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# COMPARATIVE ANALYSES OF PROXIMATE COMPOSITION, BIOACTIVE COMPOUND AND ANTIOXIDANT ACTIVITY IN DIFFERENT PARTS OF GREEN AND RIPE PASSION FRUIT

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**ABSTRACT**

The current research was undertaken to compare the proximate composition and antioxidant activity of different parts of green and ripe passion fruit. The proximate composition, bioactive compounds and antioxidant activity of different parts of passion fruit were analyzed by standard methods. According to the results, the ash content of the peel and seed of ripe passion fruit was higher than that of the green one, but only significant ($P<0.05$) for the seed. Besides, the crude fiber, carbohydrates, and protein content of the peel, pulp, and seed of ripe passion fruit were relatively higher ($P<0.05$) than those of the green one. At $P<0.05$, the fat content of green peel and pulp was higher than that of ripe, but the seed content of ripe was higher. The peel and pulp of green passion fruit contain the highest amounts of total polyphenol content (TPC) and total flavonoid content (TFC) than ripe passion fruit ($P<0.05$). The highest amount of TPC is contained in the seed of green passion fruit than in ripe fruit ($P>0.05$), but the seed of ripe fruit contains TFC almost twice as much as green fruit ($P<0.05$). It was also found that the peel and pulp of ripe passion fruit contain a higher percentage of total antioxidant activity (TAA) and vitamin C ($P<0.05$) than the pulp of a green one. The seed of the green one contains a slightly higher percentage of TAA than the seed of the ripe fruit ($P<0.05$), but vitamin C was opposite ($P<0.05$). It is concluded that the pulp, peel, and seed of green and ripe passion fruit have great potential as a health-promoting source that is normally underutilized.

## 1. Introduction

Micronutrients may be found in abundance in fruits and vegetables. Furthermore, these foods are high in phytochemical compounds (mostly polyphenols), which have a variety of wellbeing properties (Singh *et al.,* 2016a). These phytochemicals reduce oxidative stress and have synergistic actions, resulting in anti-inflammatory, antibacterial, anti-mutagenic, anti-tumor, and cognitive activities (Kang *et al.,*

2011; Zielinski *et al.,* 2014; Sing *et al.,* 2016b). Polyphenols have been found in a broad variety of fruits and vegetables. Furthermore, they provide enough amounts of dietary fiber, which is crucial for maintaining intestinal health as well as preventing cardiovascular illnesses, cancer, obesity, and diabetes (Elleuch *et al.,* 2011). As a result, in the human diet, frequent eating of fruits and vegetables is suggested. Bangladesh is endowed with a wide variety of fruits and was ranked sixth in the world for tropical fresh fruit output in 2017 (FAOSTAT, 2019). A large number of tropical fruits, sometimes referred to as indigenous or small fruits, are underutilized. These fruits are not commonly available in national or international marketplaces since they are not commercially grown. These fruits are typically found in backyards, unused highlands, hill tracts, and along roadsides. These fruits require no special care or agricultural management, which is why they are referred to as "underutilized small indigenous fruits" in Bangladesh, where they are being decimated year after year. These small fruits, on the other hand, can be an excellent source of vitamins and antioxidants (Molla *et al.,* 2021).

Passion fruit, or *Passiflora edulis*, is a tropical and subtropical fruit that is important due to its balanced nutrition and health advantages (He *et al.,* 2020). The genus Passiflora is the biggest in the Passifloraceae family, with over 500 species. Passiflora edulis, in particular, stands out due to its economic and therapeutic significance. (Dhawan *et al.,* 2004). It is commonly planted in tropical and subtropical locations across the world, particularly in South America, Florida, the Caribbean, South Africa, and Asia (Zhang *et al.,* 2013; Yuan *et al.,* 2017; Hu *et al.,* 2018). In Bangladesh, passion fruit, locally named Tang Phal, which is high in vitamins A and C, has been grown in Chittagong's hill areas for a few years, but it is not available in other areas. However, the Bangladesh Agricultural Research Institute developed a local variety called BARI Passion Fruit-1 in 2003, which has been growing in some areas of Panchagarh district (Daily Star, 2022).

Apart from their enormous economic and nutritional potential (Santana & Naves, 2003), there are very few manufactured goods on the market. However, there is very little information on the chemical characteristics and potential of these fruits, especially when it comes to their green to ripe, pulps and edible seeds, and the material that is accessible is dispersed or does not meet scientific requirements. Furthermore, in Bangladesh, research on the bioactive components and antioxidant activity of passionfruit is pretty scarce. As a result, the current study was conducted to determine the proximate composition, bioactive compounds, and antioxidant activity of different parts of green and ripe passion fruit accessible in Chittagong, Bangladesh, in order to enhance awareness of these fruits and to expand the possibilities for their use in new high-value products.

## 2. Materials and methods

### 2.1. Research plan and study location

Investigative research based on proximate composition, bioactive compound and antioxidant activity of different parts of green and ripe passion fruit. Samples of green and ripe passion fruit were purchased from the local market in Cox's Bazar, Chittagong, Bangladesh. The study was conducted in the research laboratory of the Food Technology and Nutritional Science (FTNS) department at Mawlana Bhashani Science and Technology University, Santosh, Tangail-1902, Bangladesh.

