Utilization of Some Citrus Peels in Formulating Functional Cookies and Pasta

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ABSTRACT

Orange peels (OP), mandarin peels (MP) and lemon peels (LP) were analyzed and utilized in preparing functional cookies and pasta. The gross chemical composition revealed the following ranges: Moisture: 70.05-77.82%, crude protein: 4.44-9.91%, crude fat:8.64-12.79%, ash: 10.37-15.13% and carbohydrates: 62.17-76.51%. Moreover, total sugars ranged from 30.70 to 33.35%, crude fibers: 5.48-8.73%, neutral detergent fibers "NDF": 12.43-21.83%, acid detergent fibers "ADF" 10.94-13.52%. Meanwhile, considerable variations were traced in contents of mineral elements. Organoleptic evaluation revealed statistical acceptance of cookies fortified with 5, 10 and 15% of (OP) with 10% superior to the control. The cookies supplementation with OP and MP resulted in increasing the cookies thickness as compared to the control. On the other hand, pasta fortified with 5% (OP) was the most acceptable as well as a considerable increase in the weight percentage and the residue retained in the cooking water as compared to the control. The data revealed the potentiality of utilization of citrus peels under study (OP, MP and LP) in manufacture functional cookies. For pasta, OP and MP were superior to LP..

Keywords: Orange peels, mandarin peels, lemon peels, functional cookies and pasta.

INTRODUCTION

The global food production is expected to increase by 60% by 2050, which will contribute to a more significant generation of agro industrial wastes, making it an aggravating situation for the environment (Leite *et al*., 2019).

Citrus fruits are the world's largest fruits sector with an annual production of > 100 million tons. Approximately 20% of the total weight of citrus peels is wasted as by-products in conventional food processing, contributing to some environmental pollution (Shehata *et al*., 2021). With the increasing public concern about waste production, utilizing the waste generated from popular fruits, which are rich in high added value compounds has become a focal point (Aqilah *et al.,* 2023).

Recently, with increasing the industrial citrus waste to more than 40 million tons in the world, there is a global interest in extracting beneficial compounds from agro by-products for use in food preservation (Shahidi *et al*., 2019). It is worth to mention that citrus peels exhibited potent antioxidant activity along with antimicrobial activity against several food borne pathogens (Contini *et al*., 2014, Shehata *et al*., 2021). Notwithstanding, numerous studies have acknowledged the presence of polyphenols, vitamins, minerals, dietary fibers, essential oils and carotenoids content that make citrus a health- benefit to enhance fruit in prevention of degenerative diseases (Wang *et al*., 2014, Amutha *et al*., 2017).

The huge amounts of wastes (especially peels) generated in the citrus industry are majorly discarded and not converted to any useful products. Researchers as well as consumers prefer using natural food additives and healthy food ingredients than their counterparts synthetic analogues. By-products of food processing industries have added value by identification and isolation of their bioactive compounds (Rafiq *et al*., 2018). The peels of orange fruits can be blended with wheat flour. The composite flour has good functional and pasting properties. The incorporation of flour from dried orange peels in wheat flour blends could be useful in food preparation such as baking where good hydration and viscosity of flour are preferred (Rwubastse *et al.,* 2014).

The present work aimed to investigate the chemical composition and bioactive compounds of orange peel (OP), mandarin peel (MP) and lemon peel (LP). Moreover, these peels were utilized in formulating functional cookies and pasta.

MATERIALS & METHODS

Materials:

About 20 kg of each of orange, mandarin and lemon fruits were collected from a farm at Hosh-Essa, Al-Beheira Governorate, Egypt during February and March 2018.

Wheat flour (72% extraction ratio), sugar, eggs, shortening, baking soda, salt and vanilla were purchased from the local market, Alexandria, Egypt.

Methods:

Samples preparation:

The freshly collected fruits (orange, mandarin and lemon) were washed with tap water followed by distilled water. Fruits were peeled manually. The fresh peels were dried in an air oven at 50 °C (X 4733, England) for 10 h., ground using laboratory grinder (Moulinex- AR1044) and sieved through 50 mesh sieves, finally packed in polyethylene bags and stored in refrigerator at 5°C until analysis.

Chemical composition

Proximate chemical composition (Moisture, crude protein, crude fat, crude fiber and ash contents) were determined according to AOAC (2000), while total carbohydrate content was calculated by difference.

Total, reducing and non-reducing sugars were determined according to AOAC (2000).

Ascorbic acid was determined in fresh citrus peels using 2,6-dichlorophenol indophenol dye according to Ranganna (1977), except that 4% oxalic acid in 8% glacial acetic acid was used for extraction of samples (Plummer 1978).

Minerals (Ca, Mg, Mn, Zn, Fe and Cu) were determined in ash solution using Atomic Absorption Spectrometer (AAS) (300VA-50-60 Hz-100-240V) UK, whereas Na and K were determined using Flame Photometer Model PEP7 as described in AOAC (2000).

