Utilizing Papaya Wastes (Peels and Leaves) for The Development of Functional Biscuits with Promising Health Benefits

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ABSTRACT: Papaya (*Carica papaya* L.) belongs to the family Caricaceae it is widely cultivated in tropical regions. Papaya is rich in various bioactive components, which are attributed to its antioxidant properties. Large amounts of fruit by-products are discarded daily by the food industry, representing a significant loss of nutrients. The present study aims to evaluate the chemical, biochemical, and functional properties of dried peels and leaves of papaya fruit to produce value-added healthy ingredients for the fortification of Biscuits. Results of the proximate chemical analysis revealed that leave powders (PL) possess significantly higher protein and ether extract than peels powders (PP), while (PP) contained significantly higher crude fiber and ash content than (PL), Results also indicated that (PP) contained a significant higher concentration of vitamin C, total phenolics, total flavonoids and tannins than(PL) being(209.21mg/100g,1138.80mgGAE/100g,536.41mgRE/100gand157.27mg/100g)respectively, whereas PL showed higher significant concentration of total carotenoids than PP. The Antioxidant activity of PP and PL powders revealed that PP had significantly higher antioxidant activities as measured by DPPH and FRAP (48.81and43.38%), respectively. Biscuits prepared at 5, 10, and 15% substitution with (PP) showed high acceptability in all parameters as control as well as physical properties. The proximate chemical composition of substituted (PP) biscuits enhanced the nutritive and health value of biscuits. The same trend was also applied on substituting biscuits with PL (2-4-6%) where results indicated satisfactory organoleptic and physical properties at 6% substitution level.

Keywords: ***papaya wastes, Leaves, Peels, functional Biscuits, health benefits***

INTRODUCTION

Papaya (*Carica papaya* L.) belongs to the family Caricaceae, is recognized as a tropical evergreen tree that originated in Central America and Mexico **(Kumar and Sreeja 2017, Joymak *et al*., 2021)**. In 2020, the global output of papayas (*Carica papaya* L.) amounted to 13,894,705 tons **(FAOSTAT, 2022)**. As reported by the FAO (2020), it is anticipated that worldwide papaya production will increase by 2.1 percent annually, reaching approximately 16.6 million tons by 2029 **(FAO, 2020)**.

To our knowledge the Bulletin of the agricultural statistics indicates that in the 2020/2021 period, papaya production is categorized under other fruits (including kiwi, avocado, papaya, carob, nabq, and mixed tree varieties), covering a total area of 2,756 feddans and yielding 12,952 tons. Additionally, in 2021, the area dedicated to papaya along with other fruits expanded to 4,321 feddans, resulting in a total production of 25,611 tons. **(Ministry of Agriculture and land Reclamation, 2020 /2021).**

Carica papaya is a nutraceutical species, known for its tasty fruit and health benefits. Every part of the plant including the roots, bark, skin, seeds, and flesh possesses medicinal qualities and exhibits a broad range of pharmacological actions, along with being a rich source of potent antioxidants. Papaya is abundant in numerous bioactive substances, such as carotenoids, phenolic compounds, vitamins A, C, E, and B vitamin (pantothenic acid), as well as minerals like potassium and magnesium, folate, and fiber. These compounds contribute various positive health effects on our bodies, primarily due to their antioxidant characteristics **(Aravind *et al*., 2013).**

During processing operations, residues and by-products are often discarded as waste due to insufficient handling techniques. It is estimated that, on average, 30–50% of processed food is thrown away as agro-industrial waste **(Lin *et al.*, 2013; Dávila *et al*., 2014)**. By-products from papaya account for about 20-25% of the fruit's total weight and primarily consist of peels and seeds **(Pavithra *et al*., 2017)**.Waste from fruits and vegetables, including skins, peels, pomace, rinds, kernels, and seeds, is a valuable source of numerous phytochemicals such as dietary fibers, polyphenols, carotenoids, flavonoids, and polysaccharides that can be recovered and used **(Haldhar *et al*., 2018 and Wheeler *et al*., 2018).** Papaya peel (PP) is the primary by-product of papaya processing, accounting for around 12% of the fruit's weight. PP contains valuable bioactive compounds that can be utilized as dietary additives, nutraceutical supplements, and new food and pharmaceutical products. Traditionally, PP has been applied in animal feeds, cosmetics, and various home remedies. **(Medina *et al*., 2013 and Parniakov *et al*., 2015)**. It was found that papaya peels are rich in fiber which increased the opportunity to develop new products (**Calvache *et al*., 2016**). Also, it contains protein, carbohydrates, ash, fat, and minerals (phosphorous and potassium), as well as a source of antioxidants (**Jamal *et al*., 2017).**

Papaya leaves are part of the papaya plant which contains many good nutrients such as bioactive components. Bioactive components in papaya leaves are very abundant such as alkaloids, flavonoids, saponins, and papain. Some of these components are beneficial to the body because they have a role as antioxidants. These antioxidant compounds can prevent heaps of degenerative diseases such as heart attacks, leukemia, and premature aging **(Vuong *et al*., 2013).**

Biscuits constitute a major component of human snacks in most part of the world. **(Hasker *et al*., 2016) .**Supplementary foods should be such, if taken in small quantity, could provide the necessary amount of nutrients. They should be made in the form of ready to eat snacks, drinks, etc. Biscuit has been good for a long time as a processed food for vulnerable group (**Ahmad and Ahmed, 2014).** The majority of people around the world consume biscuits for their nutritional value, and therefore in recent years, researchers have fostered their attention to improving biscuits' nutritional value by supplementing or fortifying them with various ingredients such as folic acid, dietary fiber, vitamins E (tocopherol), polysaccharides, barley, and whole waxy wheat flour **(Han *et al*., 2019).**

Therefore, the objective of the present research is to measure the proximate chemical composition, bioactive components functional and sensory attributes of papaya dried peels and leaves, in an attempt to produce healthy high value add biscuit products from wastes of papaya peels and leaves.