### 2.2. Analysis of proximate composition

#### *2.2.1. Analysis of moisture content*

The percentage of moisture was examined by the procedure given in AOAC (2005) method. At first, the empty crucible was dried in the oven at 105℃ for 3-4 h and transferred to the desiccators to cool. Then the empty crucible was weighed through a digital electronic balance, and 3 g of sample was placed in the crucible. Again, the weight of the crucible with the sample was collected. Then the sample in the

crucible was reserved in the oven at 105℃ for 3-4 h. After heating it was cooled in desiccators. Again, the weight of the crucible with the sample was determined until the weight became stable. The following equation was used for the calculation of moisture percentage.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Sample weight}} \times 100. \quad (1)$$

### *2.2.2. Analysis of ash content*

Ash content was measured using the AOAC (2005) method's instructions. A sample of about 3 g was taken, heated in a muffle furnace for 3–4 h at 105°C, and then heated for 3–4 h at 600°C (JSMF-45T). The sample was then cooled in desiccators, and the percentage of ash content was determined using the equation below.

$$\text{Ash content (\%)} = \frac{\text{Weight of the ash}}{\text{Sample weight}} \times 100. \quad (2)$$

### *2.2.3. Analysis of crude fat*

According to the AOAC (2005) method, the crude fat content was assessed. Overnight, a beaker containing the extracted oil was left in the incubator at 105°C. To filter and wrap, weigh approximately 5 g of the sample. The sample was then transferred into an extraction thimble, placed in a Soxhlet, which was then filled with petroleum ether in an amount equal to about 250 mL, and placed on a heating mantle. The heating mantle was turned on after the Soxhlet apparatus was connected and the water was turned on to cool them. The sample was heated at a rate of 150 drops/m for about 3–4 h. Then the beaker that had previously been weighed was filled with the solvent-extracted oil. The beaker was then kept in the oven and heated to between 80 and 90 degrees Celsius until the solvent had completely evaporated and the beaker was dried. The beaker was then moved to the desiccators to cool after drying, and its dried contents and the sample's fat content were calculated using the equation below.

$$\text{Fat content (\%)} = \frac{\text{Weight of the extracted oil}}{\text{Sample weight}} \times 100 \quad (3)$$

### *2.2.4. Analysis of crude protein*

According to the AOAC (2005) method, the crude protein content was assessed. By estimating the nitrogen content of a food product and multiplying the nitrogen value by 6.25, one can determine the protein content of that food product. Since the nonprotein content (NPN) of the material is taken into account, this is referred to as the crude protein content. By taking non protein nitrogen out, one can calculate the true protein nitrogen (which is estimated by pirating the protein in the sample with trichloro acetic acid, copper hydroxide and determining the residual nitrogen in the protein-free filtrate). The Kjeldahl method was used to estimate the nitrogen content because it is based on the fact that organic nitrogen is converted to ammonium sulfate when it is digested with sulfuric acid in the presence of copper, a catalyst. The protein content of the sample was determined using the following equation by distilling the ammonium released during the alkalinization of the solution into a known volume of a sulfuric acid.

$$\text{Protein content (\%)} = \frac{(c-b)\times 14 \times d \times 6.25}{a \times 1000} \times 100. \quad (4)$$

Here, a = sample weight in gm, b =volume of NaOH to neutralize 25mL of 0.1N $H_2SO_4$, c =volume of NaOH to neutralize 0.1N $H_2SO_4$ in control or back titration, d =strength of NaOH (normality of NaOH), 6.25 =gravimetric factor of protein in food.

#### *2.2.4.1. Digestion*

A precise measurement of 0.54 g of the sample's weight was made on weighing paper. This sample was poured into a 500 mL clean, oven-dried Kjeldal flask, and then 25 mL of pure $H_2SO_4$ and 5 g of digestion mixture were added. The flask was filled with a glass rod to prevent foaming and clumping. With the exception of the sample materials for comparison, black was transported with all reagents. The flask was subsequently heated in a Kjeldahl digestion chamber, first at a low temperature (40°C) until the mixture was no longer forth, then the temperature was raised to 60°C, and heating was continued until the solution was colorless. The

flask was cooled after the digestion period and then diluted with 100 mL of distilled water. A sample piece of litmus paper was placed in the solution and the reaction was found to be acidic.

***2.2.4.2. Distillation***

Before beginning the distillation process, the Kjeldahl apparatus distillation set was thoroughly cleaned with distilled water. The receiving 250 mL conical flask received 0.25 mL of 0.1N $H_2SO_4$. 75 mL of 40% NaOH was poured down the side of the Kjeldahl flask from a measuring cylinder. The solution turned alkaline, as indicated by the litmus paper turning blue. The flask's mouth was sealed with a stopper that had a connecting tube that led to a flask holding 0.1N H2SO4 for receiving ammonia. Water and ammonia distilled over at a steady, moderate rate as the mixture was heated to a boil. In order to prevent the $H_2SO_4$ solution from being drawn into the Kjeldahl flask, the heating was neither too slow nor too fast. So that the distilling ammonia did not escape the $H_2SO_4$ without absorption.

