INTRODUCTION

Coffee is a beverage product that ranks second in world market after oil. Many countries contribute as coffee producers, including Thailand, although only in a small portion (ICO, 2018). Based on Overland et al. (2017), most Southeast Asian countries are surrounded by oceans, so that they have a low altitude, allowing them to have tropical climates appropriate for Coffea canephora or known as Robusta. Robusta has been the second place for the coffee market product after Arabica and dominated until 40 percent on trade world (Tarno, Wicaksono, & Begliomini, 2018).

Robusta coffee has a high market in some Southeast Asian countries, particularly for 3-in-1 and 4-in-1 instant coffee products with the majority of consumers in Indonesia, Malaysia, Philippines, and Thailand (ICO, 2014). Because of those reasons, some of ASEAN countries are still concerned about developing this particular coffee species. In Thailand, majority areas that develop Robusta coffee is in the southern area, one of them is Songkhla province. This country also became an exporter of Robusta coffee since 1976 with selling until 850 tons at the time (Noppakoonwong et al., 2015).

Some goods including beverage, food, and cosmetics use coffee as their materials. Generally, only the bean as part of coffee cherry is utilized, while other parts are being a waste material (mucilage, pulp, husk, silver skin and parchment). Gouvea, Torres, Franca, Oliveira, & Oliveira (2009) reported...
that processing of one kilogram coffee bean also brings out one kilogram of coffee husk (waste). Waste is caused by coffee cherry on processing and is brought by the cultivation on the field of other coffee parts (leaves). Also, pruning stage of tree branch disperses firm residues or waste in the field plantation, although mulch and composting measurement will be sensible solution for retaining those residues (Echeverria & Nuti, 2017). However, coffee leaves is feasible treated as herbal infusion products, which positively affect human health and comprise many benefits (Chen, Kitts, Ji, & Ding, 2019). This herbal tea (Robusta and Arabica coffee leaves tea) is famous in Sumatra Island, Indonesia and Ethiopia as healthy drink (Ratanamarno & Surbkar, 2017). This product is required to a good smell and delicious taste (Novita, Kasim, Anggraini, & Putra, 2018).

Coffee species have many polyphenols that possess antioxidants and can act as natural medicines that functioned as anti-inflammatory and anti-microbial agents (Blinová, Širotiak, Bartošová, & Soldán, 2017; Bondesson, 2015). The different parts of the plant would contain varied numbers of polyphenols. In particular, the chlorogenic acid, which reduces UV radiation and is crucial for dermatology, has been found in the coffee leaves with a higher amount than in the seed parts (Patay et al., 2016b). Gaining the information, the total composition of phytochemical would be essential for improving meal and drink products from part of coffee (leaves and cherries)—however, there are no studies comparing phytochemical components among those coffee components, especially in Robusta species.

A critical part for developing of food product is preference of consumer. This commodity needs functional elements and requires flavor and other characteristics (color, appearance and aroma). For example, some consumers choose black tea compared to green tea products even though the products might be healthy for them because of the bitterness taste (Lee & Chambers, 2009). In another case, coffee leaves tea product in Ethiopia which well ground was more acceptable than the thicker because of the flavor and fascinating color after infusing (Chen, 2019). Consumption of product is caused by affective conditions (interest, happiness, expectation, etc.), and options will significantly alter development of products depending on consumer perception (Alessandro & Luisa, 2014). For instance, coffee cherry tea which combined with yogurt can be expanded more after having high rate on the consumer preference (Iriondo-DeHond et al., 2020).

This study aims to analyze phytochemical contents and sensory evaluation of coffee leaves and cherries of Robusta coffee from Songkhla, Thailand. For the evaluation of food products, namely coffee leaf tea and coffee cherry tea, this study attempts to determine how to get general consumers to accept these products.

