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Original Article

Proximate Analysis and Phytochemical Screening of Selected Fruit and Vegetable Peels Readily Available in Malaysia

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Abstract

Fruit peels are a substantial source of nutrients and specific phytochemicals that may be efficiently utilised for the creation of nutraceuticals and to enhance food security. Wastes from fruits and vegetables, especially their peels, are used to make carbon dots, biochar, edible films, and biosorbents. Although these methods are still in their infancy, these items are ecologically friendly and sustainable, and they could be useful. This research aims to assess the proximate analysis and phytochemical screening of the peels of three fruits (banana, orange, watermelon) and two vegetables (potato, bottle gourd) collected from kitchen waste. From the proximate analysis, it was found that watermelon, orange and bottle gourd possess a high value of moisture content which means these peels contain various nutrients and bioactive compounds. Banana, watermelon and bottle gourd peels had high ash content value indicating the presence of substantial minerals. Banana, bottle gourd and potato peels showed a high protein content indicating potential biological activities. From the phytochemical analysis it was found that most of the properties are present in all peels indicating their antioxidant, antimicrobial and anti-inflammatory effects. Therefore, food wastes, especially fruit and vegetable peels are rich in vital nutrients necessary for optimal human health.

Keywords: *Fruit Peels, Kitchen Waste; Proximate Analysis; Phytochemical Composition; Vegetable Peels*

Introduction

Vegetables and fruits are a broad category of plant foods with widely differing nutritional and calorie contents (Slavin, & Lloyd, 2012). Research found that peels from fruits and vegetables are a great source of fiber, proteins, carbs, and phytochemicals, mostly phenolic compounds. Fruit peels are rich in antioxidants and certain minerals that can be effectively employed for the production of nutraceuticals and to ensure food security (Hussain *et al.*, 2023; Samsuri *et al.*, 2020). On the other hand, food processing results in a considerable loss of nutritional value, and waste production poses major environmental and economic issues. Fruit and vegetable trimmings include husk, peels, pods, pomace, seeds, and stems; they are often thrown away even though they may contain valuable nutrients including carotenoids, dietary fibers, enzymes, and polyphenols that may be advantageous (Bhardwaj *et al.*, 2022). Fruit and vegetable waste, particularly peels are utilized in poor nations to create beneficial goods such as edible films, carbon dots, biochar, and biosorbents. These products are sustainable and

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environmentally benign, and they may be put to good use. However, since many of these approaches are still in their early stages, further research and advancements in our understanding are needed. Fruit and vegetable peels are becoming more and more popular as a subject for exploration because of their potential applications.

Malaysia is one of the nations that has experienced accelerated economic growth and has a large population. As Malaysia's economy expanded, it also produced a wide range of fruits and vegetables. Not only Malaysians enjoy this locally farmed food, but it is also exported to other nations. In addition to being farmed for food, Malaysian fruits and vegetables are also industrially processed to make fruit juice, canned fruit, and flavoring. Fruit wastes such as watermelon rind, mango peel, rambutan skin, and other fruit residues, primarily the peels and seeds, are produced in large quantities, especially in the food industrial area and in large cities like Kuala Lumpur, due to the high consumption and industrial processing of the edible parts of the fruits. Fruit waste is really one of the primary causes of municipal solid waste (MSW), which has become a more serious environmental problem (Ibrahim *et al.*, 2017). The reasons for food waste differ throughout nations, however, it is yet unknown what the characteristics and patterns of food wastes are in Malaysia. As a result, changes in consumer behavior might affect the food supply chain and food waste management (Gustavsson *et al.*, 2011; Phooi *et al.*, 2022).

The reduction of municipal solid waste is essential, and one of the methods to achieve this is by minimising fruit and vegetable waste, particularly peels. This present study seeks to examine the proximate composition of common fruit (banana, watermelon, and orange) and vegetables (potato and bottle gourd) peels. This can be utilised for renewable resources.

Materials & Methods

Study Area

Samples (domestic kitchen waste) were collected from the Kelana Jaya residential area an urban area near Kuala Lumpur Malaysia. There are many condominiums in this area, but we only focused on three big condominiums. From each condominium, six houses were selected; therefore, the samples were collected from a total eighteen houses.

Collections of Samples

During collection, we briefly explained our work to the residents and provided them with recycling bags to keep their kitchen waste and sort out only fruits and vegetable peels. Samples were collected and segregated daily for three weeks.

