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CHEMICAL COMPOSITION OF SOME SELECTED FRUIT PEELS

Feumba Dibanda Romelle[1], Ashwini Rani P.[2] and Ragu Sai Manohar[2]

[1] Food and Nutrition Research Centre, Institute of Medical Research and Medicinal Plant Studies, Yaounde, Cameroon
[3]Department of Flour Milling, Baking and Confectionary Technology, Central Food Technological Research Institute, Mysore, India

ABSTRACT: *Global fruit production has experienced a remarkable increase. In 2011, almost 640 million tonnes of fruits were gathered throughout the world. In some fruits, peels represent almost 30% of the total weight and are the primary by-product. This study aims to investigate the chemical composition of fruit peels of some selected fruits. Peels of eight fresh fruits (orange, watermelon, apple, pomegranate, pawpaw, banana, pineapple and mango) were removed and analyzed for their nutrients and anti-nutrients contents. The results showed that lipid, protein, ash, crude fiber and carbohydrates contents in fruit peels were respectively from 3.36 ± 0.37 to 12.61 ± 0.63%, from 2.80 ± 0.17 to 18.96 ± 0.92%, from 1.39 ± 0.14 to 12.45 ± 0.38%, from 11.81 ± 0.06 to 26.31 ± 0.01% and from 32.16 ± 1.22 to 63.80 ± 0.16%. The minerals composition of fruit peels was respectively from 8.30 ± 0.54 to 162.03 ± 7.54 mg/100g for calcium, 0.66 ± 0.06 to 6.84 ± 0.55 mg/100g for zinc, 9.22 ± 0.63 to 45.58 ± 2.37 mg/100g for iron and 0.52 ± 0.10 to 9.05 ± 0.34 mg/100g for manganese. Concerning anti-nutrients, oxalates, hydrogen cyanides, phytates and alkaloids levels in fruit peels were within the threshold value reported as safety limit. The phenolics content of fruit peels ranged from 0.91 ± 0.06 to 24.06 ± 0.89%. Due to the proven health benefits of phenolic compounds, peels of these fruits can be used as good ingredients in formulation of health benefits food products.*

KEYWORDS: Fruit peels, Nutrients, Anti-Nutrients, Phenolic Compounds

INTRODUCTION

Global fruit production has experienced a remarkable increase. Output has been growing at an annual rate of about 3 percent over the last decade. In 2011, almost 640 million tonnes of fruits were gathered throughout the world. India is the second largest producer of fruits after China, with a production of 81,285 million tonnes of fruits from an area of 6,892 million hectares. A large variety of fruits is grown in India, among which banana (32.6%), mango (22.1%), citrus (12.4%) and pawpaw (6.6%) are the major ones (Indian Horticulture Database, 2013).

Under the recommendation of WHO, a minimum daily intake of 400 g of fruit and vegetables must be observed, based on evidence that higher levels were protective against cardiovascular diseases and some cancers. This recommendation has led to the launch of the '5-a-day' fruit and vegetable campaign in many countries (HSCIC, 2012; Oyebode *et al.*, 2014) leading to an increase in fresh fruits consumption. In the other hand, because most of the fruits are seasonal and have low shelf-life, the majority of the fruits produced are processed to extend their availability all over the year. So fruits are usually processed into bottled fruits, juices, jams, marmalades, jellies, bars, pickles, dried or crystallized fruits, etc (UNIDO, 2004). However, fruits processing generates a great amount of wastes.