MATERIALS AND METHODS

MATERIALS

Papayas **(*Carica papaya* L.)** were obtained from Agreton Agricultural and Industrial Investment Company, 107km, Alex –Cairo Desert Road, Al- Nubaira Alexandria, Egypt. Wheat flour (72%extraction)all purpose, sugar, sun flower oil, cocoa powder, sodium bicarbonate, baking powder were obtained from the local market at Alex city - Egypt. All chemicals used in this study were purchased from EL-Gomhouria for Trading Chemicals and Drugs Co., Alex city, Egypt.

METHODS

Preparation of papaya wastes powder

Ripe papaya fruits **(*Carica papaya* L)** were selected according to maturity stage (full mature, skin is yellow and may or may not have little bright green spots). Papaya fruits were washed and then manually peeled; the peels were cut using a stainless-steel knife, peels and leaves were rinsed with water to remove any adhering mucilage, and then they were blanched at 100 ºC for 3-4 min. and dried at 50 ˚C for 16-18 h until constant weight at a processing plant for dehydrating fruits and vegetables (Agro Misr) located in Al-Rass El-Soda Alexandria, Egypt. Then the dried peels and leaves were ground using an electrical mill (SEB 21260), sieved to obtained particle size of 60 mesh and kept in low density polyethylene bags and stored at -18°C until further analysis.

A B C

Figure (1) Preparation of papaya wastes powder
A: Papaya fruit B: Papaya peels powder C: Papaya leaves powder

Functional properties:

Water holding capacities (WHC)

Powdered samples were determined following the method described by **(Ang, 1991)**. By using a glass rod, a sample of 2 g was mixed with 30 ml of distilled water in a 50 ml centrifuge tube. The slurry was allowed to stand for 10 min, and then centrifuged at 2000 xg for 15 min. After centrifugation, the supernatant was drained and the wet precipitate was weighed. The result was expressed as g of water per g sample.

Oil holding capacity (OHC)

Oil Holding Capacity was measured according to **Garau *et al*., (2014).**Samples (0.2g) were mixed with sunflower oil (1.5g), left overnight room temperature and then centrifuged (1500xg., 5min).The supernatant was decanted and the sample was weighed. OHC was evaluated based on the increase in weight and expressed as g of oil absorbed/g dry sample.

Proximate composition of papaya powders

Moisture content, crude protein, crude ether extract, crude fibers, and ash contents of peels and leaves powder were determined according to the methods described in the **AOAC (2007). * Nitrogen free extract calculated by difference=100-(Moisture content + Crude ether extract+ Crude protein +Crude fiber+ Ash) .**Total sugars were determined as invert sugars according to the titrametric method of Lane and Eynon after acid hydrolysis as described in the **AOAC (2007).** Reducing Sugars were determined in the lead free filtrate before inversion using Lane and Eynon as described in the **AOAC (2007).**

Extraction of Papaya Samples for Chemical Analysis

One gm of each papaya sample is extracted three times with 20 ml of methanol for 20 min with sonication, followed by filtration, pooling and evaporation of solvent at 40ºC under reduced pressure till complete dryness using rotary evaporator (Heidolph , Germany). The resulting extract was reconstituted in methanol at a concentration of 1mg/ml.

Determination of the total phenolics content (TPC) in powders

The TPC of peels and leaves powder was determined using the Folin–Ciocalteau reagent method according to the methodology of **(Singleton and Rossi ,1965)**, where the total phenolic content was expressed as mg gallic acid equivalent /gram from the calibration curve of gallic acid.

Total flavonoids content

Total flavonoids content of extracts were determined according to **(Barros *et al*., 2011).** The absorbance was measured at 510 nm using a spectrophotometer (Pg T80+, England). A calibration curve of Rutin was prepared and total flavonoids content were determined (mgRE/100g).

Total carotenoids (Carotenoids as β- carotene)

Total carotenoids (Carotenoids as β carotene) (mg 100g-1) were determined by a modified method of **(Ranganna *et al*., 1997)** using acetone and petroleum ether as extracting solvent and measuring the absorbance at 450 nm. The total carotenoid content was calculated using the following formula;

$$\text{Carotenoids content}(\mu g/g) = \frac{A \times V(mL) \times 10^4}{A_{1cm}^{1\%} \times P(g)}$$

where A = Absorbance; V = Total extract volume; P = sample weight; $A_{1cm}{}^{1\%}$=2592 (β-carotene Extinction Coefficient in petroleum ether).