Sample Preparation

The segregated peels were sundried separately. After fully dried, all peels were ground by an electric mixture grinder. Each peel powder was kept in an airtight bottle for further research.

Process of Proximate Analysis

The proximate analysis part was conducted at the University Putra Malaysia Serdang campus in the Nutrition Department adopting the methods by the Association of Official Analytical Chemists (AOAC, 1990; AOAC, 2005). The process was done as follows:

Measuring Moisture Content

This method consists of measuring the weight lost by the sample due to the evaporation of water. The present study was performed by taking the sample in an aluminium cup. First, the weight of the empty aluminium cup was measured and then along with the sample, it was reweighed. The aluminium cup along with the sample will be kept overnight (16-18hours) in a tray dryer where the temperature was maintained at 100^0C 105^0C. After an overnight drying the sample was collected in a desiccator, cooled and reweighed along with the aluminium cup.

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where,
W_1 = Weight of empty aluminum cup
W_2 = Weight of aluminum cup + sample before drying in a tray dryer
W_3 = Weight of aluminum cup + sample after drying overnight (16-18 hours) in tray dryer at 100°C-105°C

Measuring Ash Contents

In our present study total ash content of kitchen waste was determined by the following methods: At first tare weight of silica dishes (7-8 cm diameter). Weigh 5 gm of the sample into each. Ash the material not more than 525^{0}C for overnight, in a muffle furnace. Cool the dishes and weigh them. The difference in weights gives the total ash contents and is expressed as a percentage.

Measuring pH value

One gram of each sample was taken in a flask and added with 20ml of distilled water and kept for 30 minutes then the pH of each sample was measured using a pH meter.

Measuring Acidity

For measuring the acidity, one gram of each sample was diluted with 50ml of distilled water and mixed at 700 rpm for two minutes and centrifuged. 0.1(N)NaOH solution was taken in burette &10ml of diluted sample in100 ml conical flask. 1-2 drops of phenolphthalein were used as an indicator. The endpoint was detected by a change in colour (sample colour to light pink). From the titer value obtained from the titration process, the calculation was done for the % of total acid expressed as citric acid (eq.wt.= 70).

Calculation:

$$\% \text{ Total acid} = \frac{\text{Titre} \times \text{Normality of alkali} \times \text{Volume made up} \times \text{Equivalent weight of acid} \times 100}{\text{Volume of sample taken for estimation} \times \text{weight of volume of sample taken} \times 10^3}$$

Measuring Total Nitrogen

Kjeldahl Method was followed for measuring the nitrogen content in samples. One gram of each sample was taken in a Kjeldahl digestion flask adding two tablets of Kjeldahl sulphate with 12 ml of H_2SO_4 and run on a digestion chamber. The ammonium sulphate formed is decomposed with an alkali (NaOH), and the ammonium liberated is absorbed in excess of neutral boric acid solution which is done in a distillation apparatus. Finally, the solution obtained in the previous step is titrated with 0.2N HCl.

Calculation :

$$\text{Nitrogen } \% = \frac{[(\text{Sample -Blank) titre}] \times \text{Normality of HCl} \times 14 \times \text{Volume made up of the digest} \times 100}{\text{Aliquot of the digest taken} \times \text{Weight of the sample taken} \times 1000}$$

Measuring Protein Content

The percentage of protein was calculated using the formula below:

$$\text{Protein } (\%) = \text{Nitrogen } (\%) \times 6.25$$

Measuring Fat Content

The Soxhlet method was followed for measuring the fat content in samples. Soxhlet method is a semi-continuous solvent extraction method. A ground sample is to be weighted in a porous thimble and then placed in an extraction chamber suspended above a flask/container containing solvent. The flask is heated, the solvent is evaporated and converted onto liquid at the condenser and passes through the sample extract the lipids and channel them into the flask. After several hours of extraction, the flask containing the solvent is removed and evaporated.

Calculation

$$\text{Fat,(g/100g)} = (W2 - W1 \div S) \times 100$$

W1=Weight of dried aluminium/glass cup
W2= Weight of dried aluminium/glass cup after extraction
S=Weight of sample

Phytochemical Analysis

For phytochemical analysis, Nostro *et al.*, (2000) was referred with slight modification. 10 gram of each sample was mixed with 100ml of 95% methanol and kept in shaking incubator at 200rpm at 37^0C for 18hours. Next. the solution was filtered using whatman filter paper and dried in a water bath at 50^0C. For phytochemical testing, a 20% (w/v) stock solution of each dry extract was prepared in pure dimethylsulfoxide (DMSO).

