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# Physicochemical properties of pomelo (*Citrus grandis* L. Osbeck) byproducts

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**Abstract**
*Pomelo (Citrus grandis L. Osbeck) is known as the largest citrus fruit in the worlds. The fresh pulp often consumed directly meanwhile pomelo byproducts including peels; exocarp: flavedo and endocarp: albedo and lamella were discarded. A significant yield of waste was produced and may result in high cost of waste management. Therefore, the present study was carried out after freeze-drying (FD) to discover the physico-chemical properties (water activity (aw), total soluble solids (TSS), pH and vitamin C) of pomelo byproducts (flavedo, albedo and lamella). Results showed that the overall byproducts contain lower water activity (<0.7) value after dried, whereas for TSS albedo (2.43°Brix) and lamella (2.23°Brix) showed significantly ($p < 0.05$) higher value compared to flavedo (1.77°Brix). Similar with pH analysis, significant lower value of flavedo (5.44) was observed in comparison with albedo (5.78) and lamella (5.70). Nevertheless, lower pH value indicates the presence of higher concentration of vitamin C in flavedo (30.52 mg AA/100g DW) more than albedo (25.83 mg AA/100g DW) and lamella (17.48 mg AA/100g DW). Noteworthy information of the byproducts could be further applied in nutraceutical approach and functional foods for commercial purposes.*

Keywords: Physicochemical, pomelo byproduct, water activity, pH, vitamin C

## Introduction

In South Eash Asia, pomelo (Citrus grandis (L.) Osbeck) fruits was categorized as a native citrus fruit. In Malaysia, famous pomelo varieties is known as Sha Ting, Tambun, Ledang and Melo Mas (Shah et al., 2013). The weight of pomelo fruit is around 1 - 2 kg per pieces; the largest size in citrus family. Significant yield (~50%) of peels per fruits was discarded every year. The peels comprised of different parts of peels which covers the flesh of the fruits. Flavedo is a greenish part where it is the outermost peels of the fruits, the endocarp containing the thickest peels and spongy texture in whitish color; albedo and the pinkish in color of the skin that covers the juice sacs directly known as lamella **(Figure 1)**.

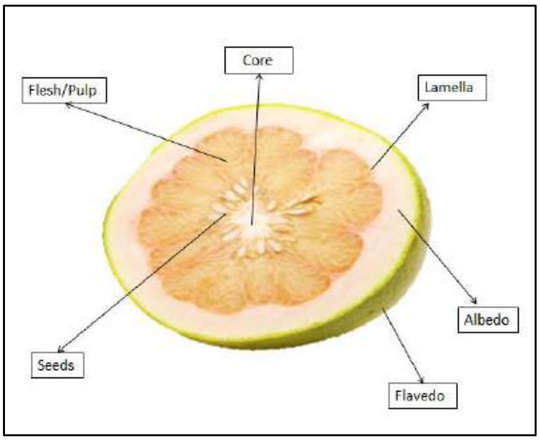


*Figure1. Cross section of pomelo fruits (adapted from Rahman et al., 2018a)*

Nowadays, high demand of waste valorization into beneficial compound was superior practices. Previously, most of the researchers focuses and elaborate on physicochemical properties of the pomelo pulp which involve different varieties such as Tambun (PO52) and Ledang (PO55) from Malaysia (Shah et al., 2014) properties of the flesh, effects of storage time on the texture of pomelo fruits (Sirisomboon and Lapchareonsuk, 2012), phenolic identification of the pomelo fruits using HPLC and the effects of enzyme pectinase on clarification of pomelo juice obtained using UV-C (Shah, et al. 2014). As for byproducts known as peels, most of the researchers focus potential source of pectin, optimum condition to extract pectin from albedo, potential source of carbon to treat waste water, potential source of antimicrobial, essential oil identification from flavedo part, effects of post-drying on pomelo peels and its phenolic content (Rahman et al. 2016, 2018b). However, limited information can be found for identification of physicochemical properties in different parts of pomelo peels known as flavedo, albedo and lamella generally. Therefore, the current study focuses on comparison of physicho-chemical properties of pomelo byproducts (flavedo, albedo and lamella).