***2.2.4.3. Titration***

Utilizing three drops of methyl red as an indicator, the ammonia absorbed in the receiving flask containing 0.1N $H_2SO_4$ was titrated with 0.1N NaOH. A blank reagent was also distilled and titrated similarly.

$$\text{Protein (\%)} = \frac{(\text{mL of sample} - \text{mL of blank}) \times 0.1 \times 1.4007}{\text{sample weight}} \times \text{Protein factor.} \quad (5)$$

***2.2.5. Determination of crude fiber content***

According to the AOAC (2005) method, the crude fiber content was assessed. 200 mL of boiling 0.225 N (1.25% w/v) sulfuric acid was added to the sample after it had been weighed to be about 5 g (W) of moisture and fat free sample. After 30 m of boiling, water was added to the mixer to keep the volume constant. After boiling, the mixture was filtered, and the remaining material was repeatedly washed in hot water to remove any remaining acids. Then, to the acid-free residue, 200 mL of 0.313 N (1.25%) NaOH were added. After 30 m of boiling, filtering, and hot water washing, the residue was made alkali-free. After cleaning the mixture with ether and alcohol, respectively, the residue was prepared for estimating crude fiber. Following that, the porcelain crucible was weighed, the leftovers were kept inside, and it was heated for 3 h at 105°C in the oven. After that, the sample was cooled in desiccators. The sample's weight is determined and considered (A). The sample is then heated to 600ºC for 3–4 h in a muffle furnace. The crucible containing the sample was then cooled in desiccators. Next, the sample is weighed. This weight is considered as weight (B). The crude fiber content of the sample is determined by subtracting the weight (B) from the weight (A). Crude fiber content was calculated using the following equation:

$$\text{Crude fiber (\%)} = \frac{A-B}{W} \times 100. \quad (6)$$

where, W = weight of moisture and the fat-free sample taken, A = weight of the crucible with contents after ashing, and B= weight of the crucible with contents before ashing.

***2.2.6. Determination of carbohydrate content***

The anthrone method was used to calculate the carbohydrate content. In order to convert carbohydrates into simple sugars, concentrated sulfuric acid is used. Glucose is dehydrated to hydroxymethyl furfural in a hot acidic medium. The product of this compound and anthrone has a green color and a maximum absorption wavelength of 620 nm. In a different test tube, 0.5 mL of standard glucose solution, 4 mL of anthrone reagent, and a previously prepared sample are combined for this purpose. Using a UV spectrophotometer, measure the absorbance at 620 nm after mixing and boiling the ingredients. The following equation was used to determine the amount of carbohydrates.

Conc. of unknown = (Absorbance of unknown/Absorbance of standard) × Conc. of standard. (7)

**2.3. Analysis of bioactive compounds**

***2.3.1. Determination of total phenolic content (TPC)***

Using the Folin-Ciocalteu method, the TPC of all the herbs and spices was ascertained. By creating the dilutions of (0.1, 0.5, 1.0, 2.5, and 5 mg/mL) in methanol, a standard gallic acid curve was created. Each of these dilutions was

diluted each time in 100 µL of water, which was then combined with 100 µL of Folin-Ciocalteu reagent and left to stand for 6 m. 500 µL of distilled water and 1 mL of sodium carbonate at 7% were then added to the reaction mixture. At 760 nm, the absorbance was measured spectrophotometrically after 90 m. All the samples underwent the exact same process. The amount of gallic acid equivalents (mgGAE/g) used to measure the TPC of the herbs and spices

***2.3.2. Determination of total flavonoid content (TFC)***

The TFC was determined by an aluminum chloride complex-forming assay. A calibration curve for quercetin was constructed by preparing the dilution of (0.1, 0.5, 1.0, 2.5 and 5mg/mL) in methanol. 100 µL of each of the quercetin dilutions was mixed with 500 µL of distilled water and then with 100 µL of 5% Sodium nitrate and allowed to stand for 6 minutes. Then 150 µL of 10% aluminum chloride solution was added and allowed to stand for 5 m after which 200 µL solution of 1M Sodium hydroxide was added sequentially. On a UV spectrophotometer, the absorbance of this reaction mixture was measured at 510 nm. All the samples underwent the exact same process. And (mgQE/g) was calculated as the TFC.

**Table 1.** Concentration and absorbance of gallic acid

| Concentration (mg/mL) | Absorbance at 760 nm |
|---|---|
| 0.1 | 0.71 |
| 0.5 | 1.024 |
| 1 | 1.23 |
| 2.5 | 2.007 |
| 5 | 3.088 |