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By-products of fruits processing industry considered as fruits wastes consist mainly of core, seeds, pomace and peels, contain large amounts of water and are in a wet and easily fermentable form. If not processed further, these agrowastes produce odor, soil pollution, harborage for insects and can give rise to serious environmental pollution (Shalini and Gupta, 2010). Before, some attempts were made to use agrowastes essentially for livestock feed and fuel purposes. Recently, scientists were able to develop high value products from these by-products such as cosmetics, medicines and the recovery seems to be economically attractive (Ashoush and Gadallah, 2011). The idea of utilising fruit by-products mainly the peels which in some fruits represent almost 30% of the total weight, have slowly gaining popularity especially when researchers found that peels possessed better biological activities than other parts of the fruit (Moon and Shibamoto, 2009). More recently, with the increasing interest for natural sources of bioactive compounds and the popularity of the concept of functional foods, food products enriched with fruit peels are been developed (Babiker *et al.,* 2013 ; Altunkaya *et al.*, 2013). However the potential application of fruit peels in food supplementation depends strongly on their chemical composition. Hence in this study, the nutritional composition of some fruit peels is investigated with the aim of exploiting the potential value of these peels.

MATERIALS AND METHODS

Procurement of fruits

Three kilograms of each fresh and fully ripe fruits (pawpaw, pineapple, mango, apple, banana, orange, pomegranate, and watermelon) were purchased from the Mysore District Hopcoms (CFTRI). The fruits used were *Carica pawpaw* var. local (pawpaw local), *Ananas cosmos* var. Smooth Cayenne (Pineapple Smooth Cayenne), *Mangifera indica* var. Alphonso (mango Alphonso), *Malus sylvestris* var. Red Delicious (apple Red Delicious), *Musa acuminata* var. Cavendish (banana Cavendish), *Citrus sinensis* var. Navel (orange Navel), *Punica granatum* var. red cultivar (red cultivar of pomegranate) and *Citrullus lanatus* var. green cultivar (watermelon regular).

Preparation of fruit peels

Fresh fruits were washed and allowed to dry at room temperature. For mango, pawpaw, apple, banana and pineapple, all the peel was removed using either a scraper or a sharpened knife. For watermelon, pomegranate and orange, only the colored part of the peel were carefully peeled to minimise the inclusion of albedo which is an inner layer of spongy white tissue. The yield was recorded and fresh peels were dried at 50° C then ground to obtain a fine powder.

Determination of proximate composition

Moisture content was determined after oven drying to a constant weight at 105 °C. Ash, proteins, lipids and crude fibers were analyzed according to AOAC methods (AOAC, 1990; AOAC, 2000) and carbohydrates content was determined according to FAO (1982) by difference as follows:

Carbohydrate % = 100 – (moisture % + protein % + ash % + lipid % + crude fiber %).

Determination of mineral composition of fruit peels

An amount of 2 g of fruit peels was dried in an air oven at 105 °C for 3 hours. The dried sample was next charred until it ceased to smoke. The charred sample was then ashed in a muffle furnace at 550°C until a whitish or greyish ash was obtained. The ash was treated with concentrated hydrochloric acid transferred to a volumetric flask and made up to 100 mL before submission to atomic absorption spectrophotometry (AAS).

For AAS, a SHIMADZU atomic absorption flame emission spectrophotometer model AA-670 IF with an air-acetylene flame, and wavelength respectively set to 422.7 nm for calcium, 279.5 nm for manganese, 248.3 nm for iron and 213.9 nm for zinc determination was used. Stock solutions (1000 ppm) of calcium, manganese, iron and zinc were used to prepare working standard solutions with at least 4 concentrations within the analytical range. To eliminate phosphorus interference, lanthanum chloride was added to working standard solutions of calcium and to the test ash solution destined to calcium determination so that the final solutions contained 1% La. Concentration of each mineral contained in test solutions was calculated from the standard curve prepared.

Determination of anti-nutrients in fruit peels

The levels of anti-nutrients like hydrogen cyanides, phytates, alkaloids, oxalates and phenolic compounds were investigated using standardized procedures.

Determination of hydrogen cyanides content

The hydrogen cyanide content in fruit peels was determined by the procedure described by AOAC (1995).

Determination of phytates content

An amount of 4 g of fruit peel was soaked into 100 mL of 2% hydrochloric acid for five hours and was filtered. A volume of 25 mL of the filtrate was taken into a conical flask and 5 mL of 0.3% ammonium thiocyanate solution was added. The mixture was titrated with a standard solution of iron (III) chloride until a brownish-yellow colour persists for 5 min (Reddy *et al.*, 1982).