Dietary fiber fractions including neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose, cellulose and lignin were analyzed using the method of Goering & Van Soest (1970), pectin content was determined according to Egan *et al.* (1976). Pectin was precipitated as calcium pectates using calcium chloride in acidic medium. The pectin content was calculated as follows: pectin = calcium pectates (g) × 100/102

Technological methods

Cookies preparation

Cookies were prepared according to Hooda & Jood (2005) and Kolawole *et al*. (2020) from blends containing 0, 5, 10, 15% of orange and mandarin peels powder as shown in Table (1) and Figure (1).

Table 1: Amount of different ingredients in cookies formula

Ingredient	Amounts
Wheat flour*	152 g
Sugar	102 g
Whole egg	2 eggs
Baking soda	4 g
Vanillin	1 g
Shortening	78 g
Salt	Trace

*Wheat flour (72% extraction ratio).

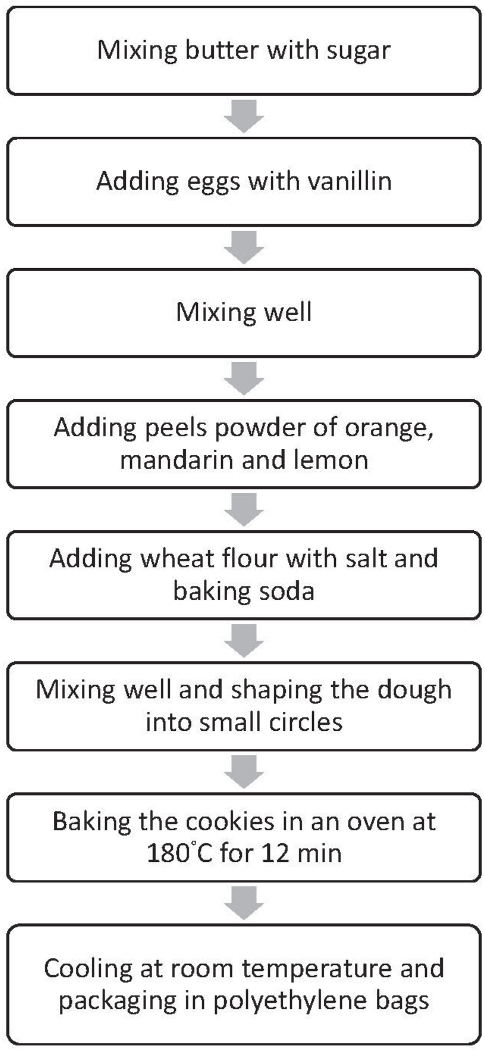

Fig. 1: Flow sheet for cookies preparation

Cookies were also prepared from blends containing 0, 2, 4 and 6% of lemon peels powder. Moreover, some physical properties of cookies including thickness (mm) and area (mm^2) were determined.

Pasta preparation

Pasta was prepared from blends containing 0, 5, 10, 15% of orange, mandarin and lemon peels powder. The formula included 50 g wheat flour semolina (72% extraction ratio), 20 ml water and 1 g of salt. The wheat flour semolina was blended with water and salt, the mixture was mixed well and then placed in the apparatus Titania "made in Italy". The dough after shaping was dried in the oven at 60°C. Dried pasta were cooked in boiling water with salt for 6 minutes for determination of cooking quality and serve for the sensory evaluation (Ahmed, 1972, Ramy, 1976).

Sensory evaluation

Samples along with the control were subjected to sensory evaluation test. Ten trained panelists were asked to evaluate the samples according to the method described by Hooda & Jood (2005) on a hedonic scale consisting of 9 points ranged from 1(extremely dislike) to 9 (extremely like). Colour, texture, taste, odour and overall acceptability were subjectively evaluated.

Statistical analysis

The data were carried out in triplicates and reported as mean values ± standard deviation (SD). The data were analyzed using SAS program ver. 9.1 (2009) as a factorial experiment with three replications according to Gomez & Gomez (1984). Means were compared using the least significant difference at 0.05 level of probability.

RESULTS AND DISCUSSION

Gross chemical composition:

Table (2) shows the gross chemical composition of orange peels (OP), mandarin peels (MP) and lemon peels (LP). The moisture content ranged between 70.05 and 77.82% in OP, MP and LP. In accordance, Abd El-Aal & Halaweish (2010) mentioned the same ranges of the moisture content (71.87% and 73.74%) in *Baladi* orange peels and *Novel* orange peels, respectively. The moisture content according to other authors ranged between 67.69 and 81.23% (M′hiri *et al*., 2015, Ojha & Thapa, 2017, Ibrahim & Hamed, 2018, Tejada-Ortigoza *et al*., 2018).

The crude protein content in OP, MP and LP ranged from 4.44 to 9.91%. The OP exhibited significantly ($P \leq 0.05$) the lowest crude protein content (4.44%), on contrary to LP which possessed significantly ($P \leq 0.05$) the highest content (9.91%) as shown in Table (2).