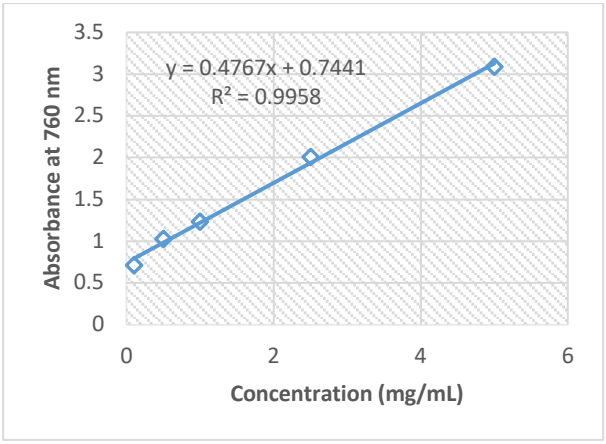


**Figure 1:** Standard curve of gallic acid

**Table 2:** Concentration and absorbance of quercetin

| Concentration (mg/mL) | Absorbance at 510 nm |
|---|---|
| 0.1 | 0.089 |
| 0.5 | 0.168 |
| 1 | 0.244 |
| 2.5 | 0.436 |
| 5 | 0.733 |

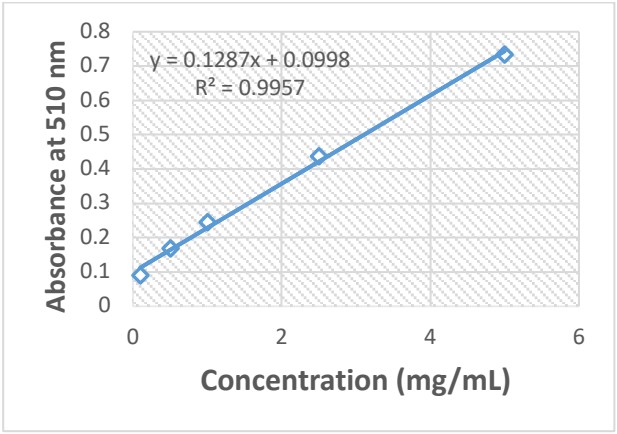


**Figure 2:** Standard Curve of quercetin

## 2.4. Analysis of antioxidant activity

***2.4.1. Determination of total antioxidant activity***

Using the free radical scavenging technique 2,2-Diphenyl-1-picrylhydrazyl (DPPH), the antioxidant properties of the extracts were assessed (Brand-Williams et al., 1995). In methanol, oxidized DPPH produces a deep violet hue. An antioxidant compound reduces

DPPH by giving it an electron, changing its color from deep violet to yellow as a result. A spectrophotometer is used to measure the absorption at 515 nm, which yields the sample's percent inhibition (Shirazi, 2014). Getting the sample extract ready Weighing 2g of the sample, 10 mL of methanol was added to the beaker. then extracted for 4 h while using a magnetic stirrer. After extracts were obtained, what-man filter paper No. 42 was used to filter them. The absorbance of a freshly made 0.002% solution of DPPH in methanol was measured at 515 nm. A 3 ml solution of DPPH was added to 50 µl of the pure extract, which was then left to stand in the dark for 15 m. At 515 nm, the absorbance was once more measured. The formula below was used to determine the extract's percentage inhibition of DPPH:

Percent of Inhibition: (A-B/A) × 100. (8)

Where, A is the absorbance of pure DPPH in oxidized form and B is the absorbance of the sample taken after 15 m of reaction with DPPH.

#### *2.4.2. Determination of vitamin C content*

According to the AOAC method (2000), vitamin C content was measured. This was accomplished by titrating 10 mL of a standard vitamin C solution with the dye solution in a conical flask. A sample of 4-6 g was taken, thoroughly homogenized with 3% metaphosphoric acid, and then filtered through two layers of muslin cloth. After centrifuging the filtrate at 3,000 rpm for 10 m, the supernatant was titrated with a solution of 2, 6-dichlorophenol indophenols. By contrasting the titration results with a standard vitamin C solution, the amount of vitamin C in the extract was calculated. The following formula was used to determine the vitamin C content:

Percentage (%) of vitamin C content (mg/100g) = (mg of vitamin C obtained weight of sample (g)) × 100. (9)

### 2.5. Statistical analysis

Descriptive statistics were calculated for all variables using the SPSS software package (version 25.0; IBM Corp., Armonk, New York, NY, USA), and all of the values are expressed as the mean ± SD. The significance of the differences between the means of the two samples was determined by comparing the means of paired samples t-test. Differences were considered to be significant at $p<0.05$ (*).

## 3. Results and discussions

### 3.1. Proximate composition in different parts of passion fruit

#### *3.1.1. Moisture content in different parts of passion fruit*

The current study has found that the moisture content of the peel, pulp, and seed of green passion fruit was 85.98±1.69, 92.11±1.70, and 27.30±0.79 g/100g respectively, and the moisture content of the peel, pulp, and seed of ripe passion fruit was 76.24±0.93, 85.02±0.47 and 28.95±0.97 g/100g respectively. It is clear that the moisture content in peel and pulp of green passion fruit was higher and statistically significant ($P<0.05$) than ripe one but in seed, ripe passion fruit has higher moisture content but not statistically significant ($P<0.05$). However, among peel, pulp and seed of green and ripe passion fruit, pulp contain highest amount of water. The moisture content of pulp of green passion fruit is almost similar to previous study (Adeyeye and Aremu, 2017), who has found the moisture content of pulp was 87.5±0.028 g/100g. On the other hand, the moisture content of pulp of ripe passion fruit is slightly higher than previous study (Kulkarni and Vijayanand, 2010) where they found the moisture content of pulp of ripe passion fruit was 81.5±0.2 g/100g, and also higher in case of seed of ripe passion fruit than previous study done by Ramaiya, Bujang and Zakaria (2018) who have found that the moisture content of seed of ripe passion fruit was 11.09±0.40 g/100g.