Determination of alkaloids content

About 5 g of each sample was weighed and dispersed into 50 mL of 10% acetic acid solution in ethanol. The mixture was well shaken and then allowed to stand for about 4 h before it was filtered. The filtrate was then evaporated to one quarter of its original volume on hot plate. Concentrated ammonium hydroxide was added drop wise in order to precipitate the alkaloids. A pre-weighed filter paper was used to filter off the precipitate and it was then washed with 1% ammonium hydroxide solution. The filter paper containing the precipitate was dried on an oven at 60 ^{o}C for 30 min, transferred into desiccators to cool and then reweighed until a constant weight was obtained. The constant weight was recorded. The weight of the alkaloid was determined by weight difference of the filter paper and expressed as a percentage of the sample weight analyzed (Harborne, 1973).

Determination of oxalates content

Fruit peel (2 g) of the sample was digested with 10 mL of 6 M hydrochloric acid for 1 h and

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made up to 250 mL in a volumetric flask. The pH of the filtrate was adjusted with concentrated ammonium hydroxide solution until the colour of solution changed from salmon pink colour to a faint yellow colour. Thereafter, the filtrate was treated with 10 mL of 5% calcium chloride solution to precipitate the insoluble oxalate. The suspension was now centrifuged at 2500 rpm, after which the supernatant was decanted and the precipitate completely dissolved in 10 mL of 20% sulphuric acid. The total filtrate resulting from the dissolution in sulphuric acid is made up to 300 mL. An aliquot of 125 mL of the filtrate was heated until near boiling point and then titrated against 0.01 N of standardized potassium permanganate solution to a faint pink colour which persisted for about 30 s (Oke, 1966).

Determination of total phenolics content

Total phenolics content in fruit peels were analyzed for total phenolics content according to the Folin-Ciocalteu method (Dewantoo *et al.*, 2002). An amount of 2 g of fruit peels paste was extracted with 20 mL of ethanol 80% for 1 h. The mixture was centrifuged at 3000 g for 10 min and the supernatant collected. To a volume of 100 µL of fruit peels extracts, were added 1.150 mL of distilled water and 250 µL of the Folin-Ciocalteau solution. After 6 min, 2.5 mL of a solution of sodium carbonate 7% were added and the volume was adjusted to 6 mL with distilled water. The mixture was allowed to stand for 90 min. Optical density was measured at 760 nm using a spectrometer. The calibration curve was obtained using gallic acid as standard and the concentration ranged from 20 to 600 mg/mL. The results were expressed as gallic acid equivalents/100 g of sample.

RESULTS AND DISCUSSION

Proximate composition of fruit peels

The yield of fruit peels and their nutrients content are presented in table 1. Table 1 reveals that the yield of peels in studied fruits ranged from 6.44 ± 0.02 to 33.81 ± 0.56%. The yield of banana peel obtained (33.81 ± 0.56%) was similar to the finding of Nagarajaiah and Prakash (2011) stating that banana peels form about 18-33% of the whole fruit. Similarly, the proportion of peels in pomegranate (11.69 ± 0.03%) was consistent with the finding of Eikani *et al.* (2012) who reported that pomegranate peel constitutes 5 to 15% of its total weight.