The results of the crude protein content for OP, MP and LP ranged from 4.0 to 6.5%, 4.39 to 7.4% and 7.89 to 9.42%, respectively in accordance with the results found by many authors (Nassar *et al*., 2008, Rivas *et al*., 2008, Al-Saadi *et al*., 2009,

Table 2: Chemical composition of orange, mandarin and lemon peels (dry weight basis)

Component (%)	OP	MP	LP
Gross chemical composition Moisture content	72.33± 0.29 ^{b}	77.82± 0.38 ^{a}	70.05± 0.95 ^{c}
Crude protein *(N × 6.25)	4.44 ± 0.06^{c}	6.63 ± 0.06^{b}	9.91 ± 0.38^{a}
Crude oil	8.64 ± 0.38^{c}	10.1 ± 0.23^{b}	12.79 ± 0.38^{a}
Ash	10.41 ± 0.18^{b}	10.37 ± 0.07^{b}	15.13 ± 0.12^{a}
Total carbohydrate	76.51 ± 0.8 ^{a}	72.9 ± 0.77 ^{a}	62.17 ± 0.31^{b}
Total sugars	32.82 ± 0.6 ^{ab}	33.35± 0.31 ^{a}	30.7 ± 0.64 ^{b}
Reducing sugars	30.9± 0.55 ^{b}	33.16± 0.57 ^{a}	28.6 ± 0.46 ^{c}
Non-reducing sugars	1.79 ± 0.05 ^{a}	0.18 ± 0.25 ^{b}	1.99 ± 0.42 ^{a}
Ascorbic acid content (mg /100 g) (wb)	35.27± 0.00 ^{b}	44.36±0.00 ^{a}	29.43± 0.00 ^{c}

Where: OP: orange peels, MP: mandarin peels, LP: lemon peels.
The results are expressed as mean values ± SD. Samples were analyzed in triplicate.
The values having different letters within the same row are significant by ($P \leq 0.05$) different.

Janati *et al.*, 2012, Ojha & Thapa, 2017, Olabinjo *et al*., 2017, Mhgub *et al*., 2018).

LP had significantly ($P \leq 0.05$) the highest total lipid content (12.79%), followed by OP (8.64%) and tailed by MP (10.1%) as shown in Table (2). Awad *et al*. (2008) reported that total lipid content of OP and MP were 9.52% and 11.15% while Ani & Abel (2018) reported (9.74%) for *Citrus maxima* peels which are in accordance with the results obtained in the present study. Moreover, The total lipid content of citrus peels ranged between 1.1 and 4.98% being in accordance with Janati *et al*. (2012), Zahra *et al.* and Mhgub *et al.* (2018). On the other hand, Qi *et al.* (2021) reported that total lipid content of citrus peels (0.93%) was lower than the result obtained in the present study.

Table (2) reveals that LP possessed significantly ($P \leq 0.05$) the highest ash content (15.13%) on contrary, MP. had only 10.37%. On the other hand, OP had 10.4% total ash. Awad *et al.* (2008) mentioned that the ash content of OP and MP were 4.24% and 4.06%, respectively. Janati *et al*. (2012) reported that the ash content of LP was 6.26% while Mhgub *et al* (2018) found that the ash content in OP was 4.3% and 4.53% in LP. Qi *et al*. (2021) mentioned that ash content 3.83% of citrus peel was lower than the result in the present study.

As shown in Table (2), a range from 62.17% to 76.51% was figured out for the carbohydrate content of OP, MP and LP. Meanwhile, Ojha & Thapa (2017) mentioned that the carbohydrate content of MP was 79.88%.

The ascorbic acid content in OP, MP, and LP were 35.27, 44.36 and 29.43 mg / 100 g (wb), respectively as shown in Table (2)

Table (2) shows that the content of total sugars in OP, MP and LP were 32.82%, 33.35% and 30.7%, respectively being higher than that reported by Al-Saadi *et al.* (2009) as (23.8%), whereas, Torrado *et al*. (2011) found that the total sugar content in OP varied between 29.0 to 44.0%.

Crude and dietary fiber and pectin contents

The crude fiber content of orange peel (OP), mandarin peel (MP) and lemon peel (LP) as well as the neutral detergent fiber (NDF), the acid detergent fiber (ADF), hemicellulose and the pectin contents are given in Table (3). Orange peel had significantly ($P \leq 0.05$) the highest crude fiber content (8.73%), followed by LP (6.51%). MP exhibited significantly ($P \leq 0.05$) the lowest crude fiber content (5.48%). The obtained results by many authors showed that the crude fiber content of citrus peels varied between 5.01 and 15.4% (Janati *et al*., 2012, Ojha & Thapa, 2017, Olabinjo *et al*., 2017, Zahra *et al.*, 2017, Mhgub *et al.*, 2018).

Notwithstanding, MP had significantly ($P \leq 0.05$) the highest content of NDF (21.83%) followed by OP (17.85%) which was lower than the results (50.14 and 50.81%, respectively) reported by Ibrahim & Hamed (2018). Moreover, LP (12.43%) was very lower than results reported by the aforementioned reference (51.54% and 51.84%).

It was obvious that OP had the highest contents of ADF and cellulose (13.52% and 12.4%, respectively) that was in agreement with Ververis *et al.* (2007) who found that ADF of OP was 15.7%, followed by LP (11.32% and 10.18%) and finally MP (10.94% and 9.87%, ADF and cellulose, respectively). Also, Qi *et al*. (2021) reported that the total dietary fiber, soluble dietary fiber and insoluble dietary fiber for citrus peels were 57.03, 16.08 and 40.95%, respectively.