#### *3.1.2. Ash content in different parts of passion fruit*

The present study found that the ash content of the peel, pulp, and seed of green passion fruit was 1.32±0.03, 0.94±0.04 and 0.29±0.08 g/100g respectively. On the other hand, the current research found that the ash content of the peel,

pulp, and seed of ripe passion fruit was 1.38±0.16, 0.42±0.29 and 0.76±0.20g/100g respectively. So, it is clear that the ash content of the peels of both green and ripe passion fruit was almost the same, whereas the pulp of green passion fruit contained more than double that of the ripe one but was statistically non-significant (P<0.05) and the ash content of the seed of green and ripe passion fruit was statistically significant (P<0.05). The previous study was done by Adeyeye and Aremu (2017) and found that the ash content of the peel, pulp, and seed of passion fruit was 0.898±0.612, 0.34±0.014, and 2.26±0.014 g/100g respectively.

### *3.1.3. Crude fat content in different parts of passion fruit*

The present study has found the fat content of peel, pulp, and seed of green passion fruit of 1.70±0.02, 1.39±0.02, 16.32±0.56g/100g, and 0.38±0.03, 0.86±0.06, 23.79±0.38g/100g respectively in the case of ripe passion fruit. It is stated that the seed of both green and ripe passion fruits contains highest amount of fat than peel and pulp of both types of passion fruit. However, peel and pulp of green passion fruit contains slightly higher fat than ripe one but seed of ripe passion fruit contain relatively higher fat than seed of green passion fruit but all the samples of green and ripe passion fruit showed statistically significant at p<0.05. One study (Adeyeye and Aremu, 2017) found that the fat in peel was 0.805±0.693g/100g and (Ramaiya, Bujang and Zakaria, 2018) found fat in seed was 29.65±0.41g/100g and Kawakami *et al.* (2022) found between 12.31±0.68 to 32.65±0.45g/100g in seed in different varieties. However in the case of the pulp and peel one study (Adeyeye and Aremu, 2017) found a lower amount of fat than the present study.

### *3.1.4. Crude protein content in different parts of passion fruit*

The present study found that the protein content of peel, pulp and seed of green passion fruit was 1.76±0.08, 3.37±0.11 and 8.11±0.23g/100g and 7.49±0.18, 3.95±0.10 and 16.21±0.32g/100g respectively for ripe passion fruit. From our study we can see the protein content of pulp of ripe passion fruit is slightly higher than green fruit but protein content of peel and seed of ripe fruit is too much higher than of green passion fruit and seed contain the higher amount of protein but all the samples of green and ripe passion fruit showed statistically significant at p<0.05. Previous study done by Kawakami *et al.* (2022**)** found that the protein content of seed of ripe passion fruit between 13.07±0.12to 17.57±0.31g/100g whereas, Ramaiya, Bujang and Zakaria (2018**)** found 12.71±0.10g/100g of protein in seed of ripe passion fruit and Silva *et al.* (2015**)** found 11.80±0.20g/100g of protein in seed of passion fruit. According to Fonseca *et al.* (2022**)** peel, pulp and seed of passion fruit contain 6.47-7.5, 2.2-3.0 and 12.2-13.2g/100g of protein, which is almost similar to the present study.

### *3.1.5. Crude fiber content in different parts of passion fruit*

The crude fiber content of the peel, pulp, and seed of green passion fruit was 26.43±0.09, 1.35±0.06 and 41.45±0.53 g/100g respectively, whereas ripe passion fruit was 32.20±0.34, 1.64±0.05 and 47.68±0.54 g/100g respectively. It is clear that the crude fiber content increases with the maturity of passion fruit as the crude fiber content of ripe passion fruit is higher than that of green passion fruit in peel, pulp, and seed, which is statistically significant (P<0.05). Among the three samples, seed contains the highest amounts of crude fiber, pulp contains the lowest amounts, and peel is in the middle. The fiber content of peel and seed in the present study of both green and ripe was almost the same as in the previous study (26.98±0.48) and (48.18±0.64) g/100g respectively), but in the case of pulp it was negligible, which is not related to our present study (Ramaiya, Bujang and Zakaria, 2018; Kawakami *et al.*, 2022).

### *3.1.6 Carbohydrate content in different parts of passion fruit*

The present study found that the carbohydrate content of peel, pulp, and seed of green passion fruit was 41.36±0.42, 10.25±0.28 and 38.73±0.32 g/100g respectively, whereas in ripe passion fruit it was 50.51±0.28, 12.71±0.14 and 54.85±0.31 g/100g respectively in case of peel, pulp, and seed. So, it is suggested that all

parts of ripe passion fruit have contains more carbohydrates than all parts of green passion fruit, and it is statistically significant at $p<0.05$. However, previous studies showed that seed of passion fruit has contain more carbohydrates than peel and pulp. Kawakami *et al.* (2022) found carbohydrates between 49.44±1.16 to 71.07±0.00 g/100g in seed, and Adeyeye and Aremu (2017) found 77.6±0.049 g/100g in seed, whereas 11.9±0.028 g/100g in pulp and 66.2±2.83 g/100g in peel.