Table 1: Proximate composition of fruit peels

Fruit	Yield (g/100 g of fresh weight of fruit)	Proximate composition (g/100g dry peel)				
		Crude proteins	Lipids	Ash	Crude fibers	Carbohydrates
Pawpaw	10.21 ± 0.04	18.06 ± 0.92	5.47 ± 0.67	10.22 ± 0.05	12.16 ± 0.06	37.49 ± 0.74
Pineapple	9.17 ± 0.67	5.11 ± 0.02	5.31 ± 0.74	4.39 ± 0.14	14.80 ± 0.01	55.52 ± 0.92
Mango	9.94 ± 0.03	5.00 ± 0.09	4.72 ± 0.55	3.24 ± 0.18	15.43 ± 0.13	63.80 ± 0.16
Apple	10.20 ± 0.03	2.80 ± 0.17	9.96 ± 1.52	1.39 ± 0.14	13.95 ± 0.10	59.96 ± 0.44
Banana	33.81 ± 0.56	10.44 ± 0.38	8.40 ± 1.15	12.45 ± 0.38	11.81 ± 0.06	43.40 ± 0.55
Orange	14.27 ± 0.05	9.73 ± 0.63	8.70 ± 0.65	5.17 ± 0.98	14.19 ± 0.01	53.27 ± 0.10
Pomegranate	11.69 ± 0.03	3.46 ± 0.02	3.36 ± 0.37	6.07 ± 0.07	17.63 ± 0.05	59.98 ± 1.52
Watermelon	6.44 ± 0.02	12.42 ± 0.08	12.61 ± 0.63	5.03 ± 0.80	26.31 ± 0.01	32.16 ± 1.22

Values are means ± standard deviations of three replicate measurements.

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In the eight analysed fruit peels, the protein content ranged from 2.80 ± 0.17 to 18.96 ± 0.92%; the minimum level was found in apple peel and the maximum in pawpaw peels. This protein content found in pawpaw peels (18.06 ± 0.92%) was comparable to 17.9% obtained by Munguti *et al.* (2006) but higher compared to the protein content (14.1%) found in Solo pawpaw peel by Okai *et al.* (2010). The protein content in mango peel (5.00 ± 0.09%) was comparable to the crude proteins levels (4.68% and 4.32%) found in mango peels respectively by Omutubga *et al.* (2012).

The lipids content of fruit peels ranged from 3.36 ± 0.37 to 12.61 ± 0.63 % with pomegranate peels having the lowest content and watermelon peels the highest level. The lipids content in apple peels, pawpaw peels, orange peels and in mango peels was comparable to the content obtained respectively in apple star peel (8.94%) by Ukana *et al.* (2012), in pawpaw peel (5.78%) by Okai *et al.* (2010), in orange peel (9.52%) by Magda *et al*. (2008) and in mango peels (4.80%) by Omutubga *et al.* (2012). The lipids content found in banana peel (8.40 ± 1.15%) was comparable to 7.9% obtained by Munguti *et al.* (2006) but lower than 13.1± 0.2 %, value found in banana peel by Wachirasiri *et al*. (2009). This might be due either to the differences in varieties or to geographical factors.

The ash content of fruit peels under study varied from 1.39 ± 0.14% in apple peels to 12.45 ± 0.38% in banana peels. Similar observations was made by Emaga *et al*. (2007) who reported that the ash content in different banana peels varied from 6.4 to 12.8%. The concentrations of ash found in pomegranate peels (6.07 ± 0.07%) and in mango peels (3.24 ± 0.18%) were comparable to the level found by Naseem *et al.* (2012) in pomegranate peels (5.01 ± 0.14%) and in mango peels (3.88%) by Omutubga *et al.* (2012).

The crude fibers and carbohydrates content of fruit peels respectively ranged from 11.81 ± 0.06 to 26.31 ± 0.01% and from 32.16 ± 1.22 to 63.80 ± 0.16%. The crude fibres level observed in pomegranate peels (17.63 ± 0.05%) was comparable to the content obtained with peels of white cultivar of pomegranate (17.53 ± 0.74%) by Ismail *et al.* (2014). However, the carbohydrates level observed in pomegranate peels (59.98 ± 1.52%) was lower than 78.67% in pomegranate peel by the same author. This might be due either to the differences in varieties of cultivars.

Mineral composition of fruit peels

Minerals play a key role in various physiological functions of the body, especially in the building and regulation processes. Fruits are considered as a good source of dietary minerals (Ismail *et al*., 2011). The mineral composition of fruit peels is represented in table 2.