It is worth to mention that, MP had significantly ($P \leq 0.05$) the highest content of hemicellulose (10.89%) followed by OP (4.33%) and finally LP (1.11%). Meanwhile, Qi *et al*. (2021) reported that hemicellulose content of citrus peels was 10.09%, being very close to hemicellulose content in MP (10.89%).

The lignin content in LP was 1.14% followed by OP (1.12%), then MP (1.07%) as shown in Table (3). On the other hand, the result found by Qi *et al*. (2021) for citrus peels was 8.76%.

It can be observed from Table (3) that the significantly ($P \leq 0.05$) pectin content for MP (17.72%) and LP (19.04%) were comparable, while OP had the highest content of pectin (25.84%) as compared with MP and LP, although it was lower than the result reported by Liu *et al*. (2012) where the pectin content in OP ranged from 51.1% to 55.4%. The result is higher than the result reported by Qi *et al*. (2021) for citrus peels being 15.23%.

Minerals content

Table (4) shows the minerals content in OP, MP and LP. The significant ($P \leq 0.05$) high content of calcium could be traced in LP (2185.19 mg / 100 g), followed by OP (1147.15 mg / 100 g) and

Table 3: Crude and dietary fiber and pectin contents of orange, mandarin and lemon peels (dry weight basis)

Component (%)	OP	MP	LP
Crude fiber	8.73 ± 0.08[a]	5.48 ± 0.12[c]	6.51 ± 0.21[b]
NDF	17.85 ± 2.41[a]	21.83 ± 1.58[a]	12.43 ± 4.55 [b]
ADF	13.52 ± 0.42[a]	10.94± 0.78[a]	11.32 ± 0.2 [a]
Cellulose	12.4 ± 0.30[a]	9.87 ± 0.27[b]	10.18 ± 0.84 [b]
Hemicellulose	4.33 ± 2.83[a]	10.89 ± 1.5[a]	1.11 ± 4.75 [a]
Lignin	1.12 ± 0.5[a]	1.07 ± 0.08[b]	1.14 ± 0.01[a]
Pectin	25.84 ± 1.53[a]	17.72 ± 2.55[a]	19.04 ± 6.12 [a]

where: OP: orange peels, MP: mandarin peels, LP: lemon peels.
NDF: Neutral detergent fiber. ADF: Acid detergent fiber.
The results are expressed as mean values ± SD. Samples were analyzed in triplicate.
The values having different letters within the same row are significantly ($P \leq 0.05$) different.

MP (683.2 mg / 100 g) which is especially important for female. Also, LP exhibited significantly ($P \leq 0.05$) high sodium content (1164 mg / 100 g), followed by OP (623.0 mg /100 g) and MP (614.0 mg /100 g). On the other hand, the amount of potassium was significantly ($P \leq 0.05$) higher in OP (7670.0 mg / 100 g) and MP (6140.0 mg /100 g) as compared to LP (2667.0 mg /100 g). Iron, a very important mineral was found in OP (63.0 mg /100 g), LP (54.9 mg /100 g) and MP (48.8 mg / 100 g). On the other hand, there were traces of zinc in OP, MP and LP (5.4, 3.5 and 4.8 mg /100 g respectively). The same result was found regarding copper and manganese in OP (4 and 4.5 mg /100g, respectively), MP (5.7 and 3.2 mg /100 g) and LP (7.8 and 5.3 mg /100 g). Meanwhile, OP, MP and LP were found to contain considerable amounts of magnesium (81.0, 69.7 and 92.1 mg / 100 g, respectively). Minerals in OP were lower than that found by Al-Saadi *et al*. (2009). The minerals content of LP as reported by Janati *et al* (2012) were Na (755.5), K (8600), Ca (8452.5), Cu (4.94), Fe (147.65) Mg (1429.5), Zn (13.94) and P (6656.25) mg/100 g. Ani & Abel (2018) reported that minerals content in *Citrus maxima* peel extract were Ca (515.78), Fe (9.06), Mg (5.39), K (8.75) and Na (274.77) mg /100 g. From Table (4) it is shown that citrus peels contain higher amount of K, followed by, Ca, then Na, Mg, Fe, Cu, Zn and finally Mn.

