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Effect of Different Extraction Methods on the Physico-chemical Properties of Pomelo Juice

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The present study was carried out to analyze the physico-chemical properties of fresh juice obtained from pomelo fruit. It is aimed to study the effects of different commercial extraction techniques on the physico-chemical properties of the pomelo juice. The juices from Malaysian pomelo fruit from variety Tambun (PO52) were extracted using four different techniques; hand squeezing (EM-1), blending (EM-2), screw press type (EM-3) and centrifugal type (EM-4). Results revealed that juices that had been prepared by EM-3 had a higher juice yield (77.25 %) compared to EM-4 (73.14 %) followed by EM-2 (70.88 %) and EM-1 (53.07 %).With respect to the effect of extraction methods of tested juices, EM-3 showed the highest extraction efficiency, the lowest extraction loss, and the lowest moisture content of residue waste. Results suggest that pomelo juice processed by EM-2 had significantly ($p<0.05$) higher level of total soluble solids and ascorbic acids of juice compared with the other extraction techniques. No significant differences ($p>0.05$) were detected in pH for all types of extraction, while pomelo juice extracted by EM-3 showed the highest level of lightness and ascorbic acid.

1. Introduction

Pomelo fruit scientifically known as C. grandis (L.) Osbeck, is a type of citrus fruits which belongs to the family Rutaceae. The pomelo is native to southeastern Asia and all of Malaysia. In Malaysia, pomelo is widely grown in the state of Perak, Kedah, Melaka, Kelantan and Johor (DOA, 2012). There are a few popular varieties of pomelo in Malaysia which known as Tambun (White or pink), Shatian and Melomas. Tambun White pomelo is the most popular type due to its juiciness, sweetness and delicious taste (Toh et al., 2013). The common name was pomelo while the current Malaysian names are limau abong, limau bali, limau besar, limau betawi and pummelo. The other spellings for pomelo include Chinese grapefruit, jabong, pompelmous or shaddock. Fresh fruits give the most directly available vitamins and nutrition in the human diet but they could be easily deteriorated and perishable. However, to overcome the problems, fruits can be processed into juice. Fresh fruit juices normally contain the nutrients which are naturally found in whole fruits. Furthermore, juices can be consumed more conveniently compared with the consumption of whole fruits (FAO, 1992).
Extraction is a technique to move targeted compound from one phase to another (Dean, 2009). Extraction of juice by producing the high yield juice while preserving the nutritive values are the crucial expectation in beverage industry. The ultimate aim is to extract as much yield as it can in order to achieve higher profit. It is even better if the press can be extracted till lowest moisture content, which can lower the disposal costs as well (Yang et al., 2011).The benefits of using a technology or machine, for extraction are time saving, improvement of efficiency, increase of capacity and reduction of spoilage and waste (Abulude et al., 2007).
Currently, there are limited reports on evaluation of the physico-chemicals content in pomelo fruit processed by different extraction techniques. The objective of this research was to study the physico-chemical characteristics of pomelo juice obtained by different household extraction techniques. The work underlines the effect of different extraction techniques on the quantity and quality of juices obtained.

2. Materials and Methods

Fresh harvested pomelo fruits from Tambun variety were used in this study. Pomelo fruits were obtained in February 2014 from Jabatan Pertanian Daerah Kinta, Ipoh, Perak Darul Ridzuan, Malaysia. The fruits were stored in refrigerator at 10°C until they were used for experiment. Pomelo fruits were inspected thoroughly for any damage and spoilage, then, the selected fruits were thoroughly washed in tap water to remove dirt and dust particles.

Fruit flesh of pomelo fruits was manually peeled. The thick fruit rind was peeled off after incision of longitudinal cuts with a sharp knife onto the spongy rind to reveal the juicy segment of fruit flesh. The fruit was separated into individual segments and the lamella was peeled and discarded. Care must be taken to avoid any seeds or peel because only fruit flesh was used in this experiment. Hand press extraction, screw press type juice extractor, blending type and centrifugation type juice extractor were used in the study. The tested pomelo juice extraction methods were as the following:

Extraction method 1 (EM-1): pomelo fruit was cut into half. Each half of pomelo fruit was squeeze by hand and filtering through a nylon sieve.

Extraction method 2 (EM-2): extraction of pomelo flesh was done by blending method. Blender used was household blender and only fruit flesh were blend without addition any water. The pulp and juice were separated by means of nylon sieve.

Extraction method 3 (EM-3): extraction of fruit flesh was done by using screw press method.

Extraction method 4 (EM-4): extraction of fruit flesh was done by centrifugal method of extraction.