Ascorbic acid (Vitamin C)

Ascorbic acid content was determined by direct titration method with 2, 6-dichloro-endo-phenol indophenols dye **(AOAC, 2007).**

Total condensed tannins

Condensed tannins were determined according to the method of **(Sun *et al*., 1998**) .where 50 μL of diluted sample; 3 mL of 4% vanillin solution in methanol and 1.5 mL of concentrated HCl were added. The mixture was allowed to stand for 15 min, and absorption was measured at 500 nm against methanol as a blank. The amount of total condensed tannins is expressed as mg (+)-catechin/g DW. All samples were analyzed in triplicate.

DPPH radical scavenging activity

Antioxidant activity of samples were measured by evaluating the free radical scavenging activity of the 1,1- Diphenyl-2-picryl-hydrazyl (DPPH) radical according to a modified method by **Brand-Williams *et al*. (1995).** Briefly, 0.3 ml methanolic extract was added to 2.7 ml DPPH 0.1 mmol in methanol solution. The reaction mixture was vortex–mixed well and incubated for 30 min at room temperature in the dark. Absorbance was measured spectrophotometrically at 517 nm. The antioxidant activity was expressed as percentage of inhibition of DPPH radical and calculated from the equation:

Inhibition (%) = [(A DPPH – A Sample) / A DPPH] x 100
A Sample = the absorbance of sample.
A DPPH = the absorbance of the control.

Ferric reducing antioxidant power (FRAP) assay

The reducing power of ethanolic extracts was according to the method cited by **Oyaizu, (1986).**which involves the presence of antioxidants in extract to reduce the ferricyanide complex to the ferrous form. One milliliter of extract in different dilutions was added to 2.5 ml phosphate buffer (0.1M) pH and 2.5 ml potassium ferricyanide (1%w/v). The mixture was then incubated in a water bath at 50ºCfor 20min followed by 2.5 ml trichloroacetic acid (10%w/v) solution. The contents of thetubes were mixed well and 2.5 ml of solution was removed from each tube. To this, 2.5ml solution 2.5 ml water and o.5ml ferric chloride solution (0.1%w/v) were added. The mixtures were allowed to stand for 30 min before absorbance measurments were taken at 700nm. Triplicate tubes were prepared for each extract. Increased absorbance of the reaction mixture indicated increased reducing power.

Preparation of biscuits:

Biscuits were processed according to the method of **(Chandra *et al*., 2015)** The standardized formulation for biscuit had ingredients as 100 g flour, 45g sugar, 45g sun flower oil ,1.25g sodium bicarbonate, 1.25 g baking powder and 7g cocoa powder (Table1) They were baked at 180 ºC for 10-15 min. For functional application, papaya peels powder and papaya leaves powder were added in the creaming phase to replace 5, 10,15% (PP) after performing preliminary trials for choosing suitable levels, and 2,4,6,8%(PL) according to **(Jiang1 *et al*., 2022)** of wheat flour used in biscuits formula respectively ,as shown in (Table 1).

Table (1): Formulas of biscuit made from wheat flour with different ratio of papaya peel powder (PP) and papaya leaves powder (PL) (g/100g) .

Ingredients	Control	BPP5*	BPP10	BPP15	BPL2**	BPL4	BPL6	BPL8
Wheat flour	100	95	90	85	98	96	94	92
peel powder	-	5	10	15	-	-	-	-
Leave powder	-	-	-	-	2	4	6	8
Sugar	45	45	45	45	45	45	45	45
Cocoa powder	7	7	7	7	7	7	7	7
Sunflower oil	45	45	45	45	45	45	45	45
Sodium bicarbonate	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Baking powder	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25

*BPP 5: blends (5% papaya peels powder)
BPP10: blends (10% papaya peels powder)
BPP15: blends (15% papaya peels powder)

** BPL2: blends (2%papaya leaves powder
BPL4: blends (4%papaya leaves powder)
BPL6: blends (6%papaya leaves powder)
BPL8: blends (8%papaya leaves powder)

Measurement of physical properties of Biscuit

Physical properties of biscuits such as weight, diameter, thickness, and spread ratio were determined **(Hooda and Jood, 2005) .**Biscuit was weighed after removed from the pan. Average weight of 6 piece (g), diameter of 6 pieces (mm) and thickness of 6 pieces (mm). Spread ratio was calculated by dividing the average value of diameter (mm) by the average value of thickness (mm).

Proximate composition of Biscuit

Moisture content, crude protein, crude ether extract, crude fibers, and ash contents of Biscuit were determined according to the methods described in the **AOAC (2007). * Nitrogen free extract calculated by difference=100-(Moisture content + Crude ether extract+ Crude protein +Crude fiber+ Ash) .**

Determination of the total phenolics content (TPC) in Biscuit

The TPC of Biscuit was determined using the Folin–Ciocalteau reagent method according to the methodology of **(Singleton and Rossi, 1965)**, where the total phenolic content was expressed as mg gallic acid equivalent /gram from the calibration curve of gallic acid.

Sensory evaluation

Ten trained panelist from staff and post – graduate students at Faculty of Agriculture Saba Basha Alexandria University evaluated the biscuit for colour , flavour, texture, test, crispiness and overall acceptability. A nine -point hedonic scale was used to rate the sensory properties where 9 is (Like extremely) and 1(Dislike extremely).The rating were then given numerical values**.** Randomly coded samples were presented to the panelists on white plates and served one at a time. Panelists were instructed to rinse their mouth with tap water before starting and between sample evaluations**. (Hooda and Jood,2005).**

Statistical analysis

All results were presented as mean± Standard deviation (SD).Data was subjected to one-way analysis of Variance (ANOVA) using (SPSS/PC+)Version-22 soft ware package. Means were further differentiated using Duncan`s Multiple Range Test at P<0.05 **(Steel *et al*, 1997)**.