## Materials and methods

### *Plant materials*

The pomelo (*Citrus grandis* (L.) Osbeck) fruit was obtained from P052 Tambun White variety at Department of Agriculture Kinta District, Ipoh, Perak. Then, the fruit was cleaned thoroughly and was separated physically into flesh and peels (flavedo, albedo and lamella) as shown in **Figure 1**. Overall parts was separated and undergone freeze drying process prior to further analysis

***Drying process***

Freeze drying process was conducted by freezing the flavedo, albedo and lamella (~100g) first in ultra-low freezer (MDF-U2086S; Sanyo, Japan) at -85°C overnight and undergoing lyophilized process using freeze-dryer (VirTis Benchtop K, PA, USA) (Rahman et al., 2016) for approximately 96 hr. The dried byproducts were grind into powder and was used for physicochemical analysis.

***1) Physiocchemical analysis***

***i) Determination of water activity***

Water activity is a measurement of the availability of water for biological reactions in the sample. The water activity (aw) was measured with a dew point hygrometer at 25 °C (Aqualab series 3TE. Decagon Devices Inc., Pullman) (Shamsudin, et al., 2015).

***ii) Determination of pH***

Determination of pH as an indicator of acidity or basicity of a solution. This is to indicate the limitation of the spoilage microorganism to be able to react during storage period. The samples were dip into a distilled water and filtered to obtain the filtrate solution. An electrode pH meter was dipped into the filtrate solution. It is an important parameter used to determine whether the potential food spoilage microorganisms are liable to grow during storage. The samples were squeezed to obtain their juice and the pH of the juice was measured using an electrode pH meter.

***iii) Determination of total soluble solids (ºBrix)***

The major soluble solids presence in fruits also known as sugar. Total soluble solids (TSS) indication can be used to determine the general estimation of sugar content. TSS was determine by using a digital refractometer (AR-2008, Kruss, Germany). A substantial amount of filtrate by-products was dropped onto the refractometer and measured as °Brix. Triplicate value were recorded and average value was obtained.

***iv) Determination of Vitamin C (Ascorbic acid)***

Vitamin C (ascorbic acid) is an essential dietary component which could not be synthesized by the body. Ascorbic acid was measured by using 2,6-dichlorophenol indophenol (DCPIP) as the titrant based on Ali, et al. (2015) and Toh, et al. (2013) with a slight modification. Dried samples (1 g) was homogenized with 3% metaphosphoric acid (20 mL) and was filtered using filter paper (Whatman No. 4) to obtain the filtrate. Briefly, standard ascorbic acid (AA) standard (1%) solution was prepared and was used to calculate vitamin C in the samples. The filtrate (5 mL) was titrated with DCPIP (0.1%) indicator using No. 967.21, AOAC method (AOAC, 2002). The final value of vitamin C was expressed as mg AA/100g of sample

***Statistical analysis***

Statistical analysis was performed using IBM SPSS Statistics 21.0 version based on a Duncan's test in order to evaluate the significant difference ($p$ <0.05) between the mean values. The confidence intervals were significant based on 95% and the final value were expressed as the average ± standard deviation.

Results and discussion

***Physicochemical properties of pomelo byproducts***

Table 1 showed the result of water activity (aw) and total soluble solids (TSS) from different parts of pomelo byproducts. Water activity is an indicator for stability of end products. Results showed that overall parts of pomelo peels are considered stable enough as it falls within the recommendation level (<0.7) (Geankoplis, 2003). Nevertheless, the flavedo (0.398) showed significantly higher (p<0.05) compared to albedo (0.372) and lamella (0.360). It could be due to the flavedo consist of parenchyma cell which are more compact (Thielen et al., 2015) and the space of the movement of moisture taking longer time during drying process. Therefore, the bound moisture could be trapped within the microstructure of the solid materials and leads to aw level higher than other parts. Consistent with the structure of albedo which most of it is porous (Thielen et al., 2015) and the size of the capillary cell is big enough to eases the removal of moisture from inside to outside during drying process. In addition, the thickness also plays an important role affecting the level of water activity. Lamella is the thinnest peels compared to flavedo and albedo due to the nature behavior that its cover juice sacs (flesh) directly. Nevertheless, it comprise strong structure and elastic enough to hold the juice sacs intact (Sirisomboon and Lapchareonsuk, 2012).