**MATERIALS AND METHODS**

This research was conducted from October 2018 to July 2019. The phytochemical analysis was conducted at the Plant Science Laboratory of Natural Resources Faculty, Prince of Songkla University, Thailand. On the other hand, the sensory evaluation analysis was observed in Hatyai, Songkhla Province coffee shops.

Ripe coffee cherries (red color) and young leaves (1\textsuperscript{st}-4\textsuperscript{th} leaves, 3-4 weeks after emergence and have yellow-green color) (Ratanamarno & Surbkar, 2017) of Robusta coffee from Prince of Songkla University Field, Songkhla province in Southern Thailand were prepared as samples for this study. Some chemical reagents that were needed, such as 95 percent ethanol (Merck, Germany), TPTZ solution (Sigma Alderich), sodium acetate, Folin reagent, NaCO\(_3\), NaNO\(_2\), FeCl\(_3\)\(_6\)H\(_2\)O, FeSO\(_4\), AlCl\(_3\), NaOH were manufactured by Ajax Finechem (Australia).

**Preparing the Samples**

The samples were processed in the oven at 60°C for drying during seventy-two hours and then milled and diluted with 95 percent ethanol (Merck, Germany) with one to ten ratio between samples and ethanol. 100 ml of ethanol was mixed by 10 g of sample. The extracts were stored in a lightless place before the analyzing step (less than 7 days). The samples were filtered and followed by centrifuged processing (Cryste, Korea) about fifteen minutes at 4,000 rpm to separate silt from the solution. The samples were then, evaporated and steamed (50°C) to minimalize ethanol content from the sample by rotary evaporator (Buchi, Switzerland) and water bath (LAUDA-Brinkmann, USA), respectively. For the next step, a balm glass bottle was used to keep 0.025 g of each sample for the preparation of the stock. The sample was then diverse with ethanol (3 replications for the analysis).
Phytochemical Analysis

Total Tannin Content (TTC) and Total Phenolic Content (TPC)

Both parameters used the Folin Ciocalteu method according to Sultana, Anwar, & Ashraf (2009) with minor modifications and different concentrations of reagents. For TTC, the Folin reagent around 1.6 ml was diluted with distilled water at the ratio of 1:5. They were then, combined with the tannin standard (0.1 ml of 1:20, v/v) and 7.0 percent NaCO$_3$ 2 ml and shaken and stored in the lightless condition for 1.5 hours. However, TPC was analyzed by combining the Folin reagent around 2 ml with distilled water at the ratio 1:5. They were mixed with phenolic standard (0.1 ml of 1:20, v/v) and 7.5 percent NaCO$_3$ 1.5 ml. The solution was whipped and kept in lightless condition for approximately two hours. The graph was arranged by applying gallic acid as much as 25 mg to be 50 ml or 500 mg/l solvents. The solvent absorbance was calculated by a spectrophotometer (Thermo Scientific, USA) at 760 nm for TTC and 751 nm for TPC.

The Total of Flavonoid Content (TFC)

According to Chang, Yen, Huang, & Duh (2002), this parameter was evaluated by applying the aluminum chloride colorimetry approach. The distilled water around 4 ml was fused with the sample and 5 percent NaNO$_2$ or as much as 0.4 ml and 0.3 ml, respectively. The next step was adding 0.3 ml of 10% AlCl$_3$ after five minutes of incubation, and the solvent was granted to stand for six minutes. Two ml of 1 mol/l NaOH was added and then put aquadest into 10 ml volume of solvent. The solution was left for 15 minutes and absorbance measurement was carried out at 510 nm by spectrophotometer machine (Thermo Scientific, USA). The graph of standard AlCl$_3$ solvent was projected for TFC, and the description was illustrated as mg equivalent/100g of DW.