**Table 3.** Proximate composition of passion fruit

| Parameters (g/100g) | Peel | Mean±SD | P-value | Pulp | Mean±SD | p-value | Seed | Mean±SD | p-value |
|---|---|---|---|---|---|---|---|---|---|
| Moisture | Green | 85.98±1.69 | 0.010 | Green | 92.11±1.70 | 0.030 | Green | 27.30±0.79 | 0.071 |
| | Ripe | 76.24±0.93 | | Ripe | 85.02±0.47 | | Ripe | 28.95±0.97 | |
| Ash | Green | 1.32±0.03 | 0.628 | Green | 0.94±0.04 | 0.068 | Green | 0.29±0.08 | 0.025 |
| | Ripe | 1.38±0.16 | | Ripe | 0.42±0.29 | | Ripe | 0.76±0.20 | |
| Crude Fiber | Green | 26.43±0.09 | 0.002 | Green | 1.35±0.06 | 0.034 | Green | 41.45±0.53 | 0.009 |
| | Ripe | 32.20±0.34 | | Ripe | 1.64±0.05 | | Ripe | 47.68±0.54 | |
| CHO | Green | 41.36±0.42 | 0.002 | Green | 10.25±0.28 | 0.003 | Green | 38.73±0.32 | 0.000 |
| | Ripe | 50.51±0.28 | | Ripe | 12.71±0.14 | | Ripe | 54.85±0.31 | |
| Fat | Green | 1.70±0.02 | 0.000 | Green | 1.39±0.02 | 0.003 | Green | 16.32±0.56 | 0.005 |
| | Ripe | 0.38±0.03 | | Ripe | 0.86±0.06 | | Ripe | 23.79±0.38 | |
| Protein | Green | 1.76±0.08 | 0.001 | Green | 3.37±0.11 | 0.041 | Green | 8.11±0.23 | 0.001 |
| | Ripe | 7.49±0.18 | | Ripe | 3.95±0.10 | | Ripe | 16.21±0.32 | |

*Data are expressed as mean±standard deviation (SD). *P<0.05 considered as statistically significant when compared different parameters of green and ripe passion fruit. CHO: carbohydrates.

## 3.2. Bioactive compounds of passion fruit

### *3.2.1. TPC in different parts of passion fruit*

The TPC of peel, pulp and seed of green passion fruit were 57.04±2.35, 67.06±3.23 and 156.35±10.15mgGAE/g respectively. On the other hand, in ripe passion fruit it was 34.96±2.35, 42.25±3.02 and 116.48±16.35mgGAE/g of peel, pulp, and seed respectively. It is noted that TPC in all the parts like peel, pulp, and seed of green passion fruit were relatively higher than the ripe one. It is also found that seed contain the highest amount of TPC where, peel contain the lowest amounts. The difference between peel and pulp of green and ripe passion fruit was statistically significant at $p<0.05$ but in the case of seed it showed non-significance at $p<0.05$. The previous study (Gonzalez *et al.*, 2019) found that the total phenolic content of peel of the ripe fruit between 37.7±0.13 to 46.8±0.18mgGAE/g which is moderately different from the present findings and also found TPC between 105.6±0.35 to 153.4±0.78mgGAE/g in seed of ripe passion fruit using different extraction method. Janzantti *et al.* (2012) found that 41.566±0.00mgGAE/g TPC in pulp of ripe passion fruit, which is also close to the present findings.

### *3.2.2. TFC in different parts of passion fruit*

The TFC found by the current study in peel, pulp, and seed of green passion fruit were 54.82±1.71, 72.71±1.68, and 12.99±1.47mgQE/g respectively and 47.21±2.44, 56.27±1.82 and 26.66±1.18mgQE/g of TFC respectively. It is noted that the highest TFC is in the pulp of green passion fruit, and lowest in seed of green passion fruit. Overall, peel, and pulp of green fruit contain higher TFC, but seed of green fruit contain lower amount of TFC than ripe fruit but all the samples of green and ripe passion fruit were statistically significant at $p<0.05$. A previous study done by Gonzalez *et al.* (2019) found that the TFC of peel of ripe passion fruit was 55.6±0.11 mgQE/g which is almost similar to the present study, but TFC of seed in ripe passion fruit was 53.2±0.09 mgQE/g which is quite higher than current findings.

