8.6^{b}
Snacks with 0.30% MP	9.8^{a}	9.3^{a}	9.7^{a}	8.5^{b}	8.5^{b}	9.2^{a}
Control	7.5^{d}	7.5^{d}	8.1^{c}	7.5^{d}	8^{c}	7.7^{d}
Snacks with 0.60% PP	9^{a}	8.6^{b}	8^{c}	8.6^{b}	8.1^{c}	8.5^{b}
Snacks with 0.45% PP	9.4^{a}	9.1^{a}	8^{c}	7.7^{d}	8.2^{c}	8.4^{c}
Snacks with 0.30% PP	9.5^{a}	8.7^{b}	8.3^{c}	8.3^{c}	8.4^{c}	8.6^{b}

MP = Mango peels; PP= Pumpkin peels, Each reported value is the mean$\pm$ SD of three replicates. Means in the same column followed by different letters are significantly different ($p< 0.05$).

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تدعيم منتجات السناكس المبثوقة باستخدام قشور بعض ثمار الفاكهة

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أصبحت المنتجات الثانوية من صناعات تجهيز الفاكهة احد الجوانب الرئيسية للتحدى فى العالم بسبب الكميات الكبيرة المنتجة سنويا، ومع ذلك، تعتبر هذه المنتجات الثانوية مصدرا غنيا للمركبات القيمة مثل الألياف الغذائية ومضادات الأكسدة والبروتين والكربوهيدرات والمضافات الغذائية والزيوت الاساسية الخ، كما أن قشور المانجو وقشور القرع العسلى من أهم المصادر للمركبات النشطة بيولوجيا بما فى ذلك مضادات الأكسدة والبروتينات، فى هذا البحث تم تقدير المركبات الفيزيائية والكيميائية والفينولية لمسحوق قشور المانجو ومسحوق قشور القرع العسلى، كما تم تدعيم الذرة الصفراء المجروشة بنسبة (٠,٦٠%، ٠,٤٥%، ٠,٣٠%) من مسحوق قشور المانجو وبالمثل مسحوق قشور القرع العسلى، وتمت دراسة تأثير التدعيم على الخواص الفيزيائية والكيميائية لمنتج السناكس المبثوق، وأشارت النتائج إلى أن منتج السناكس المبثوق المدعم بنسبة ٠,٦٠% من مسحوق قشور المانجو لديه أعلى كثافة وصلابة (٠,٣٢٢ جم/سم^{٣} و ٢٦,٣ نيوتن، على التوالى)، بينما تم الحصول على أعلى نسبة تمدد (٢,٨%) فى العينة الضابطة، وعزز التدعيم باستخدام مسحوق قشور المانجو ومسحوق قشور القرع العسلى من نشاط مضادات الاكسدة فى المنتجات النهائية، وأظهر التقييم الحسى ان التدعيم بنسبة ٠,٣٠% من مسحوق قشور المانجو لديه أفضل الخصائص الحسية مقارنة مع عينة الضابطة التى لديها اقل الدرجات الحسية.

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