Antioxidant Activity (AA)

The activity of antioxidant (AA) was recognized by the Ferric ion reducing antioxidant power (FRAP) method, according to Panda (2012). This substance contained ten units of 300 mM NaOAc or called sodium acetate, TPTZ and FeCl$_3$.6H$_2$O mixture was added with the concentrations of 10 mM and 20 mM, respectively. The solvent was incubated for 30 minutes at 37°C. For preparing the stocks, the reagent was blended with Iron (II) sulfate solvent in various concentrations (0 mg/l, 50 mg/l, 150 mg/l, 250 mg/l, 350 mg/l, and 450 mg/l). Each 0.1 ml sample was combined with 4.5 ml of FRAP reagent and then shaken for ten minutes in a lightless room at normal temperature. Afterwards, the mixed sample was observed by spectrophotometer (Thermo Scientific, USA) at 593 nm wavelength.

Sensory Evaluation of Tea Product

The oven-dried coffee cherries and leaves were dried for three days at 60°C. Gridding was carried out to get smaller samples of tea products packaged with tea bags (2 g/bag). That sample was kept in one pack (25 tea bags/pack). Then, the survey tools were given to consumers at some coffee and tea shops as volunteers. Those included a sample, questionnaire, leaflet, and information about coffee product benefits. Then, the individual consumers tasted the coffee leaf tea and coffee cherry tea. Those were prepared from one tea bag for one cup infused with 200 ml hot water for hot tea (coffee leaves and coffee cherries), and ice for the cold product (coffee cherry mixed with honey-lemon). Honey-lemon is an additional ingredient because having a natural sweetener and beneficial effect on health (Sharma, Vaidya, & Rana, 2016). Then, individual consumers filled up questionnaires related to consumer preference about coffee leaf tea and coffee cherry tea. The questionnaire was split up to two main parts. The first part contained questions about consumer’s demographic data, such as age, gender, and habit of drinking tea. The second part had specific questions about tea, such as flavor, color, aroma, etc. A sample group of 100 consumers at various coffee and tea shops in Hat Yai city, Songkhla province, were interviewed to fill up the survey instruments. Each question item consisted of 9 feeling levels. Each feeling level was identified by Larmond (1977) those categories were 1 = Dislike extremely, 2 = Dislike, for 3 has a meaning as ‘Dislike moderately’, and 4 similar to ‘Dislike slightly’, and then 5 as median number means ‘Neither like nor dislike’, the four last categories 6, 7, 8 and 9 have the meaning Like slightly, Like, Like very much, Like extremely, respectively. For questions related to interest levels, each interest level was classified into 5 levels as 5 for the most, 4 equals to more, 3 is moderate, 2 means less, and 1 as the least.
Instrumentation and Interpretation of Data

All of data were described as mean values in addition to their standard deviations (SD). T-test was used for variance evaluation between coffee leaves and coffee cherries. The p-values ≤ 0.05 are regarded as significant on phytochemical composition. F-test analysis was performed for sensory evaluation with Bonferonni post hoc for significant data. The results of data analyses were presented by tables and graphs.

RESULTS AND DISCUSSION

Phytochemical Analysis

Table 1 illustrates that coffee leaves and cherries significantly differed in phytochemical compositions according to the T-test. The results showed that the leaves had a higher score than the cherry part in all phytochemical parameters (TPC, TTC, TFC, and AA).

The leaves of coffee had almost twice higher content of phenolic compared to the cherry part. The leaves still dominated the other parameters, namely TTC and TFC in the leaves reached three times higher than cherry (Table 1). Related with the anti oxidant activity, coffee leaves had seven times higher AA than the cherry part of Robusta coffee.