Table 4: Minerals content of orange, mandarin and lemon peels (dry weight basis)

Element (mg /100 g)	OP	MP	LP
Potassium (K)	7670.0 ± 0.5[a]	6140.0 ± 0.5[b]	2667.0 ± 0.7[c]
Sodium (Na)	623.0 ± 0.5[b]	614.0 ± 0.4[c]	1164.0 ± 0.5[a]
Calcium (Ca)	1147.15 ± 0.5[b]	683.2 ± 0.4[c]	2185.19 ± 0.7[a]
Magnesium (Mg)	81.0 ± 0.8[b]	69.7 ± 0.3[c]	92.1 ± 0.3[a]
Iron (Fe)	63.0 ± 0.7[a]	48.8 ± 0.6[c]	54.9 ± 0.5[b]
Cupper (Cu)	4.0 ± 0.3[c]	5.7 ± 0.2[b]	7.8 ± 0.5[a]
Zinc (Zn)	5.4 ± 0.05[a]	3.5 ± 0.02[c]	4.8 ± 0.03[b]
Manganese (Mn)	4.5 ± 0.02[b]	3.2 ± 0.03[c]	5.3 ± 0.05[a]

Where: OP: orange peels, MP: mandarin peels, LP: lemon peels.
The results are expressed as mean values ± SD. Samples were analyzed in triplicate.
The values having different letters within the same row are significantly ($P \leq 0.05$) different.

Sensory evaluation of cookies:

The sensory evaluation for the cookies supplemented with OP, MP and LP were evaluated by ten panelists. The colour, odour, taste and texture as well as the overall acceptability were evaluated for the control along with different supplemented cookies. The data revealed significant ($P \leq 0.05$) improvement for the overall acceptability of cookies supplemented with 5, 10 and 15% of OP being superior to the control. Also, the data given in Table (5) show that the cookies supplemented with 10% OP, judged by the panelists are significantly ($P \leq 0.05$) the most acceptable cookies in terms of colour, odour, texture, taste as well as for overall acceptability. Youssef & Mousa (2012) reported that biscuits supplemented with 10% *Baladi* orange peel powder and *Abo Sora* orange peel powder were more acceptable than the control sample in terms of colour, odour, taste, texture and overall acceptability. Moreover, supplemented biscuits with *Abo Sora* orange peel powder were more acceptable than tangerine peel powder supplemented biscuits in terms of texture, odour and overall acceptability. Awad *et al*. (2008) mentioned that the biscuits supplemented with 5% OP was significantly *($P \leq 0.05$)* more acceptable than the control in terms of colour, odour and taste.

Cookies supplemented with MP at the aforementioned three levels (5, 10 and 15%) were significantly (*$P \leq 0.05$*) the most acceptable cookies in overall acceptability even though cookies supplemented with 5% MP were the most acceptable in colour and taste. Moreover, the cookies supplemented with 15% MP were more acceptable in texture. Both treatments; cookies supplemented with 5 and 10% were more acceptable in odour than the cookies supplemented with 15% and the control as shown in Table (5). Even though, the biscuits supplemented with 5% MP were the most acceptable and superior in colour, odour and taste as mentioned by Awad *et al.* (2008).

Cookies supplemented with 2% LP were the significantly (*$P \leq 0.05$*) most acceptable and superior in terms of colour, odour, taste, texture and overall acceptability. On the other hand, the cookies supplemented with 4 and 6% were found to be significantly (*$P \leq 0.05$*) less acceptable than the control as shown in Table (5). Also, Youssef & Mousa (2012) found that biscuits supplemented with LP were more acceptable than biscuits without any addition in terms of colour, taste and overall acceptability.

In conclusion, OP, MP and LP can be used as potent antioxidants and high fiber content to produce functional cookies. Antioxidants are responsible for the defense mechanism of the organisms against the pathologies associated with the attack of free radicals. Thus, the intake of plant derived antioxidant is involved in the prevention of degenerative diseases caused like, Parkinson, Alzhemir or Artherosclerosis (Drog, 2002, Valko *et al*., 2004, 2007, Pisochi & Negulescu, 2011, Lee *et al*., 2014, Youssef & Moharram, 2014).

As for dietary fibers, which are considered as prebiotics, they possess many health benefits such as:

- Maintenance of intestinal flora and stimulation of intestinal transit.
- Change in colonic microflora, contributing to normal stool consistency, preventing diarrhea and constipation.
- Elimination of excuses substances such as glucose and cholesterol.
- Stimulation of the absorption and production of B vitamins.
- Contributing to the control of obesity and decrease the risk of osteoporosis.

(Kaur & Gupta, 2002, Manning & Gibson, 2004, De Vrese & Schrezenmeir, 2008, Abou Baker *et al*., 2014 and Anandharai *et al*., 2014).

Table 5: Sensory evaluation of cookies supplemented with OP, MP and LP at different levels