**Table 4.** Bioactive compounds content of different parts of green and ripe passion fruit

| Parameters | Peel | Mean±SD | p-value | Pulp | Mean±SD | p-value | Seed | Mean±SD | p-value |
|---|---|---|---|---|---|---|---|---|---|
| TPC (mgGAE/g) | Green | 57.04±2.35 | 0.000 | Green | 67.06±3.23 | 0.004 | Green | 156.35±10.12 | 0.113 |
| | Ripe | 34.96±2.35 | | Ripe | 42.25±3.02 | | Ripe | 116.48±16.35 | |
| TFC (mgQE/g) | Green | 54.82±1.71 | 0.005 | Green | 72.71±1.68 | 0.001 | Green | 12.99±1.47 | 0.00 |
| | Ripe | 47.21±2.44 | | Ripe | 56.27±1.82 | | Ripe | 26.66±1.18 | |

* Data are expressed as mean±standard deviation (SD). *P<0.05 considered as statistically significant when compared different parameters of green and ripe passion fruit.

### 3.3. Antioxidant activity of passion fruit

#### *3.3.1. Total antioxidant activity in different parts of passion fruit*

In the current study, the percent of inhibition was determined in order to determine the antioxidant activity. Percent inhibition in peel, pulp, and seed was 54.09±0.14, 51.23±0.22 and 60.44±0.53 respectively of green passion fruit. On the other hand, we found the percent of inhibition of peel, pulp and seed of ripe passion fruit to 63.16±0.18, 58.65±0.16 and 57.86±0.24 respectively. These data show that the percent inhibition of the peel and pulp of ripe fruit is higher than that of the peel and pulp of green passion fruit, but the seed of ripe fruit has a lower percent inhibition than the seed of green fruit. However, all the samples of green and ripe passion fruit showed statistical significance at p<0.05.

#### *3.3.2. Vitamin C content in different parts of passion fruit*

The vitamin C content of the peel, pulp, and seed of green passion fruit were 1.37±0.11, 7.06±0.10 and 0.80±0.04mg/g respectively, whereas the vitamin C content of the peel, pulp, and seed of ripe passion fruit were 6.76±0.25, 3.82±0.13 and 2.59±0.12mg/10g respectively. It is clear that the seed of the passion fruit contains the lowest amount of vitamin C, and peel and seed of ripe passion fruit contain a higher amount of vitamin C, but pulp of ripe passion fruit contains a lower amount of vitamin C than that of green passion fruit, but all the samples of green and ripe passion fruit showed statistical significance at p<0.05. Previous studies done by Fonseca *et al.* (2022) found that the pulp of ripe passion fruit contained 3.0±0.00mg/10g whereas, Genovese *et al.* (2008) found 4.30±0.06 mg/10g. These findings are almost same for the pulp of the ripe passion fruit.

**Table 5.** Overview of antioxidant activity of different parts of green and ripe passion fruits.

| Parameters | Peel | Mean±SD | p-value | Pulp | Mean±SD | p-value | Seed | Mean±SD | p-value |
|---|---|---|---|---|---|---|---|---|---|
| TAA (%) | Green | 54.09±0.14 | 0.000 | Green | 51.23±0.22 | 0.000 | Green | 60.44±0.53 | 0.009 |
| | Ripe | 63.16±0.18 | | Ripe | 58.65±0.16 | | Ripe | 57.86±0.24 | |
| Vit-C (mg/10g) | Green | 1.37±0.11 | 0.000 | Green | 7.06±0.10 | 0.000 | Green | 0.80±0.04 | 0.002 |
| | Ripe | 6.76±0.25 | | Ripe | 3.82±0.13 | | Ripe | 2.59±0.12 | |

*Data are expressed as mean±standard deviation (SD). *$P$<0.05 considered as statistically significant when compared different parameters of green and ripe passion fruit. TAA: total antioxidant activity.

## 4. Conclusions

In summary, the present study concluded that passion fruit has great potential for human health. Currently, the pulp of ripe passion fruit is widely consumed as raw or processed fruit, however, the peel and seed of green and ripe passion fruit are still underutilized. But the current study showed that besides ripe passion fruit, all the parameters of green passion fruit also have great nutritional properties. It is also demonstrated that underutilized peel and seed are good sources of dietary fiber, protein, and fat and are also rich sources of TPC, TFC, percentage of total antioxidants, and vitamin C contents. This study will be useful to consumers to plan rich fiber, protein, bioactive compounds, and antioxidant diets and to estimate the daily intakes and their impact on health. Therefore,

there is a high potential for the use of the peel, pulp, and seed of green and ripe passion fruit as a health promoting and disease-preventing source that is normally underutilized.

## 5. References


AOAC (1995). Official methods of analysis, 16th edition. Association of Official Analytical Chemists, Washington DC, USA.

AOAC (2000). Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16.

AOAC (2005). Determination of Moisture, Ash, Protein and Fat. Official Method of Analysis of the Association of Analytical Chemists. 18th Edition, AOAC, Washington DC.

Adeyeye, E. I., and Aremu, M. O. (2017). Chemical composition of the raw fruit coat, seed and pulp of passion fruit (Passiflora edulis). *Journal Trends in Science & Technology*, 2, 334–341.

Brand-Williams, W., Cuvelier, M. E., and Berset, C. (1995). Antioxidative activity of phenolic composition of commercial extracts of sage and rosemary. *LWT - Food Science and Technology, 28*, 25-30.

Daily Star (2022). Panchagarh garden adorned with exotic passion fruits. Available in https://www.thedailystar.net/news-detail-229991.