Identification Test

Test for Glycosides:

Bromine water test: To detect glycosides, the test solution was dissolved in bromine water and a yellow precipitate formed, indicating their existence (Bhandary *et al.*, 2012).

Test for Terpenoid (Triterpenoids):

In a test tube with 2 ml of chloroform, 0.5 ml of test solution was added. Next, add 3 ml of concentrated H_2SO_4 to form a layer. The reddish-brown coloring of the interface shows terpenoids (Rao *et al.*, 2016).

Test for Phenols:

Iodine test: 1 ml of test solution and added a few drops of diluent Iodine solution. If it is a fleeting red color indicating the presence of phenols (Shaikh & Patil, 2020).

Test for Saponins:

A total of 10 drops of test solution were mixed with 5 drops of hot water, cooled, then violently shaken for 10 seconds. If a large amount of foam is created for 10 minutes as high as 1 centimeter to 10 cm and does not vanish with the addition of hydrochloric acid 2N 1 drop, it indicates the presence of saponin content (Murtiningsih *et al.*, 2023).

Test for Flavonoids:

In a test tube, the 1 ml test solution was combined with a 2 ml ammonium hydroxide solution and two or three drops of concentrated sulfuric acid. The presence of yellow fluorescence indicates a favourable result for flavonoids (Alemu *et al.*, 2024).

Test for Alkaloids: (Wagner's reaction)

Mixed 1ml test sample, 1ml potassium iodide iodine, and 3 drops of concentrated sulfuric acid. If precipitation comes to be dark or reddish brown indicates the presence of alkaloids. (Das & Gezici 2018)

Test for Tannins

In a test tube, add 1 ml of test solution and 2 ml of 10% $FeCl_3$ solution in methanol. Tannins produce a green to black precipitate (Elgailani & Ishak 2016).

Statistical Analysis

To validate the results we use one way Anova (Duncan's post hoc test) by SPSS 27 tools.

Result

The Proximate analysis shows that banana peels contain good moisture content (8.46±0.54%) and a normal pH value. It also has a higher protein (0.93±0.03 %) value compared to fat and nitrogen (Table 1, Figure 1). The total acid and ash content in banana peel is respectively (0.93±0.20% & 11.60±0.92%).

Watermelon peel is a high source of moisture (13.93±0.07%) with a slight basic value. The Ash content of watermelon peel (6.20±1.39%) was lower than banana peel. Watermelon contains crude protein (0.66±0.07%) which was higher than fat and nitrogen content. Orange peel had a high moisture content (18.32±0.68%) among the five peels and slight acidic. Fat, nitrogen and protein contents in orange peel were 0.24±0.02%, 0.10±0.01%, 0.63±0.09% respectively. The value of ash content in orange peel was (4.00±0.35%). The value of pH in potato peel is almost neutral (6.42±0.01) and the presence of moisture content is medium (6.97±0.04%). Ash content in potato peel was normal (5.40±1.83%) where protein content was high (1.50±0.05%) compared to fat and nitrogen. Moisture content in bottle gourd peel (15.08±0.08%) was very high compared to other peels and pH was neutral (5.51±0.01) with a good value of ash content (9.93±0.42%). Bottle gourd peel had a high protein content value (2.14±0.13%) compared to fat and nitrogen.

Table 1: Proximate composition of different peels

	Moisture Content (%)	pH	Ash Content (%)	Total Acid (%)	Fat Content (%)	Nitrogen Content (%)	Protein Content (%)
Orange Peel	18.32±0.680^{c}	4.42±0.01^{c}	4.00±0.35^{a}	1.28±0.20^{c}	0.24±0.02^{b}	0.10±0.01^{a}	0.63±0.09^{a}
Banana Peel	8.46±0.54^{a}	5.84±0.05^{a}	11.60±0.92^{c}	0.93±0.20^{b}	0.04±0.06^{a}	0.14±0.01^{b}	0.93±0.03^{b}
Watermelon Rind	13.93±0.07^{b}	8.80±0.04^{b}	6.20±1.39^{b}	0.35±0.00^{a}	0.02±0.02^{a}	0.10±0.01^{a}	0.66±0.07^{a}
Potato Peel	6.97±0.04^{d}	6.42±0.01^{d}	5.40±1.83^{ab}	1.51±0.20^{c}	0.45±0.13^{c}	0.24±0.07^{c}	1.50±0.05^{c}
Bottle Gourd Skin	15.08±0.08^{e}	5.51±0.01^{e}	9.93±0.42^{c}	1.98±0.20^{d}	0.53±0.03^{c}	0.34±0.02^{d}	2.14±0.13^{d}

*The mean difference is significant at the 0.05 level. mean ± SD, *n* = 3, Duncan's post hoc test.