Treatment	Colour	Odour	Taste	Texture	Overall acceptability
CC	8.5 ± 0.97^{a}	8.2 ± 0.63^{a}	8.00 ± 0.47^{a}	8.2 ± 0.79^{a}	8.1 ± 0.57^{a}
CO1	8.2 ± 1.03^{a}	8.1 ± 0.88^{a}	8.00 ± 0.82^{a}	8.2 ± 0.79^{a}	8.1 ± 0.74^{a}
CO2	8.5 ± 1.08^{a}	8.5 ± 0.85^{a}	8.5 ± 1.35^{a}	8.3 ± 1.06^{a}	8.7 ± 0.82^{a}
CO3	8.25 ± 1.23^{a}	8.55 ± 0.53^{a}	8.2 ± 1.23^{a}	8.25 ± 1.03^{a}	8.5 ± 0.97^{a}
CM1	8.6 ± 1.08^{a}	8.5 ± 1.08^{a}	8.55 ± 0.9^{a}	8.45 ± 1.07^{a}	8.55 ± 0.96^{a}
CM2	8.1 ± 0.99^{ab}	8.5 ± 0.97^{a}	8.35 ± 0.82^{a}	8.1 ± 0.99^{a}	8.6 ± 0.74^{a}
CM3	7.9 ± 0.88^{b}	8.2 ± 0.79^{a}	8.2 ± 0.78^{a}	8.6 ± 0.7^{a}	8.4 ± 0.66^{a}
CL1	8.2 ± 0.95^{a}	8.20 ± 0.92^{a}	8.2 ± 0.52^{a}	8.25 ± 0.86^{a}	8.23 ± 0.66^{a}
CL2	7.7 ± 1.27^{a}	7.7 ± 0.74^{a}	7.73 ± 1.16^{a}	7.70 ± 0.92^{b}	7.7 ± 0.52^{a}
CL3	7.05 ± 1.35^{b}	7.00 ± 1.14^{b}	6.95 ± 0.73^{b}	7.00± 1.25^{c}	6.9 ± 1.17^{b}

Each value is the mean of 10 panelists evaluation.
Where: CC: Control cookies.
CO1: Cookies supplemented with 5% orange peels. CO2: Cookies supplemented with 10% orange peels.
CO3: Cookies supplemented with 15% orange peels. CM1: cookies supplemented with 5% mandarin peels.
CM2: Cookies supplemented with 10% mandarin peels. CM3: Cookies supplemented with 15% mandarin peels.
CL1: cookies supplemented with 2% lemon peels. CL2: cookies supplemented with 4% lemon peels.
CL3: cookies supplemented with 6% lemon peels
The results are expressed as mean values ± SD. The values having differentletters within a column are significantly *($P \leq 0.05$)* different.

Baking quality of cookies

The thickness and the area of the supplemented cookies and the control sample were measured and listed in Table (6). The data show that the elevation of the cookies supplementation level (5, 10 and 15%) with OP and MP resulted in increasing the supplemented cookies thickness and area as compared to the control. Also, the results in Table (6) show that increasing the supplementation level (2, 4 and 6%) with LP followed the same trend. The thickness of cookies ranged from 10.4 for the control to 11.31 mm for the cookies supplemented with 5% MP and 11.32 mm for the cookies supplemented with 5% LP.

Table 6: Thickness and area of cookies supplemented with OP, MP and LP at different levels

Treatment	Thickness (mm)	Area (mm²)
Control cookies	10.40 ± 0.02[c]	18.12 ± 1.9[a]
COP (5%)	11.28 ± 0.07[a]	18.74 ± 1.8[a]
COP (10%)	11.15 ± 0.14[ab]	18.91 ± 2.7[a]
COP (15%)	11.22 ± 0.11 [a]	18.22 ± 4.04[a]
CMP (5%)	11.31 ± 0.02[a]	20.15 ± 3.96[a]
CMP (10%)	11.26 ± 0.06[a]	19.39 ± 1.95[a]
CMP (15%)	11.04 ± 0.51 [ab]	18.85 ± 0.77[a]
CLP (2%)	11.32 ± 0.03[a]	16.62 ± 1.44[a]
CLP (4%)	11.16 ± 0.15[ab]	17.86 ± 1.57[a]
CLP (6%)	10.77 ± 0.68[bc]	17.1 ± 1.11[a]

COP: cookies supplemented with orange peels. CMP: cookies supplemented with mandarin peels.
CLP: cookies supplemented with lemon peels. The results are expressed as mean values ± SD.
The values having different letters within a column are significantly ($P \leq 0.05$) different.

The point of interest is that the supplementation of cookies with the three types of peels investigated here (OP, MP and LP) resulted in an elevation of the thickness of the cookies at 5% for OP and MP as well as at 2% for LP and exhibited significantly ($P \leq 0.05$) the highest thickness for cookies followed by a decrease in the thickness by increasing the concentrations to 10% as well as for 15%.Consequently, the incorporation of these peels in cookies structure lead to improve the texture of cookies.

Furthermore, Table (6) shows that increasing the supplementation level (5, 10 and 15%) with OP and MP resulted in increment of the area for the supplemented cookies as compared with the control. In contrast, the addition of LP at different concentrations (2, 4 and 6%) exhibited a decrease in the area of the cookies compared with the control sample.

Sensory evaluation of pasta supplemented with OP, MP and LP:

The sensory evaluations of pasta supplemented with OP, MP and LP are listed in Table (7). The pasta was supplemented with OP, MP and LP at three different levels (5, 10 and 15%) and subjected to sensory evaluation along with the control.

It was obvious that pasta supplemented with 5% OP was significantly ($P \leq 0.05$) the most acceptable and gained significantly ($P \leq 0.05$) the highest scores for appearance, colour, odour, taste, tenderness and stickiness as compared with the two other supplemented pasta, as well as the control.