Table 2: Mineral composition of fruit peels

Fruit	Elements (mg/100g dry peel)			
	Calcium	Zinc	Iron	Manganese
Pawpaw	11.44± 2.09	2.68± 0.47	27.61± 0.15	0.52 ± 0.10
Pineapple	8.30±0.54	6.46 ± 0.43	25.52± 3.38	5.32 ± 0.49
Mango	60.63± 4.58	0.66 ± 0.06	12.79±1.56	4.77 ± 0.22
Apple	14.89 ± 2.25	0.95 ± 0.09	25.63 ± 2.47	1.28 ± 0.10
Banana	19.86 ± 0.24	1.72 ± 0.17	15.15 ± 0.36	9.05 ± 0.34
Orange	162.03±7.54	6.84 ± 0.55	19.95 ± 0.50	1.34 ± 0.27
Pomegranate	52.92±1.34	0.98 ± 0.11	9.22 ± 0.63	0.58 ± 0.08
Watermelon	11.21±0.58	3.78 ± 0.27	45.58 ± 2.37	1.25 ± 0.34

Values are means ± standard deviations of three replicate measurements.

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Calcium is an important constituent of bones and teeth and it is actively involved in the regulation of nerve and muscle functions (Soetan *et al*., 2010). The calcium content of fruit peels ranged from 8.30 ± 0.54 to 162.03 ± 7.54 mg/ 100 g. The minimum content was found in pineapple peel and the maximum in orange peels. The calcium content in banana peel (19.86 ± 0.24 mg/ 100g) was comparable to 19.20 mg/g of peel observed by Anhwange *et al*. (2009). The calcium content in apple peels (14.89 ± 2.25 mg/ 100 g) was lower than 48.9 ± 0.99 mg/ 100 g obtained by Manzoor *et al.* (2012) in apple peels. According to Leterme *et al*. (2006), several factors like variety, state of ripeness, soil type, soil condition, and irrigation regime may cause variation in the mineral and trace elemental contents in different types of fruits as well as within different parts of the same fruit.

Zinc is particularly necessary in cellular replication and the development of the immune response. Zinc also plays an important role in growth; it has a recognized action on more than 300 enzymes by participating in their structure or in their catalytic and regulatory actions (Salgueiro *et al*., 2002). Zinc levels in the fruit peels ranged from 0.66 ± 0.06 to 6.84 ± 0.55 mg/100 g, with the minimum being in mango peels and the maximum in orange peels. Zinc contents observed in peels of apple (0.95 ± 0.09 mg/100 g) and of pawpaw (2.68 ± 0.47 mg/100 g) were comparable to values obtained respectively by Soetan *et al*. (2010) in apple peels (0.9 ± 0.06 mg/100 g) and by Santos *et al.* (2014) in pawpaw peels (3.28 ± 0.06 mg/100 g).

Iron carries oxygen to the cells and is necessary for the production of energy, synthesis of collagen and the proper functioning of the immune system. Manganese is known to aid the formation of skeletal and cartilage. Iron and Manganese levels in analysed fruit peels ranged respectively from 9.22 ± 0.63 to 45.58 ± 2.37 mg/ 100g and from 0.52 ± 0.10 to 9.05 ± 0.34 mg/ 100g. The lowest level in both minerals was found to be in pomegranate peels while the highest levels are respectively found in watermelon for iron and in banana peels for manganese. However, the contents in both iron and manganese observed in banana peels are respectively lower than 0.61 and 76.20 mg/g obtained in banana peels by Anhwange *et al*. (2009).

Anti-nutritional composition of fruit peels

The anti-nutrients of fruit peels are given in table 3.

Oxalates can bind to calcium in food thereby rendering calcium unavailable for normal physiological and biochemical roles (Ladeji *et al*., 2004). The oxalate content in the eight fruit peels under study ranged from 41.02 ± 1.18 to 2,283.77 ± 2.66 mg/100 g. The lowest content was found in pawpaw peels and the highest in pomegranate peels. Oxalates content found in watermelon peels (128.40 ± 14.30 mg/100 g) was not consistent to 0.07 mg/ 100g found by Johnson *et al.* (2012) on dried watermelon rinds. This difference could be due to the part of the rind used since our study was conducted on pericarp.