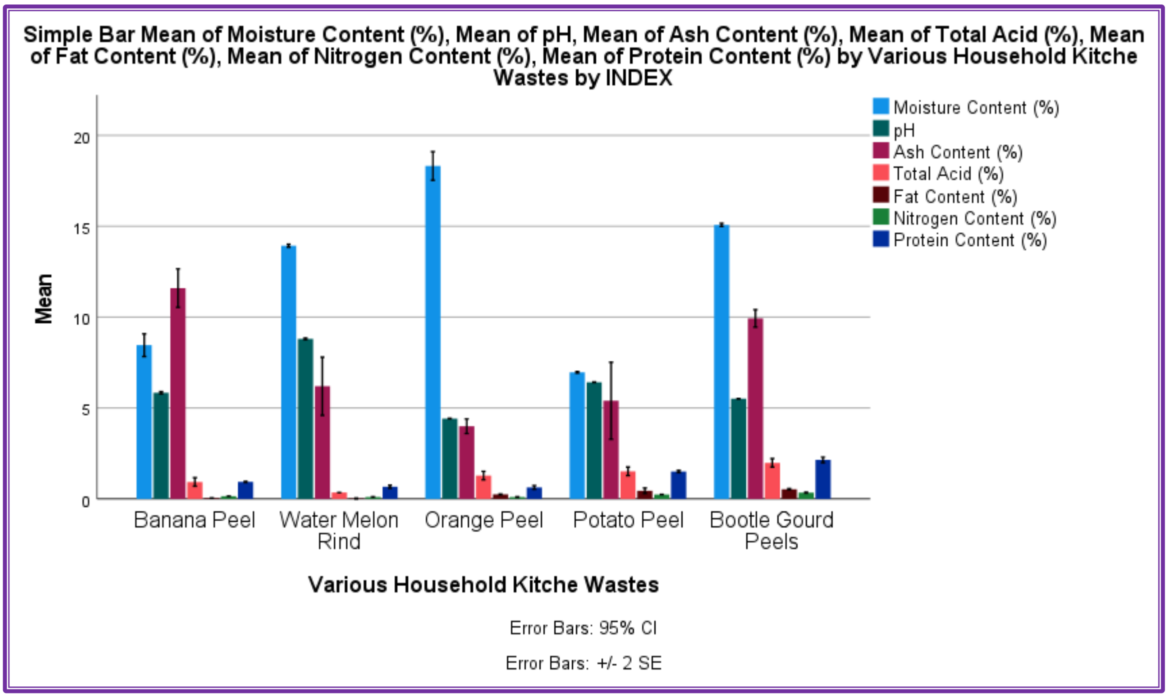

Figure 1. Proximate composition of different peels

Identification tests for all peels showed that all phytochemical compounds are present in the selected peels which is clearly mentioned in Table 2. From Table 2, it is observed that terpenoid, phenolic compound and flavonoids are absent in bottle gourd peel where sapoins is absent in orange peel. The remaining tests showed good results. This means that the peels have potential antioxidant, antimicrobial and prevention of disease activities.