Addition of OP at 10 and 15% resulted in significant ($P \leq 0.05$) decrease in the scores given for appearance, colour, odour, taste, tenderness and stickiness of the pasta. Chusak *et al*. (2020) found that the addition of 5% ripe or unripe fruit powder to pasta had the highest score in all estimated attributes. Meanwhile, Essa & Mohamed (2018) reported that textural attributes were altered after the addition of pomegranate peel fiber to macaroni. This effect may be explained by the interaction of dietary fiber with the structure of the gluten protein network.

The data given in Table (7) represent the sensory evaluation of pasta supplemented with MP at different concentrations compared to the control. It was clear that pasta control exhibited significantly ($P \leq 0.05$) the highest scores given by panelists for tenderness, stickiness, taste, odour, colour and appearance than other treatments. Pasta supplemented with 5% and 10% MP had significantly ($P \leq 0.05$) higher scores in colour, odour, taste, tenderness and stickiness as compared with that supplemented with 15% MP. Meanwhile, pasta supplemented with 5 and 10% MP were very comparable to each other. Pasta supplemented with 5% LP was more acceptable than their counterparts belonging to the other two concentrations (10 and 15%) in terms of stickiness, tenderness, taste, odour, colour and appearance. Even though, pasta control was significantly ($P \leq 0.05$) the most acceptable in terms of taste, colour, odour, tenderness, stickiness and appearance. Thus, orange peels powder may be a promising functional component for pasta fortification, although, MP and LP did not show the same trend.

Table 7: Sensory evaluation of pasta supplemented with OP, MP and LP at different levels

Treatment	Appearance	Colour	Odour	Taste	Tenderness	Stickiness
PC	8.5 ± 0.53 a	8.5 ± 0.53a	8.5 ± 0.53a	8.4 ± 0.52 a	8.5 ± 0.53 a	8.5 ± 0.53 a
PO1	8.52 ± 0.5a	8.55 ± 0.5 a	8.53 ± 0.49 a	8.55 ± 0.5 a	8.55 ± 0.5 a	8.55 ± 0.5 a
PO2	7.75 ± 0.35b	7.65 ± 0.63 a	7.75 ± 0.35b	7.73 ± 0.35 b	7.75 ± 0.35 b	7.55 ± 0.35 b
PO3	7 ± 0.67 c	7 ± 0.94 a	6.9 ± 0.46 c	6.8 ± 0.46 c	7 ± 0.67c	7 ± 0.67 b
PC	8.5 ± 0.53 a	8.5 ± 0.53a	8.57 ± 0.53a	8.5 ± 0.53 a	8.5 ± 0.53a	8.5 ± 0.53 a
PM1	7.75 ± 0.49 b	7.8 ± 0.42 a	7.8 ± 0.42 b	7.85 ± 0.41 b	7.8 ± 0.42 b	7.8 ± 0.42b
PM2	7.75 ± 0.35 b	7.75 ± 0.35 a	7.75 ± 0.35 b	7.65± 0.41 bc	7.55 ± 0.44 bc	7.65 ± 0.41 bc
PM3	7.15 ± 0.34 c	7.15 ± 0.6a	7.15 ± 0.34 c	7.15 ± 0.33 c	7.15 ± 0.34 c	7.15 ± 0.34 c
PL1	7.6 ± 0.52b	7.6 ± 0.52 a	7.6 ± 0.52 b	7.6 ± 0.52 b	7.6 ± 0.52 b	7.6 ± 0.52b
PL2	6.6 ± 0.39 c	6.6 ± 0.39 a	6.5 ± 0.62 c	6.5 ± 0.62 c	6.6 ± 0.39 c	6.6 ± 0.39 c
PL3	5.7 ± 1.74 d	6 ± 0.79 a	5.8 ± 1.44 d	5.8 ± 1.43 d	5.7 ± 1.74 d	5.7 ± 1.74 d
LSD	0.59	4.8	0.51	0.5	0.56	0.55

Each value is the mean of 10 panelists evaluation. PC: Control pasta. PO1: Pasta supplemented with orange peels 5%. PO2: Pasta supplemented with orange peels 10%. PO3: Pasta supplemented with orange peels 15%. PM1: Pasta supplemented with 5% mandarin peels. PM2: Pasta supplemented with 10% mandarin peels. PM3: Pasta supplemented with 15% mandarin peels. PL1: Pasta supplemented with 5% lemon peels. PL2: Pasta supplemented with 10% lemon peels. PL3: Pasta supplemented with 15% lemon peels. The results are expressed as mean values±SD. The values having different letters within a column are significantly ($P \leq 0.05$) different.

Cooking quality of pasta

The percentage of weight increase and the residue retained in cooking water for supplemented pasta and the control were measured and listed in Table (8). The data show that elevation of pasta supplementation level (5, 10 and 15%) with OP, MP and LP resulted in a considerable increase in the weight percentage and the residue retained in cooking water compared with the control.