Coffee leaves contain a huge phytochemical compound in that it is a good opportunity to develop product including as a tea product. Based on Patay et al. (2016a), Bengal and Arabica coffee leaves contain more various phenolic and flavonoid than coffee seed. Coffee leaves are the only organ of coffee plant which comprise mangiferin (the antioxidant that have function as anti-inflammation) (Chen, Kitts, Ji, & Ding, 2019), and the young coffee leaves were being the highest value for this compound (Acidri et al., 2020; Campa et al., 2017). The young coffee leaves also contain higher value for the other phytochemical compositions than the mature stage leaves. The composition of TPC and AA on coffee leaf tea product from Robusta species is higher when using 3rd and 4th leaves from from the shoot terminal flush (Novita, Kasim, Anggraini, & Putra, 2018). Ratanamarno & Surbkar (2017) reported that young leaves of Arabica coffee had higher AA compositions than mature ones. The higher TFC content in young coffee than mature leaves was also reported by Chen, Kitts, Ji, & Ding (2019) and Maxiselly, Anusornwanit, Rugkong, Chiarawipa, & Chanjula (2022).

Cherry part of coffee also contains a high polyphenol value as one important factor for AA, which will depend on ripening stage and fruit species. Gralec, Wawer, & Zawada (2019) informed that the composition of phenolic compound and antioxidants in fruits depends on their ripening and post-harvest processing. According to Patay et al. (2016a), Liberica (1.86 percent) as local Africa coffee and Bengal (3.67 percent) as a wild species are larger for TPC in immature cherry than Arabica coffee (1.63 percent). Another factor causing variation in cherry compositions is processing of coffee. The three kinds of coffee processing are dry, semi-wet, and wet processing. The TTC values of coffee cherry on dry and wet process has a significant difference. Based on Echeverria & Nuti (2017) report, the dry processing cherry contained ± 5 g/100 g DW while, the wet has 1-9 g/100 g DW for tannin value.

Table 1. Phytochemical compositions of leaves and cherries of Robusta coffee originated from Songkhla province, Thailand

<table>
<thead>
<tr>
<th>Samples</th>
<th>Phenolic compound content (mg gallic acid equivalent/100 g DW Mean ± SD)</th>
<th>Tannin content (mg tannic acid equivalent/100 g DW Mean ± SD)</th>
<th>Flavonoid content (mg catechin equivalent/100 g DW Mean ± SD)</th>
<th>Antioxidant activity content (mg Fe (II) equivalent/100 g DW Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee leaves</td>
<td>13.00±1.08</td>
<td>14.68±0.86</td>
<td>13.27±1.18</td>
<td>22.96±0.70</td>
</tr>
<tr>
<td>Coffee cherries</td>
<td>7.50±0.50</td>
<td>4.00±0.27</td>
<td>4.37±0.22</td>
<td>3.75±0.25</td>
</tr>
<tr>
<td>T-test</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>C.V. (%)</td>
<td>8.2</td>
<td>6.85</td>
<td>9.66</td>
<td>3.96</td>
</tr>
</tbody>
</table>

Remarks: The values of mean ± SD are averages from three samples for each kind of sample, evaluated individually in triplicate (n = 1x3x3); (**) if value was significantly different from mean value (p ≤ 0.05 and p ≤ 0.01).
Based on the phytochemical containment of coffee leaves and cherry, utilizing those materials for expanding tea product will be potential with some factors should be put into account. The important factors that should be deliberated are growth or ripening phase, species, and post-harvest processing.

**Sensory Evaluation**

All categories including age, gender, and frequency of tea consumption is illustrated on Fig. 1. For the gender category (Fig. 1b), the values describe a bit identical portion between man and woman consumers although have dominant groups in age categories such as from 21 to 30 years old and 31-40 years old (Fig. 1a) and tea consumption frequency (1-3 times/week) (Fig. 1c). Color, flavor, aroma, aftertaste feeling, and the overall of tea quality were classified by consumers. By approaching tea products made from leaves and cherries of coffee, the study indicated that significant values were found for aftertaste feeling and overall (Table 2). Coffee cherry tea mixed with ice, honey, and lemon had the highest values for both parameters. Table 2 also illustrates all of the mean values that had $>6$ (Like slightly) and some of the parameters that had $>7$ (Like), such as the color of the product (coffee leaves and cherries), aftertaste, and overall parameters of coffee cherry tea mixed with honey lemon. On the other hand, regarding interest level, some consumers rated coffee cherry tea (hot tea) with the highest value (5) (Fig. 2), even though coffee cherries had an inferior phytochemical composition than coffee leaves. Meanwhile, interest level on a score of 4 was dominated by coffee cherry tea mixed with honey, lemon, and ice, while coffee leaf tea became consumers’ choice.