RESULTS AND DISCUSSION

Functional properties of papaya peels and leaves

Functional properties are intrinsic physiochemical characteristics that reflect the complex interaction between the composition structure, conformation and physicochemical properties of protein and other components .It can be used to determine the technological impact of a given ingredient on a food product **(Singh, 2001).** The results in Table (2) indicated that the peels had higher water absorption capacity (5.99%) than leaves while leaves possess higher oil absorption capacity (1.58%) than peels (1.01%).

WHC is the measure of association of hydrophilic group of protein with water **(Singh, 2001).**On the other hand OHC serves as a flavor retainer and increase mouth feel. Higher oil absorption capacity is preferable for stabilizing of food products with high fat content and emulsion **(Kinsella and Melachouris, 1976)**. Table 2 shows the water absorption and oil absorption capacities of peels and leaves powder of papaya fruit.

Table (2): Functional properties of papaya peels and leaves

Functional properties	Peels	Leaves
Water absorption capacity %	5.99±0.08a	4.25±0.03b
Oil absorption capacity %	1.01±0.02b	1.58±0.04a

All values are means ±standard division of triplicate analyses.
The values having different letters within a row are significant ($p \leq 0.05$).

Proximate chemical composition

The proximate chemical composition of peels and leaves of papaya fruit is represented in Table 3. Peels contained: 13.96% moisture, 2.92 % crude ether extract, 6.87% crude protein, 6.30% crude fiber, 15.34% ash and 68.57% nitrogen free extract, while leaves contained 6.00% moisture, 4.24% crude ether extract, 7.43% crude protein, 3.53% crude fiber, 15.14% ash and 69.65% nitrogen free extract on dry weight basis. As can be seen, there were no significant differences between ash content of peels and leaves. While, there were significant differences among all other determined parameters. These results indicate that leaves had significant higher crude ether extract, crude protein and nitrogen free extract values than ripe peels, while peels had significant higher moisture content and crude fiber than leaves.

Table (3): Proximate chemical composition of papaya fruit peels and leaves on dry weight basis.

Component %	Peels	Leaves
Moisture content	13.96± 0.04^{a}	6.00±0.01^{b}
Crude ether extract	2.92±0.07^{b}	4.24±0.04^{a}
Crude protein	6.87±0.07^{b}	7.43±0.03^{a}
Crude fiber	6.30±0.11^{a}	3.53±0.08^{b}
Ash	15.34±0.11^{a}	15.14±0.18^{a}
Nitrogen free extract *	68.57±0.07^{b}	69.65±0.04^{a}
Total sugar	16.74±0.05^{a}	4.86±0.06^{b}
Reducing sugar	13.64±0.02^{a}	2.77±0.03^{b}

Means ±SD; the values having different letters within a row are significant ($p \leq 0.05$).
* Nitrogen free extract calculated by difference.
NFE % =100- (Crude ether extract+ Crude protein +Crude fiber+ Ash).

The data presented in Table 3, also show that papaya fruit peels and leaves contained 16.74 and 4.86% total sugars, 13.64, and 2.77% reducing sugars, respectively with significant differences between them. It was obvious that peels had sugars content higher than leaves .As a matter of fact, the results of the fore- mentioned proximate chemical analysis of our research were lower than those reported **by Ahmed and Abdel-Rahman , (2022)** who found that ,the fiber content of PP was 11.02%, while protein, , and crude fat, were 12.47%, and 6.5%, respectively, with the exception of crude ether , ash and proteins in our research (2.92%,15.34% and 11.67%)which were higher than the values reported by **Martial-Didier *et al*. ,(2017).** Furthermore, **Santos *et al*. (2014)** determined the content of protein (15.03-18.18 g/ 100g) in papaya peels of two cultivars, which were higher than the data obtained in our research, while ash content (11.31-11.85g/ 100g) were lower than the data obtained in our research.

The variation in proximate composition of the papaya fruit peels and leaves that were reported by previous authors may be due to the variations in stage of ripening, the harvesting time, variety, cultivation, climate, beside other factors**(Ornelas-paz *et al*., 2008 ; Sancho *et al*.,2011).**

Bioactive components

Table (4) show some bioactive components of papaya fruit peels and leaves which include vitamin C, total phenolic, total flavonoids, total tannins and total carotenoids .The results indicated that peels had higher vitamin C content (209.21 mg/100g than leaves (91.91 mg/100g). It was also clear that Papaya peels powder (PP) contain higher significant amounts of total phenolic, total flavonoid and total tannins content than papaya leaves powder (PL). The values of total phenolic, total flavonoid and total tannins content in PP were(1138.80 mg GAE/100g , 536.41 mg RE/100g and 157.27 mg/100g), respectively, while PL had 946.1mg GAE/100g , 310.09 mg RE/100g and 72.93 mg/100g, respectively. While, the total carotenoids content , showed no significant difference between peels and leaves being 11.49 and 11.51 mg/100g, respectively.

Table (4): Bioactive components of papaya fruit waste on dry weight basis.