*Table 1. Water activity and total soluble solids of pomelo byproducts*

| Parts of pomelo byproduct | Water activity (aw) | Total soluble solids (TSS) (°Brix) |
|---|---|---|
| Flavedo | $0.398 \pm 0.005^{a}$ | $1.77 \pm 0.06^{c}$ |
| Albedo | $0.372 \pm 0.007^{b}$ | $2.43 \pm 0.06^{a}$ |
| Lamella | $0.360 \pm 0.006^{b}$ | $2.23 \pm 0.06^{b}$ |

Final value were expressed as the average ± standard deviation, Similar letter within column showed not significantly ($p$>0.05) different between different parts of pomelo by-products.

Total soluble solids (TSS) considered as the sugars available from the product. TSS value of different parts of pomelo byproducts can be observed in Table 1. As can be seen, the TSS value increases with increasing sugar content in the following order: [albedo (2.43°Brix) > lamella (2.23°Brix) > flavedo (1.77°Brix)]. This is thought to be a general indicator of carbohydrate content in albedo which consistent with result obtained by Rahman et al. (2018). The result reported on the carbohydrate content of albedo (71.42%), lamella (68.44%) and flavedo (56.34%). In addition, previous researcher had found that albedo remarkably containing multiple chain of carbohydrate content namely pectin (Gamonpilas et al. 2015; Methacanon, et al., 2014) which might contribute to the higher level of TSS compared to other parts.

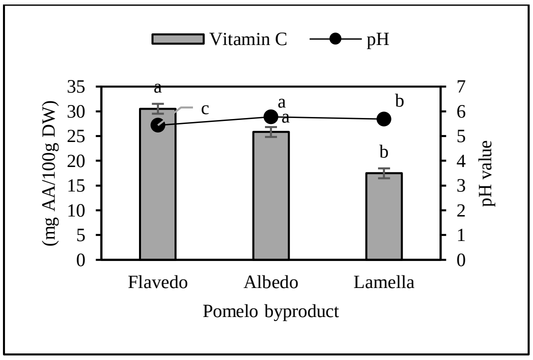


*Figure 2. Vitamin C and pH of different parts of pomelo byproducts*

The pH level can be considered as an indicator for acidity of end product. pH value and vitamin C of different parts of pomelo residues was compared (Figure 2). Significant different (*p* <0.05) of pH value was observed in flavedo compared to albedo and lamella. Flavedo (5.44) contain significant (*p* <0.05) low pH value which considers higher concentration of H+ ion was recorded compared to albedo (5.78) and lamella (5.69). This is believed to be occur due to the present of higher concentration of vitamin C in flavedo (30.52 mg AA/100g DW). Ascorbic acid (Vitamin C) is one of the essential nutrition that is beneficial to the health. The concentration of vitamin C is decreasing from flavedo (30.52 mg AA/100g DW) > albedo (25.83 mg AA/100g DW) > lamella (17.48 mg AA/100g DW). Low value of vitamin C in albedo and lamella was ~15% and ~43% respectively. Nevertheless, albedo did not differed (p >0.05) significantly to flavedo. Previous research found that the trend whereby the concentration of bioactive compound is lower/higher from outer peels towards the flesh (Abdullah et al., 2012).

***Conclusion:***

Physicochemical properties (water activity, total soluble solids, pH and vitamin C) of different part of pomelo peels namely flavedo, albedo and lamella was investigated. In general, different parts of freeze-dried pomelo byproducts possesses significantly differed properties. As for water activity (aw), overall parts showed within recommended level (<0.7) of dried product can be stored for longer period of time. Albedo showed higher TSS and pH value compared with other parts can be used for potential source of pectin or cosmetic application. Higher concentration of vitamin C of flavedo could be used as supplements or functional food for pharmaceutical company. Different aspects of physicochemical properties can be used as a reference for further application in food industry, cosmetic application, and Nutraceutical Company.

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