Table 2: Phytochemical tests for different peels

Sample	Result	Observation
Determination of Glycoside		
Orange peels	(+)	Yellow colour observed
Banana peels	(+)	Yellow colour observed
Watermelon rinds	(+)	Yellow colour observed
Potato peels	(+)	Yellow colour observed
Bottle gourd skins	(+)	Yellow colour observed
Determination of Terpenoid		
Orange peels	(+)(+)	Deep reddish-brown colour observed
Banana peels	(+)	Reddish-brown colour observed
Watermelon rinds	(+)	Reddish-brown colour observed
Potato peels	(+)(+)	Deep reddish-brown colour observed
Bottle gourd skins	(-)	No colour observed
Determination of Phenols		
Orange peels	(+)	Red precipitate observed
Banana peels	(+)(+)	Deep red precipitate observed
Watermelon rinds	(+)(+)	Deep red precipitate observed
Potato peels	(+)(+)	Deep red precipitate observed
Bottle gourd skin	(-)	No precipitated observed
Determination of Saponins		
Orange peels	(-)	Foam not found
Banana peels	(+)	Foam observed
Watermelon rinds	(+)	Foam observed
Potato peels	(+)	Foam observed
Bottle gourd skins	(+)	Foam observed
Determination of Flavonoids		
Orange peels	(+)	Yellow colour observed
Banana peels	(+)	Yellow colour observed
Watermelon rinds	(-)	Yellow colour not observed
Potato peels	(+)	Yellow colour observed
Bottle gourd skins	(-)	Yellow colour not observed
Determination of Alkaloids		
Orange peels	(+)(+)	Deep reddish-brown colour observed
Banana peels	(+)(+)	Deep reddish-brown colour observed
Watermelon rinds	(+)(+)	Deep reddish-brown colour observed
Potato peels	(+)(+)	Deep reddish-brown colour observed
Bottle gourd skins	(+)(+)	Deep reddish-brown colour observed
Determination of Tannins		
Orange peels	(+)(+)	Deep green to black precipitate observed
Banana peels	(+)(+)	Deep green to black precipitate observed
Watermelon rinds	(+)	Green to black precipitate observed
Potato peels	(+)(+)	Deep green to black precipitate observed
Bottle gourd skins	(+)(+)	Deep green to black precipitate observed

(+) = positive reaction; (-) = negative reaction; (++) = highly positive reaction

Discussion

Numerous plants that are mostly used as food and medicinal herbs have been shown to have some active compounds. In order to use these plants for a variety of purposes, a great deal of study has been done to identify the phytochemical compositions and proximate compositions of distinct plant sections. This study aimed to assess the phytochemical and proximate compositions of peels from three fruits and two vegetables commonly found in Malaysia.

It was found from our research that glycoside, terpenoid, phenolic compounds, saponins, flavonoids, alkaloids, and tanin were found in waste banana peels which was supported by previous studies (Onojah & Emurotu 2017; Puraikalan, 2018) According to earlier reports, these phytochemicals have a variety of pharmacological and biological roles. Therefore, the existence of these bioactive compounds in banana peels indicates that the peels have significant untapped therapeutic potential (Chimdi *et al.*, 2024). In this research, the moisture content of banana peel is 8.46±0.54%. The freshness and shelf life of foods and processed goods are indicated by their moisture content; a high moisture content makes food items more susceptible to microbial spoiling and short shelf life, which may cause degradation. A sign that a banana peel is less vulnerable to microbial assault is its high moisture content (Tsado *et al.*, 2021). The result of the present study found that the presence of crude protein is 0.93±0.03% which is higher than nitrogen and fat is supported by Chimdi *et al.*, 2024. Significant nutritional and possible health advantages are revealed by the proximate composition and bioactive components of banana peels, underscoring the possibility of using this baking waste in a variety of applications (Segura-Badilla *et al.*, 2022; Puraikalan, 2018).

The powdered watermelon peel showed substantial levels of ash, protein, and moisture content, as shown in Table 1 which is in line with the research of Hussain *et al.*, (2024) The peels, which are often seen as waste streams, also contain some fat and protein. The Cucurbitaceae family of fruits is an excellent source of ash, fat, fibre, and carbohydrates. The phytochemical composition of the various portions of these fruits varies (Bai *et al.*, 2020) Plant dietary ash is helpful in establishing and maintaining the acid-alkaline balance of the blood system in regulating hyperglycemia conditions, even though the ash content of a plant food is determined by the mineral elements present (Yargamji, *et al.*, 2024). From this study, it is found that the pH value and total acid of watermelon peel were recorded at 8.80±0.04, and 0.35±00, respectively. The pH and titratable acidity of the watermelon flesh are typically observed as the quality properties that contribute to the fruit's flavour. The optimal equilibrium between sourness from the acidity and sweetness is determined by these factors. Consequently, the intensity of the fruit's saccharine essence will be influenced by the quantity of titratable acidity (Sabeetha *et al.*, 2017). Saponins, tannins, alkaloids, flavonoids, steroids, triterpenoids and glycoside are those of phytochemical compounds presented in watermelon peels as observed in Table 2 which is in line with the previous study by Neglo *et al.* (2021). The presence of alkaloids, tannins and saponin is known to possess antimicrobial anti-fungal and antibacterial properties (Tabiri *et al.*, 2016; Voutquenne-Nazabadioko, 2018; Arapitsas, 2012). It was established that watermelon peels have nutritional and essential contents as they can be used in bakery industry (Al-Sayed, & Ahmed 2013; Imoisi *et al.*, 2020).