Component	peels	Leaves
Vitamin C (mg/100 g)	209.21±3.58[a]	91.91±0.89[b]
Total phenolics (mg GAE /100g)	1138.80±1.56[a]	946.1±0.53[b]
Total flavonoids (mg RE /100g)	536.41±1.44[a]	310.09±2.50[b]
Total tannins (mg/100g)	157.27±2.64[a]	72.93±1.95[b]
Total carotenoids (mg/100g)	11.49±0.13[a]	11.51±0.19[a]

Means ± SD on a dry weight basis.
The values having different letters within a row are significant ($p \leq 0.05$).

These results were higher than those achieved by **Ahmed and Abdel-Rahman, (2022)** who found that the total phenolic recorded (838 and 367.66 mg GAE/ 100 g sample) in peels. On the other hand, **Martial-Didier *et al*., (2017)** reported lesser concentration of total phenolic content in papaya (*Carica papaya L. var solo 8*) peels (65.48 mg GAE/100 g) on dry weight. Meanwhile, **Santos *et al*., (2014),** found that tannic acid in two cultivars of papaya ranged between (55.3 and 57.5mg tannic acid/100g) in peels, which were lower than our data.

Phenolic compounds are important fruit constituents because they exhibit antioxidant activity by inactivating lipid free radicals or preventing decomposition of hydroperoxides into free radicals. Besides, papaya peels protect the fruit and seeds from environmental factors (**Khan *et al*., 2021**).

Antioxidant Activity

Antioxidants have been hypothesized to play an important role in preventing chronic disease, due to their ability to prevent oxidative damage caused by reactive species to vital biomolecules like lipids and proteins **(Peter, 2001).**

The antioxidant activity was measured by DPPH radical scavenging activity and FRAP as shown in table (5). The results indicated that the peels had higher significant antioxidant activity as measured by DPPH inhibition (48.81%) and FRAP (43.38) than leaves. DPPH is a free radical compound that has been widely used to determine the free radical- scavenging ability of various samples **(Amarowicz *et al*., 2010).**

Table (5): Antioxidant activity of papaya fruit waste as measured by DPPH and FRAP

Antioxidant activity	Peels	Leaves
DPPH inhibition(%)*	48.81±1.14a	41.49±1.06b
FRAP**	43.38±0.82a	27.13±0.54b

All values are means ±standard division of triplicate analyses
The values having different letters within a row are significant ($p \leq 0.05$).
*DPPH free radical scavenging activity. **Ferric-reducing antioxidant power (FRAP)

Ferric reducing antioxidant power (FRAP) was conducted on the extracts of papaya peels and leaves to confirm its antioxidant potential. The results revealed that the extract of papaya peels had higher significant ferric reducing antioxidant property (43.38%) compared to leaves extract (27.13).Antioxidant assays are used to evaluate the antioxidant potential of papaya peels and leaves extracts and fractions. It is essential to measure the ability of the chemical components in papaya peels and leaves extracts to scavenge free radicals and prevent the formation of reactive oxygen species (ROS).High levels of ROS can cause abnormal cell signaling and subsequent cellular damage **(Winterbourn, 2008).**Several studies have linked (ROS)to several chronic diseases such as neurodegeneration ,cancer, diabetes, and inflammation**(Mittal *et al*., 2014;Swietek *et al*., 2019).** Phenolic compounds in papaya peels and leaves are composed of a significant number of hydroxyl groups, which may enhance their ROS scavenging capacity **(Swietek *et al*., 2019).**It is worth noting that the high FRAP activity of the peel is attributed to phenols and carotenoids**(Kreft *et al*., 2006)**

Biscuits substitute with papaya peels powder

Biscuits are very attractive food product for vulnerable groups (children and old adults). Biscuits are the most popularly consumed bakery products , because of their relative low cost value among other processed foods, varied taste, easy availability and longer shelf life **(Hooda and Jood . ,2005 : Ajila *et al*., 2008).** The organoleptic properties and the appearance of these formulated biscuits with papaya peels powder (PP) are given in Table 6 and Figure 2.

The scores of panelists showed that all samples were accepted. The scores of organoleptic properties were slightly increased, by increasing the level of PP. There were no significant differences between the three levels of PP (5, 10 and 15 %) which were more pronounced in all properties as they were highly accepted as control. .Based on sensory evaluation, the formulation containing high levels of PP were more acceptable by the panelists.

Table (6): Organoleptic properties of biscuit substitute with different levels of papaya peel powder.

Treatment	Colour	Texture	Odour	Taste	Crispiness	Total acceptability
Control	7.70±1.15[a]	7.60±1.07[a]	7.41±1.26[a]	7.60±1.07[a]	7.50±1.08[a]	7.70±1.05[a]
BPP%						
5	8.20±0.52[a]	7.90±0.33[a]	8.00±0.56[a]	7.90±0.51[a]	7.90±0.66[a]	7.95±0.89[a]
10	8.25±0.67[a]	8.10±0.22[a]	7.80±0.85[a]	7.80±0.19[a]	8.00±0.21[a]	8.00±0.98[a]
15	8.00±1.05[a]	8.15±0.78[a]	7.60±0.57[a]	7.60±0.05[a]	8.10±0.82[a]	8.10±0.73[a]

PP: Biscuit peel powder Means ± SD.
Means in a column not sharing the same letter are significantly different at $p \leq 0.05$.