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Table 3: Anti-nutrients levels in fruit peels

Fruit peels	Oxalates content (mg %)	Hydrogen cyanides content (mg %)	Alkaloids content (%)	Phytates content (%)	Total phenolics content (%)
Pawpaw	41.02 ± 1.18	69.83 ± 0.01	15.36 ± 1.63	3.16 ± 0.30	2.65 ± 0.14
Pineapple	129.06 ± 15.95	71.50 ± 0.02	16.19 ± 3.28	1.99 ± 0.01	1.42 ± 0.09
Mango	404.88 ± 13.06	45.90 ± 0.01	8.34 ± 1.21	1.63 ± 0.10	24.06 ± 0.89
Apple	89.07 ± 2.46	96.04± 0.03	7.99 ± 1.19	1.42 ± 0.20	8.86 ± 0.09
Banana	280.88 ± 12.37	116.26 ± 0.02	6.88 ± 0.78	6.02 ± 0.61	7.40 ± 0.17
Orange	99.78 ± 6.16	39.79 ± 0.01	5.44 ± 0.72	2.34 ± 0.47	13.54 ± 0.96
Pomegranate	2,283.77 ± 2.66	26.96± 0.01	6.50 ± 0.62	1.33 ± 0.10	22.67 ± 0.27
Watermelon	128.40 ± 14.30	121.02 ± 0.02	10.09 ± 1.78	0.70 ± 0.17	0.91 ± 0.06

Values are means ± standard deviations of three replicate measurements.

Hydrogen cyanide is an extremely poisonous substance formed by the action of acids on metal cyanides. The levels of hydrogen cyanides ranged from 26.96 ± 0.01 to 121.02 ± 0.02mg/ 100g. The lowest level was obtained in pomegranate peels and the highest in watermelon peels. The hydrogen cyanide content found in banana peels (116.26 ± 0.02 mg/100g) was comparable to 133 ± 10 mg/100g observed by Anhwange *et al.* (2009). Large dose of hydrogen cyanide can cause death within few minutes, while smaller dosages may result to stiffness of the throat, chest, palpitation and muscle weakness. The result obtained falls within the threshold value (below 350 mg/ 100g) reported as safety limit (Anhwange *et al.*, 2009).

The alkaloids content in fruit peels ranged from 5.44 ± 0.72 to 16.19 ± 3.28%, pineapple peels having the highest alkaloids content and orange peels the lowest. The alkaloid contents observed in the analysed fruits are lower than 29.5% of alkaloids found by Adeniyi *et al.* (2009) in Irish potatoes.

Phytic acid found in plant materials is known for its chelating effect on certain essential mineral elements such as Ca, Mg, Fe and Zn to form insoluble phytate salts (Agte *et al.*, 1999). Phytates in fresh fruit peels analysed ranged from 0.70 ± 0.17 to 6.02 ± 0.61%. The lowest level was found in watermelon peels and the highest in banana peels. The phytates level obtained in pomegranate peels (1.33 ± 0.10%) was lower than 10.5% evaluated by Calín-Sánchez *et al.* (2013) in fresh pomegranate arils. This value (10.5%) observed by Calín-Sánchez *et al.* (2013) in fresh pomegranate arils was even higher compared to the maximum value observed in our study on fruit peels.

The phenolics content of fruit peels ranged from 0.91 ± 0.06 to 24.06 ± 0.89%. Watermelon and mango peels contain respectively the lowest and the highest phenolics content. In humans, phenolic compounds have been reported to exhibit a wide range of biological effects including anti-bacterial, anti-inflammatory and antioxidant properties (Han *et al.*, 2007).

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CONCLUSION

Watermelon, pawpaw, orange, pineapple, banana, apple, mango and pomegranate have important proportions of peels. Those peels are sources of nutrients (lipids, proteins, minerals, etc.) with levels of anti-nutrients below the safety limits. Anti-nutrients like phenolic compounds are also phytochemicals that possess proven health benefits. Therefore, peels of these fruits can be used as good ingredients in formulation of health benefits food products.

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