Phytochemicals are plant compounds that are non-nutritive and exhibit varying degrees of disease-preventive properties (Oikeh *et al.*, 2013). Phytochemical analysis in the present study of orange peel methanolic extract showed the presence of tannins, terpenoids, flavonoids, phenolic compounds, alkaloids and glycoside except for saponins which in line with Gotmare, & Gade *et al.*, (2018) As almost all phytochemicals are present in the waste of orange peel, it have a great value in the pharmacological study (Devasagayam *et al.*, 2004). Alkaloids, which are found in large amounts in orange peel, are naturally occurring nitrogenous bases that have been used for a long time to treat parasites, protozoa, and malaria. (Akinlabu *et al.*, 2024) From proximate analysis of this study it is observed that moisture content of orange peel is very high (18.32±0.68%), pH is slightly acidic (4.42±0.01) and ash content is (4.00±0.35%) which is almost in line with M'hiri *et al.*(2015). Elevated moisture plays a significant role in enhancing the rate of food spoilage. Orange peel contains more protein content compared to nitrogen and fat. Orange peels may be a valuable source of protein in animal feed formulations (Akinlabu *et al.*, 2024). As orange peels contain phytochemical properties with good protein value, it may be useful as an ingredient in the bakery industry (Zaker *et al.*, 2016; Okpala, & Akpu 2014).

The analysis of potato peel content in this research revealed the presence of phenolic compounds, flavonoids, alkaloids, tanin, terpenoid and sapoins which is in line with the previous study conducted by Hidayat *et al.* (2024) and Tiarasanti *et al.*, (2024). Because of the presence of these phytochemical compounds, potato peels have wound healing activity, may prevent cell mutations, anticarcinogenic, antibacterial, anti-inflammatory, anti-allergic activities (Anggraini *et al.*, 2018; Gebrechristos *et al.*, 2020; Silva-Beltrán *et al.*, 2017; Wahyudi *et al.*, 2020). This study revealed that the value of pH in potato peel is almost neutral (6.42±0.01) and presence of moisture content is medium (6.97±0.04%). Ash content in potato peel is normal (5.40±1.83%) where protein content is high (1.50±0.05%) compared to fat and nitrogen which is similar to Cozma *et al.* (2024). As there is the presence of the above nutritional elements, potato peels can be used as food products (Rahman *et al.*, 2015; Akter *et al.*, 2023).

Nutritional analysis of the edible portion (peels) of bottle gourd shows the presence of good amounts of nutritional elements in our study. It is found that bottle gourd peels have high moisture and ash content values,15.08±0.08% & 9.93±0.42%, respectively, where pH value of bottle gourd peels is slightly acidic and also have high protein content (2.14±0.13%) comparing to fat and nitrogen that is almost line with the previous study (Sadef *et al.*, 2022). Phytochemical screening indicated the presence of various beneficial compounds except for flavonoids and phenolic compounds (Akter *et al.* 2019). As the presence of the above nutritional elements in bottle gourd peel waste can be used as food and bakery products (Sharma *et al.*, 2023; Ghufran Saeed *et al.*, 2022).

About 42% of fruit and vegetable waste is produced only by families, 38% by the food processing sector, and 20% by other food chain segments as revealed by Baiano (2014). Half of the fresh fruit and vegetable peels that are produced by the food processing industry and homes are mechanically eliminated. These leftover peels that possess a high amount of phenolic contents, proteins, lipids, fibre, carbohydrates, and energy are promising factors for their high nutritional value and antioxidant activity. Fruit and vegetable peels are of tremendous scientific curiosity and potential food because they contain a range of bioactive elements, particularly phenolic content for medical and biological uses.

Conclusion

Food wastes particularly from, fruit and vegetable peels are included as vital source of nutrients necessary for the maintenance of optimum human health. The present investigation illustrated that fruit peels are more nutritious as a result of their substantial total phenolic content. This study indicated that the promotion of kitchen waste utilisation, namely fruit and vegetable peel waste, at the commercial level is advisable. They are economically viable and nutrient-dense substances that provide health advantages. The present study revealed that the commercial extraction of significant bioactive components from natural fruits and vegetable peels, which serve as a source of natural antioxidants, making them high-value goods with economically appealing recovery potential.

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Conflict of Interest

The authors declare there is no conflict of interest.

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