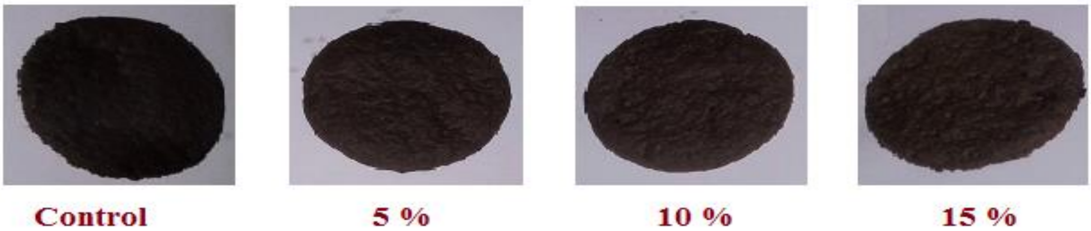

Figure (2): General appearance of biscuits substituted with papaya peels powder (PP) at different levels.

Physical properties of biscuits

Physical properties such as weight, diameter, thickness and spread ratio of biscuits are summarized in Table 7. The results indicated that there were slight differences in the physical characteristics such as weight, diameter, thickness and spread ratio among the biscuits which were made from 100% wheat flour (control) and those substituted at 5, 10, and 15 with papaya peels powder. It was observed that, while raising the replacement to 15% PP significant decrease, were observed, it was seen that the weight of biscuits decreased gradually from (5.05 to 4.30 g) with increasing the proportion of papaya peels powder. Also there was an obvious decrease in diameter from (45.60 to 39.50 mm), while, thickness of biscuits showed no significant difference by increasing the concentration of papaya peels powder.

Table (7): Physical characteristics of biscuits substitute different levels of papaya peels powder.

Treatment	Weight (W (g))	Diameter (D (mm))	Thickness (T (mm))	Spread ratio (D/T)
Control	5.05±0.09[a]	45.60±0.57 [a]	5.10±0.09[a]	8.94±0.23[a]
BPP%				
5	4.76±0.25[a]	43.20±0.22[a]	4.90±0.17[a]	8.81±0.40[a]
10	4.40±0.71[b]	42.00±0.74[b]	4.80±0.15[a]	8.75±0.36[a]
15	4.30±0.11[b]	39.50±0.54[b]	4.80±0.12[a]	8.22±0.30 [b]

BPP: Biscuits peel powder Means ± SD.
Means in a column not sharing the same letter are significantly different at $p \leq 0.05$.

The spread ratio is an important characteristic for determining the quality of biscuits. Biscuits with higher spread ratios are the most desirable **(Chauhan *et al*., 2016)**. The spread ratio of all PP biscuits containing different concentrations showed no significant differences between control and biscuits samples substituted at 5 and 10 % PP, while, at 15% substitution with PP significant decrease was observe compared to control being 8.22%. These results may be mainly due to the dilution of gluten **(Kohajdová *et al*., 2014)**. This result agreed with **Ajila *et al*. (2008) and Ashoush and Gadallah (2011)** who mentioned low value of spread ratio for biscuits incorporated with mango peel powders. The results of the physical properties of biscuits showed that supplementation of whole wheat flour with papaya peels powder gave slight difference between the samples as they all compared favourably with the control. The above results confirmed the successful use of papaya peels powder up to 15% replacing wheat flour in preparing biscuit with satisfactory acceptable quality.

Proximate chemical analysis of biscuits substituted with papaya peels powders

Generally, the moisture content of biscuits increased significantly ($P < 0.05$) by increasing the level of PP incorporation. As observed in Table 8, incorporation of PP in the biscuit samples significantly increased fat, protein with no significant differences compared to control. Meanwhile, high significant increase of crude fiber and ash content were observed as level of substitution increased compared to control.

As was expected, there was significant increase in the crude fiber and ash content of the biscuit samples. The values of crude fiber increased from 2.71% in control sample to 5.02 in sample incorporated with 15% PP. Also, the values of ash increased from 5.52% in control sample to 8.53 in sample incorporated with 15% PP. Crude fiber composition is a measure of the quality of indigestible cellulose ,pentose, lignin, and other indigestible materials **(Akajiaku *et al*., 2018)**. Because flours obtained from PP are rich in protein and fiber contents, they can be added in foods as alternative nutrient sources, which reduce waste and increases value to the fruit. The presence of fiber, vitamin C, phenolic compounds, ash, in PP flour makes it beneficial for human consumption **(Santos *et al*., 2014)**

Fiber plays a significant role in papaya, contributing to its nutritional value and potential health benefits, as it contributes to digestive health, Blood sugar control, Cholesterol reduction, Satiety and weight management, prebiotic properties, Anti-inflammatory effects, Supports healthy gut motility. Overall, the fiber content in papaya makes it a nutritious and healthy addition to a balanced diet, supporting digestive health, satiety, and overall well-being **(Maryam.,*et al*.,2024).**

Regarding to the total phenolic content, the results revealed that there was an improvement in the phenolic content with increasing the levels of PP. The results in Table 8 showed that increasing the levels of PP gradually increased the content of phenolic contents compared to control biscuit sample. Biscuit treatments containing 15% PP had the highest total phenolic (421.99 mg GAE /100g).compered to control. **Jiang *et al*., (2022)** found that the same behavior.

Table (8): Proximate chemical composition and total phenolic content of biscuits containing different concentrations of papaya peels powders.