After the extraction process, the juice and the waste pulp were separated and both were collected for analysis. The juice was filtered through a clean muslin cloth and kept for 24 h in refrigerator (4^{o}C) for sedimentation. Then, the clear juice was used for physico-chemical analyses. Weight of juice extracted was measured using an analytical balance (B204-S, Mettler Toledo, Switzerland). Juice yield was calculated using Eq (1) , while extraction efficiency, extraction capacity and extraction losses were measured using equation Eq (2) and Eq (3), respectively (Ndubisi et al. 2013).

$$juice\ yield(\%) = \frac{weight\ of juice}{weight\ ofpulp} x\ 100\% \quad (1)$$

$$extraction\ efficiency(\%) = \frac{weight\ of juice\ extracted}{weight\ of juice\ extracted + weight\ of\ residual\ waste} X\ 100 \quad (2)$$

$$extraction\ loss\ (\%) = \frac{weight\ of\ feed - (weight\ of juice\ extracted + weight\ of\ residual\ waste)}{weight\ of\ feed} X100 \quad (3)$$

Moisture content of residual waste after extraction was measured using moisture analyzer while total soluble solids were measured by placing a few drops of juice on a digital refractometer (PAL-α, Atago, Japan) with a scale of 0-85 °Brix. Titratable acidity was determined by titrimetric method using 0.1N sodium hydroxide. 10 mL of juice was pipette into a beaker and titrated with 0.1N NaOH, using phenolphthalein as an indicator (Mazumdar and Majumder, 2003). Results were expressed in citric acid (mg/ml). Titratable acidity was calculated using Eq (4):

$$titrtable\ acidity\left(\frac{mg\ citric\ acid}{ml}\right) = \frac{volume\ of\ titration\ X\ 0.1N\ NaOH\ X\ 0.064\ X\ 100}{volume\ of\ juice} \quad (4)$$

The pH of pomelo juice was determined using a method determined by AOAC (1994), while the ascorbic acid content was determined by visual titration method where the known volume of extracted pomelo juice was titrating against 2,6-dichlorophenolindophenol (2,6-DCPIP) dye solution until stable faint pink colour was obtained (AOAC, 1995). The results were expressed as mg ascorbic acid/100mL of fruit juice. Colour of juice was measured using a colorimeter (Ultrascan PRO, Hunter Lab, Hunter Associates Laboratory Inc, Reston, VA, USA). Juice was filled into a 50 mm glass cell to the top and placed against the reflectance port with an opaque cover. The juice colour was read through the clear glass window of the cell and expressed as lightness, L*.

The data obtained in the study were expressed as mean ± standard deviation and were done in triplicate. Statistical analyses were performed with a one-way analysis of variance using SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA) to verify the significant difference among treatments. The significance level at 5% probability level ($p<0.05$) was considered for physico-chemical assessment.

3. Results and Discussion

Figure 1 shows the effect of different extraction methods on the performance on extraction methods. Juice yield is the quantitative measurement on the amount of juice obtained from extraction process which is related to cost of production. The extraction methods evaluated for pomelo juice extraction had significantly influence the yield of juice extraction. The pomelo juice extracted by hand squeezing (EM-1) had a yield of 53.07% which is the lowest extraction yield compared to others. Pomelo juice extracted by screw type extractor (EM-3) had the highest extraction yield (77.25%), followed by centrifugal type (EM-4) and blending type (EM-2) which reported the value of 73.14% and 70.88%, respectively. These results are similar to data reported by Ram et al. (2012) in extraction of grapefruit by juicing using screw press achieving highest volume of juice yield compared to hand squeezing and blending. Nair et al. (2007) studied on different extraction techniques of pummelo juice which were osmoextraction, screw pressing, crushing and hand pressing. The results obtained that screw pressing method produced high extraction yield compared to others techniques. Similar with experiment conducted by Vishal and Sanjay (2009), reported that extraction of hill lemon juice by screw pressing produced high yield of juice as compared to others method which were pulper, hydraulic press and reaming press.

The obtained extraction efficiency of screw press type (EM-3) was the highest (72.61%) followed by EM-4 (72.45%), EM-2 (69.34%) and EM-1 (54.28%). Extraction loss determined the amount of extracted juice loss during the operations. In this experiment, there were reported that the highest extraction loss was EM-1 method followed by EM-4, EM-2 and EM-3. Moisture content determined the quality of food materials because it is known as the percent of water present in the food. For this experiment, moisture content of residual waste results showed significant differences among treatments ($p<0.05$). The lowest value of moisture waste reported in juice extracted was achieved by screw press type (74.35%).