Table 8: Cooking quality of pasta supplemented with OP, MP and LP at different levels

Treatment	Weight increase (%)	Residue retained in cooking water (g)
PC	330.44 ± 9.18 e	1.22 ± 0.5 d
PO 1	339.85 ± 7.52 e	1.92 ± 0.5 cd
PO 2	458.26 ± 10.38 b	2.00 ± 0.5 bcd
PO 3	480.45 ± 9.93 a	2.11 ± 0.5 c
PM 1	427.43 ± 9.98 c	2.98 ± 0.5 b
PM 2	459.56 ± 9.97 b	2.99 ± 0.5 b
PM 3	471.93 ± 8.99 ab	3.39 ± 0.5 b
PL 1	286.05 ± 5.12 f	2.67 ± 0.5 bc
PL 2	402.22 ± 10.26 d	2.81 ± 0.5 bc
PL 3	464.25 ± 14.65b	5.77 ± 0.5 a

PC: Control pasta, PO1: Pasta supplemented with orange peels 5%, PO 2: Pasta supplemented with orange peels 10%, PO 3: Pasta supplemented with orange peels 15%, PM1: Pasta supplemented with mandarin peels 5%, PM2: Pasta supplemented with mandarin peels 10%, PM 3: Pasta supplemented with mandarin peels 15%, PL1: Pasta supplemented with lemon peels 5%, PL2: Pasta supplemented with lemon peels 10%, PL3: Pasta supplemented with lemon peels 15%.
The results are expressed as mean values ± SD.
The values having different letters within a column are significantly($P \leq 0.05$) different.

CONCLUSION

In conclusion, the present study explored the significance of utilizing orange, mandarin and lemon peels as a good source of pivotal bioactive compounds. On the other hand, the aforementioned peels are rich sources for dietary fibers, along with numerous mineral elements. It was obvious that in general, orange and mandarin peels were favorite than lemon peels in pasta. Pasta supplemented with OP (5%) exhibited good overall acceptability, as compared to the control, even better, while the three types of peels (OP, MP and LP) under study could be used as supplements for cookies. In general, the citrus peels have become a food waste in the environment. Therefore, utilizing these components has becoming to be a possible key for reducing food waste and enhancing economic value-added for OP.

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الاستفادة من قشور بعض الموالح في تصنيع منتجات وظيفية من الكوكيز والمكرونة

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تمثل المنتجات الثانوية للصناعات الغذائية قيمة مضافة وذلك لاحتوائها على مركبات نشطة حيويا ذات مردودات صحية جيدة على الانسان، من ثم فلقد أجريت هذه الدراسة على قشور ثلاثة أصناف من الموالح هي البرتقال واليوسفي والليمون. تم تقدير التركيب الكيماوي لها واستخدامها في تصنيع منتجات وظيفية من الكوكيز و المكرونة. أوضح التركيب الكيماوي للقشور موضع الدراسة فروقا معنوية في كل مما يلي: الرطوبة (٧٠,٠٥ - ٧٧,٨٢٪)، البروتين الخام (٤,٤٤ - ٩,٩١٪) ، الدهن الخام (٨,٦٤ - ١٢,٧٩٪)، الرماد (١٠,٣٧- ١٥,١٣٪)، الكربوهيدرات الكلية (٦٢,١٧- ٧٦,٥٪)، السكريات الكلية (٣٠,٧- ٣٣,١٦٪)، حمض الاسكوربيك (٢٩,٤٣- ٤٤,٣٦ ملجم / ١٠٠ جم)، الألياف الخام (٥,٤٨- ٨,٧٣٪) ، الياف المنظفات المتعادلة NDF (١٢,٤٣- ٢١,٨٣٪)، الياف المنظفات الحامضية ADF (١٠,٩٤-١٣,٥٢٪) مع اختلافات جوهرية في محتويات العناصر المعدنية. أوضحت نتائج التقييم الحسى تقبلا كبيرا للكوكيز المدعمة بنسب ٥، ١٠، ١٥٪ قشور البرتقال وتفوقت معنويا على الكونترول. كانت الكوكيز المدعمة بنسبة ١٠٪ من قشور البرتقال هي الأكثر تقبلا من قبل المحكمين من حيث اللون و الرائحة والملمس والمذاق فضلا عن القبول العام. أدى تدعيم الكوكيز بقشور كل من البرتقال واليوسفي والليمون إلى ارتفاع سمك الكوكيز، ومن ثم فإن خلط هذه القشور إلى الكوكيز قد أدى إلى تحسين قوامها وكانت المكرونة المدعمة بنسبةٍ ٥٪ من قشور البرتقال هي الأكثر قبولا من حيث المظهر، اللون، الرائحة، الطعم، الطراوة وعدم الالتصاق فضلاً عن زيادة كبيرة في وزن المكرونة بعد الطبخ والفاقد في ماء الطبخ مقارنة مع الكونترول. بوجه عام فلقد تبين إمكانية استخدام قشور الأصناف الثلاثة من الموالح في تدعيم الكوكيز في حين كانت قشور البرتقال واليوسفي أفضل من قشور الليمون في تدعيم المكرونة.

على ضوء هذه النتائج فإنه ينصح باستخدام قشور الموالح موضع الدراسة كمدعمات للكوكيز والمكرونة، لما في ذلك من مردودات مفيدة من النواحي التغذوية والصحية والاقتصادية والبيئية.