Treatment	Moisture content (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Total phenolics mg GAE/100g
Control	6.14 ± 0.07^{d}	6.15 ± 0.05^{c}	17.24 ± 0.08^{d}	2.71 ± 0.10^{d}	5.52 ± 0.02^{d}	252.94 ± 15.17^{d}
BPP (%)						
5	6.29 ± 0.06^{c}	6.03 ± 0.07^{d}	17.63 ± 0.07^{c}	3.32 ± 0.09^{c}	6.18 ± 0.06^{c}	314.14 ± 9.37^{c}
10	6.55 ± 0.10^{b}	6.30 ± 0.05^{b}	17.85 ± 0.10^{b}	4.17 ± 0.15^{b}	7.44 ± 0.08^{b}	387.05 ± 9.97^{b}
15	6.73 ± 0.04^{a}	6.45 ± 0.13^{a}	18.11 ± 0.07^{a}	5.02 ± 0.12^{a}	8.53 ± 0.10^{a}	421.99 ± 13.52^{a}

BPP: Biscuit peel powder

Means in a column not sharing the same letter are significantly different at $p \leq 0.05$.

Table (9): Organoleptic properties of biscuit substitute with different levels of papaya leaves powder.

Treatment	Colour	Texture	Odour	Taste	Crispiness	Total acceptability
Control	7.70±1.15^{a}	7.60±1.07^{a}	7.41±1.26^{a}	7.60±1.07^{a}	7.50±1.08^{a}	7.70±1.05^{a}
BPL%						
2	8.00±0.66^{a}	7.70±0.52^{a}	7.40±0.96^{a}	7.60±0.51^{a}	7.80±0.78^{a}	7.75±0.63^{a}
4	7.80±0.75^{a}	7.80±0.56^{a}	7.30±1.05^{a}	7.40±1.07^{a}	7.80±0.84^{a}	7.65±0.68^{a}
6	7.30±1.05^{b}	7.90±0.56^{a}	7.10±1.28^{a}	7.30±0.87^{a}	7.90±1.22^{a}	7.40±1.37^{b}
8	7.10±1.07^{b}	7.90±1.05^{a}	7.00±1.07^{b}	6.80±1.37^{b}	8.00±0.94^{a}	7.05±1.13^{b}

BPL: Biscuit Leaves powder Means ± SD.

Means in a column not sharing the same letter are significantly different at $p \leq 0$.

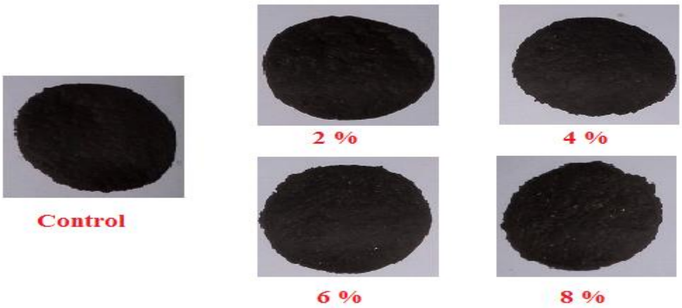

Figure (3). General appearance of biscuits substituted with papaya leaves powder (PL) at different levels.

Physical properties of biscuits

The data related to the effect of different concentrations of papaya leaves powder (PL) incorporation on physical characteristics of prepared biscuits are summarized in Table (10). These results indicated that there were slight differences in the physical characteristics such as weight, diameter, thickness and spread ratio between the biscuits which were made from 100% wheat flour (control) and those made from wheat flour with 2, 4 and 6% replacement of PL while, raising the replacement to 8% PL significant changes were observed . The values of the physical characteristics of (weight, diameter and spread ratio) were decreased by increasing the concentration of PL as compared to control.

It was observed that biscuits made from wheat flour with 2, 4, 6 and 8% replacement of papaya leaves powder the weight, diameter and spread ratio of biscuits decreased gradually from 5.05 to 4.66 g, 45.60 to 41.40 mm and 8.94 to 8.44%, respectively.

Table (10): Physical characteristics of biscuits containing different levels of papaya leaves powder.

Treatment	Weight W (g)	Diameter D (mm)	Thickness T (mm)	Spread ratio D/T
Control	5.05±0.09^{a}	45.60±0.57 ^{a}	5.10±0.09^{a}	8.94±0.23^{a}
BPL%				
2	5.00±0.20^{a}	45.20±0.74^{a}	5.10±0.17^{a}	8.86±0.40^{a}
4	4.95±0.59^{a}	44.10±0.74^{b}	5.10±0.15^{a}	8.66±0.36^{a}
6	4.70±0.69^{b}	43.20±0.54^{b}	5.00±0.12^{a}	8.64±0.30^{ab}
8	4.66±0.25^{b}	41.40±0.87^{C}	4.9±0.11^{a}	8.44±0.22^{b}

BPL: Biscuit Leaves powder Means ± SD.
Means in a column not sharing the same letter are significantly different at $p \leq 0.05$.