Screw press type operated by pressing the screw horizontally while conveying the pomelo flesh along the perforated cylindrical container. Juices were flow out via the perforated cylinder and the wastes were ejected at the end plate. The motion of screw normally is quite slow but this method allowed the screw to press efficiently the fruit flesh along the cylinder until the plate (McLellan & Race, 1995). Blending type extractor is typically used to extract juice from fruits, in which the existence of a cutter at the base encourages the fruit to slice and grind. Blending (EM-2) operation is more to manual method because the extracted juices need to be filtered by nylon filter manually. But, it was predicted that the residual waste are still wet, thus there was time-consuming, less efficient and loss of extracted juice during operations.

Regarding the centrifugal type extraction (EM-4), fruit flesh was extracted by a rotating base plate which has a cutter surface. The juices were filter out through a conical mesh wall around a plate and residual waste were ejected out into an outside container due to centrifuging forces during extraction. The cone shape of mesh surrounding the base cutter plate is insufficient for the complete squeeze of the juice (Mircea & Andrea, 2012). Normally centrifugal type extractor operates at high speed of rotating base plate. Because of high speed of rotating base plate, the fruit flesh which containing numerous juice sacs were loosened without crush well by the cutter plate. Hence, it could be a possible reason because the moisture content of waste pulp (78.42%) and extraction loss (17.57%) were reported to have the second higher value after hand squeezing method. Extraction by hand squeezing (EM-1) was tedious and time-consuming. This method reported the lowest juice yield (53.07 %), the less extraction efficiency (54.28%), the high extraction losses (21.27%), and the higher moisture content of pulp waste (81.93%) as compared to other extraction methods.

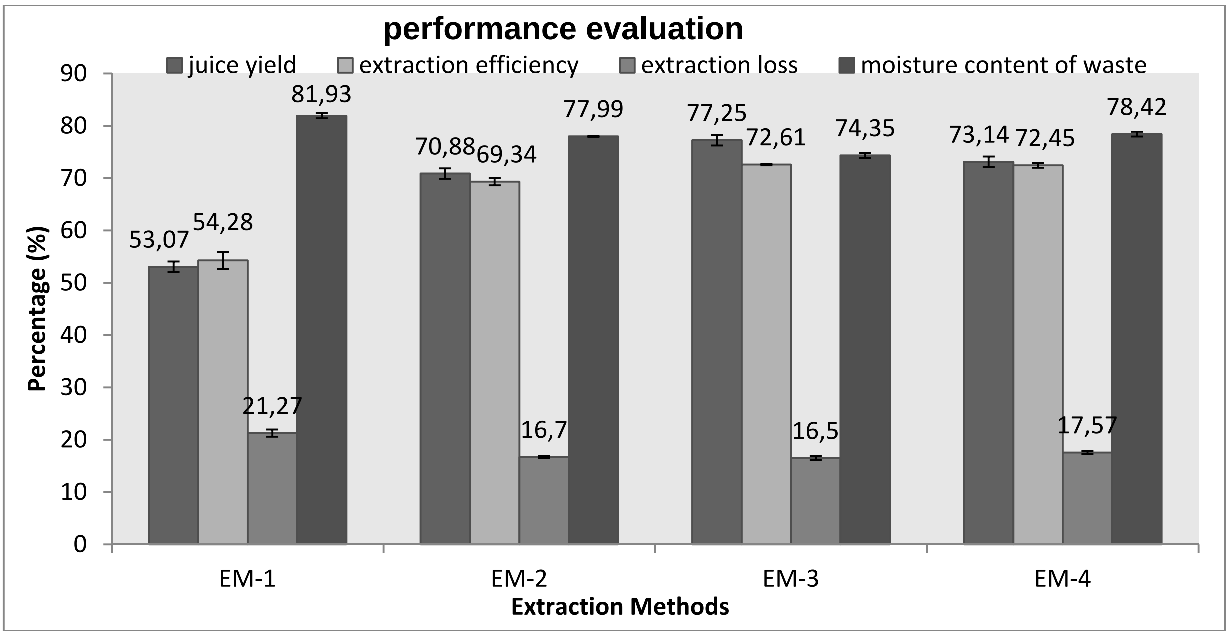

Figure 1: Performance evaluation of different extraction methods of pomelo juice

Table 1: Effect of different extraction methods on physico-chemical characteristics of pomelo juice. (EM-1= extraction by hand-squeezing, EM-2= extraction by blending,EM-3= extraction by screw press type, EM-4= extraction by centrifugal type

Juice extractor type	EM-1	EM-2	EM-3	EM-4
Total soluble solids (°Brix)	11.22 ± 0.05[a]	11.91 ± 0.03[d]	11.84 ± 0.01[c]	11.45 ± 0.02[b]
Titratable acidity (mg/100 mL citric acid)	676.20 ± 13.52[d]	608.15 ± 9.43[a]	640.05 ± 8.39[c]	620.13 ± 11.41[b]
Lightness, L*	47.3 ± 0.45[a]	47.8 ± 0.42[b]	50.9 ± 0.31[d]	48.8 ± 0.32[c]
pH	4.10 ± 0.02[a]	4.12 ± 0.01[a]	4.13 ± 0.01[a]	4.15 ± 0.03[a]
Ascorbic acid (mg / 100 mL)	51.5 ± 1.24[b]	51.9 ± 1.58[b]	54.1 ± 1.06[a]	50.2 ± 1.93[b]