Dhawan, K., Kumar, S., Sharma, A. (2001). Comparative biological activity study on *Passiflora incarnata* and *P. Edulis. Fitoter,* 72, 698–702.

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C., and Attia, H. (2011). Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. *Food chemistry*, *124*(2), 411-421.

Fonseca, A. M. A. et al (2022). Purple passion fruit (Passiflora edulis f. edulis): A comprehensive review on the nutritional value, phytochemical profile and associated health effects. *Food Research International*, 160, 111665.

FAOSTAT (2019). Statistics division, food and agriculture organization of the United Nations. Rome, Italy: Vialedelle Terme di Caracalla 00153.

Genovese, M. I. et al (2008). Bioactive Compounds and Antioxidant Capacity of Exotic Fruits and Commercial Frozen Pulps from Brazil. *Food Science and Technology International*, 14(3), 207–214.

Gonzalez, L. et al (2019). Potential uses of the peel and seed of Passiflora edulis f. edulis Sims (gulupa) from its chemical characterization, antioxidant, and antihypertensive functionalities. *Asian Journal of Pharmaceutical and Clinical Research,* 12(10), 104–112.

He, X., Luan, F., Yang, Y., Wang, Z., Zhao, Z., Fang, J., ... & Li, Y. (2020). Passiflora edulis: An insight into current researches on phytochemistry & pharmacology. *Frontiers in pharmacology*, *11*, 617.

Hu, Y., Jiao, L., Jiang, M. H., Yin, S., Dong, P., Zhao, Z. M., et al (2018). A new C-glycosyl flavone and a new neolignan glycoside from *Passiflora edulis* Sims peel. *Natural Product Research,* 32, 2312–2318.

Janzantti, N. S. et al (2012). Influence of the cultivation system in the aroma of the volatile compounds and total antioxidant activity of passion fruit. *LWT - Food Science and Technology*, 46(2), 511–518.

Kang, J., Xie, C., Li, Z., Nagarajan, S., Schauss, A. G., Wu, T., and Wu, X. (2011). Flavonoids from acai (Euterpe oleracea Mart.) pulp and their antioxidant and anti-inflammatory activities. *Food chemistry*, *128*(1), 152–157.

Kawakami, S. et al (2022). Constituent Characteristics and Functional Properties of Passion Fruit Seed Extract. *Life*, 12(1), 38.

Kulkarni, S. G. and Vijayanand, P. (2010). Effect of extraction conditions on the quality characteristics of pectin from passion fruit peel (Passiflora edulis f. flavicarpa L.). *LWT - Food Science and Technology*, 43(7), 1026–1031.

Molla, M. M., Sabuz, A. A., Chowdhury, M. G. F., Khan, M. H. H., Alam, M., Nasrin, T. A.

A., ... and Islam, M. M. (2021). Bioactive Compounds and Biochemical and Antioxidant Properties of Selected Minor Indigenous Fruits in Bangladesh. *Asian Journal of Agriculture and Rural Development*, *11*(1), 35-46.

Ramaiya, S. D., Bujang, J. S., & Zakaria, M. H. (2018). Nutritive values of passion fruit (Passiflora species) seeds and its role in human health. *Journal of Agriculture Food and Development*, 4(1), 23-30.

Shirazi, O. U. (2014). Determination of total phenolic, flavonoid content and free radical scavenging activities of common herbs and spices. *Journal of Pharmacognosy and Phytochemistry*, 3(3), 104–108.

Silva, D. C. et al (2012). Polysaccharide isolated from Passiflora edulis: Characterization and antitumor properties', *Carbohydrate Polymers*, 87(1), 139–145.

Santana, J. C., and Naves, R. V. (2003). Characterization of cerrado areas with high pequizeiro (*Caryocarbrasiliense* Camb.) density in the Southeast of the state of Goiás. *Revista Agropecuária Tropical*, 33(1), 1-10.

Singh, B., Singh, J. P., Kaur, A., and Singh, N. (2016a). Bioactive compounds in banana and their associated health benefits - A review. *Food chemistry*, *206*, 1–11.

Singh, J. P., Kaur, A., Shevkani, K., Singh, N. and Singh, B. (2016b). Physicochemical characterization of corn extrudates prepared with varying levels of beetroot (Beta vulgaris) at different extrusion temperatures. *International Journal of Food Science and Technology*, 51, 911–919.

Yuan, T. Z., Kao, C. L., Li, W. J., Li, H. T., Chen, C. Y. (2017). Chemical constituents of leaves of *Passiflora edulis*. *Chemistry of Natural Compounds,* 53, 1165–1166.

Zhang, J., Koike, R., Yamamoto, A., Ukiya, M., Fukatsu, M., Banno, N., et al (2013). Glycosidic inhibitors of melanogenesis from leaves of *Passiflora edulis*. *Chemistry and biodiversity,* 10, 1851–1865.

Zielinski, A. A., Ávila, S., Ito, V., Nogueira, A., Wosiacki, G., and Haminiuk, C. W. (2014). The association between chromaticity, phenolics, carotenoids, and in vitro antioxidant activity of frozen fruit pulp in Brazil: an application of chemometrics. *Journal of food science*, 79(4), C510–C516.

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