The spread ratio is an important characteristic for determining the quality of biscuits. Biscuits with higher spread ratios are the most desirable **(Chauhan *et al*., 2016)**. The spread ratio of all PL biscuits containing differerent concentrations showed no significant differences between control and biscuits samples which were made from 100% wheat flour and those made from wheat flour with 2, 4 and 6% PL while, raising the replacement to 8% PL significant decrease was observed . The spread ratio of the 8% PL had the lowest values which were 8.44%. These results may be mainly due to the variation of the amount of wheat flour or gluten in the formula. This may be due to the dilution of gluten **(Kohajdová *et al*., 2014)**. This result agreed with (**Ajila *et al*., 2008)** and (**Ashoush and Gadallah,2011)** who mentioned low value of spread ratio for biscuits incorporated with mango peel powders. The above results confirmed the successful use of papaya leaves powder up to 6% replacing wheat flour in preparing biscuit with satisfactory acceptable quality.

Proximate chemical analysis of biscuits
Generally, the moisture content of biscuits increased significantly ($P < 0.05$) by increasing the level of PL incorporation. Generally ,the incorporation of PL at all levels in the biscuit samples significantly increased fat, protein ,crude fiber and ash more than the control which recorded lesser value in all properties .

Table (11): Proximate chemical composition and total phenolic content of biscuits containing different concentrations of papaya leaves powders.

Treatment	Moisture content (%)	Crude protein (%)	Crude Fat (%)	Crude fiber (%)	Ash (%)	Total phenolics mg GAE/100g
Control	6.14± 0.07b	6.15±0.05b	17.24±0.08c	2.71±0.10b	5.52±0.02c	252.94±15.17d
BPL (%)						
2	6.04±0.07b	6.17±0.02ab	17.24±0.08c	3.05±0.05b	5.77± 0.13b	274.28±5.60c
4	6.17±0.02a	6.23±0.07ab	17.48± 0.03b	3.17±0.56b	5.97± 0.07a	304.83±9.43b
6	6.22±0.02a	6.28±0.07a	17.63±0.03a	3.42±0.08a	6.19 ± 0.05a	320.58±4.50a

BPL: Biscuits Leaves powder
Means in a column not sharing the same letter are significantly different at $p \leq 0.05$.

As was expected, there was significant increase in the crude fiber and ash content of the biscuit samples. The values of crude fiber increased from 2.71% in control sample to 3.42% in sample incorporated with 6% PL. Also, the values of ash increased from 5.52% in control sample to 6.19% in sample incorporated with 6% PL. Crude fiber composition is a measure of the quality of indigestible cellulose ,pentose, lignin, and other indigestible materials **(Akajiaku *et al.*, 2018).** Regarding to total phenolic content, the results revealed that there was an improvement in the phenolic content with increasing the levels PL. The results in Table (**11**) showed that increasing the levels of PL gradually increased the content of phenolic contents compared to control biscuit samples. Biscuit treatments containing 6% PL had the highest total phenolic (320.58 mg GAE /100g). The benefits of adding papaya leaves to cookies in increase fiber levels and nutritional balance **(Slavin, 2005)**.

CONCLUSION

It could be concluded that the substitution of wheat flour by papaya peels were organoleptic accepted up to 15%level (PP) and enhanced the nutritive value of biscuits and its physical characteristics. Also, the substitution of wheat flour by papaya leaves enhanced the nutritive value of biscuits with very slight effect on its physical characteristics at 6% level of substitution.

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الملخص العربي

أستخدام مخلفات قشور وأوراق البابايا لتطوير بسكويت وظيفي ذو فوائد صحية واعدة

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تنتمي البابايا (*Carica papaya* L.) الي عائلة Caricaceae وتزرع علي نطاق واسع في المناطق الأستوائية .البابايا غنية بالمكونات الحيوية النشطة المختلفة والتي يعزي اليها خصائصها المضادة للأكسدة. يتم التخلص من كميات كبيرة من مخلفات الفاكهة يوميا من قبل الصناعات الغذائية ، والتي تمثل خسارة كبيرة في المغذيات. وتهدف هذة الدراسة الي تقييم الخصائص الكيمائية والبيوكيمائية والوظيفية للقشر المجفف وأوراق فاكهة البابايا في محاولة لانتاج مكونات صحية ذات قيمة مضافة لتقوية البسكويت. وكشفت نتائج التحليل الكيميائي التقريبي ان مسحوق الاوراق تمتلك مستخلص ايثري وبروتين خام أعلي بكثير من مسحوق القشور في حين ان مسحوق القشور يحتوي علي محتوي ألياف خام ورماد أعلي بكثير من مسحوق الاوراق .أشارت النتائج أيضا الي أن مسحوق القشور تحتوي علي تركيز أعلي بكثير من فيتامين ج،الفينول الكلي ،الفلافونويدات الكلية والتانينات الكلية أعلي من الاوراق (209,21مجم/100جم,1138,80مجم جاليك/100جم,536,41ريتن/100جم و 157,27مجم/100جم)علي التوالي. أما النشاط المضاد للأكسدة في مسحوق القشور والأوراق مقاسا بالDPPH وFRAP أ ظهر وجود أنشطة مضادة للأكسدة في القشور أعلي من الأوراق (48,38% و43,38%) علي التوالي·البسكويت المعد بنسب استبدال بالقشور 5,10 و15% أظهرت قبول عالي في جميع الخواص الحسية والخصائص الفيزيائية ·عزز التركيب الكيمائي التقريبي للبسكويت المستبدل بالقشورالقيمة الغذائية والصحية للبسكويت وتم تطبيق نفس الاتجاة أيضا علي استبدال البسكويت مع الاوراق(2–4–6%) حيث أشارت نتائج الخواص الحسية والخصائص الفيزيقية مرضية عند استبدال 6%·