Results in Table 1 show the effect of extraction methods on the pysico-chemical characteristics of pomelo juice. Significant differences were detected in total soluble solids (TSS), titratable acidity, lightness and ascorbic acid. TSS levels ranged from 11.2 to11.9 °Brix. According to De Souza et al. (2012), the fruit juices with the highest possibility of consumer acceptance are those with high levels of soluble solids. The content of TSS in pomelo juice by blending (EM-2) was significantly higher than TSS in other extraction methods. The values of TSS reported in this experiment were 11.91 °Brix, 11.85 °Brix, 11.45 °Brix and 11.22 °Brix for EM-2, EM-3, EM-4 and EM-1, respectively. This is supported by Ram et al. (2012) where the grapefruit extracted by blending (12.73 %) had relatively higher content of TSS content as compared to juicing (11.48 %) and hand squeezing (11.86 %). However, studies on different extraction method of Nagpur mandarin (*Citrus reticulate* Blanco) by Sunil et al. (2011) reported that TSS level was recorded higher in centrifugal type extractor compared to screw press type extractor at the end of 6 months storage. They predicted that this result might be due to the mandarin juice sacs were squeezed higher by centrifugal than screw type extractor.
Significantly lowest content of titratable acidity was observed in pomelo juice extracted by EM-2 where the value was 608.15 mg/100mL. The highest content of titratable acidity was in pomelo juice extracted by EM-1 (676.20 mg/100mL), followed by EM-3 (640.05 mg/100mL) and EM-4 (620.13 mg/100mL). Similar data reported in the study of mandarin juice extracted by screw press and centrifugal extractor. This study obtained that titratable acidity of extracted mandarin juice by centrifugation was lower compared to juice extracted by screw press (Sunil et al., 2011). The relatively low levels of acidity present in blended pomelo juice could be due to the higher content of pulp because blending method was totally blended or crush the pomelo pulp. This reason also can be a significant reason of higher content of titratable acidity in blended pomelo juice (Ram et al. 2012).

Colour is one of the most important parameters when making a sensorial evaluation of food quality. Lightness of pomelo juice extracted by EM-3 was obtained as 50.9 which was highest value as compared to EM-1 (47.3), EM-2 (47.8) and EM-4 (48.8). Screw press extraction (EM-3) operated as pressing and filtering where the fruit flesh were pressed along a perforated cylinder. So, the waste and juice were separated by perforated cylinder and produced a clear juice. Comparing blending (EM-2) and hand squeezing (EM-1) methods, the extracted juice needs to be filtered manually with nylon filter in order to separate the juice and waste. Therefore, it might be possible where the juice is not too clear due to some existence of waste or pulp in the juice. Besides, the centrifugation method usually had high speed operation of cutter plate to extract a juice. Due to high speed, juice extracted might be oxidized and lead to cloudiness of the juice.
There were no significant differences ($p > 0.05$) in pH related with the method of juice extraction used. Shah et al. (2012) reported the pH value of pomelo Tambun variety extracted with commercial screw type extractor was 3.88. Pomelo juice extracted using EM-3 shows the highest value of ascorbic acid (54.1 mg/100 mL). Ascorbic acid is recognized as an important antioxidant compound of natural origin (Almeida et al., 2011). Ascorbic acid is highly soluble and this enables EM-3 method for pomelo juice to be suitable to produce high content of ascorbic acid. No significant variations in the levels of ascorbic acid were observed in EM-1, EM-2 and EM-4. The mechanism of centrifugal extraction (EM-4) and blending (EM-2) for juice extraction employed a cutter. This could cause a possible denaturation of ascorbic acid in pomelo juice extracted using these methods and could lead to the lower value of ascorbic acid. Besides, the cutter on blender and centrifugal extractor will generate pressure and heat, thus might be the reason of decreasing in ascorbic acid of fruit juice (Sunil et al., 2011).

4. Conclusion

The extraction of pomelo juice using a screw press type (EM-3) provided the highest extraction yield and extraction efficiency. Besides that, the loss of extraction and moisture content of waste pulp reported at minimal values. Eventhough a hand squeezing (EM-1) method of extraction is a simple method, but results showed that it was the highest in terms of moisture of waste and extraction loss, resulting the less efficient extraction method with the low extraction yield. The obtained data would be a guide in the selection of proper extraction method for pomelo juice extraction which affected the physico-chemical characteristics of the pomelo juice.

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