![Fig. 1. The percentage of variations of tea consumers classified by age (a), gender (b), and frequency of tea consumption (c)]
While the phytochemical composition of coffee leaves was better than that of coffee cherries, this did not affect the choice of consumer. Coffee cherry tea received a bit higher value for overall qualities compared to the tea made from coffee leaf, possibly due to its aroma and taste. However, many studies have indicated that phytochemical composition increases the sensory qualities of tea products (Adnan et al., 2013; Owuor & Obanda, 2001).

Fundamentally, both versions of coffee cherry tea products (hot and cold) can be nicely accepted by the consumers. However, coffee cherry tea mixed with honey and lemon along with ice seemed to enrich the flavor of the product, helping to increase consumer preference. Based on Sharma, Vaidya, & Rana (2016), honey-lemon is the ingredient capable of elevating the drink’s taste. Adding another component for the coffee cherry seems to develop the product value. Another research reported that coffee cherry processed as a yogurt product had good sensory acceptance from consumers because of the taste, appearance, and good texture (Iriondo-DeHond et al., 2020).

Depended on coffee processing, the Robusta coffee cherry has several sensory qualities (Mathur, Navya, Basavaraj, & Murthy, 2015). When the coffee cherries were soaked before drying, there was a decrease in sourness and increase in aroma. Soaking coffee cherries is one of the fermentation methods that aim to decrease caffeine. According to Muzaifa et al. (2021), Gayo-Arabica coffee cherry tea fermented for 12 hours is more acceptable than the one with shorter fermentation period.

Fig. 2. Interest in tea products made from coffee leaves and cherries cherries.

Table 2. Sensory evaluation of tea products made from leaves and cherries of Robusta coffee originated from Songkhla Province, Thailand.

<table>
<thead>
<tr>
<th>Sensory evaluation</th>
<th>Coffee leaves (Mean ± SD)</th>
<th>Coffee Cherries (Mean ± SD)</th>
<th>Coffee cherry tea mixed with honey lemon (Mean ± SD)</th>
<th>F-test (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>7.07 ± 1.13</td>
<td>7.02 ± 1.59</td>
<td>6.98 ± 1.36</td>
<td>0.08&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Aroma</td>
<td>6.08 ± 1.13</td>
<td>6.38 ± 1.52</td>
<td>6.62 ± 1.80</td>
<td>2.73&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flavor</td>
<td>6.41 ± 1.18</td>
<td>6.46 ± 1.65</td>
<td>6.59 ± 1.67</td>
<td>0.27&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Aftertaste</td>
<td>6.54 ± 1.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.57 ± 1.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.34 ± 1.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.82&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>Overall</td>
<td>6.36 ± 1.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.68 ± 1.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.26 ± 1.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.85&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Remarks: The values of mean ± SD are averages of the samples estimated individually by F-test (p ≤ 0.05); (ns) if values were not significantly different from the mean value (p > 0.05), (*) if the values were significantly different from the mean value (p ≤ 0.05). Superscript letters (a-b) within the same row indicate significant (p ≤ 0.05) differences of means within the samples of tea products.
Many factors influence the sensory evaluation of tea products. For instance, Lee & Chambers (2009) revealed that the brewing method and water temperature for the boiling process influenced the sensory evaluation-based appearance and the taste of green tea products. Meanwhile, sensory evaluation also has a high relation with the condition of consumers. The sensory result is also influenced by the consumers’ age, health, hormone, and other physical conditions of consumers (Sharif, Butt, Sharif, & Nasir, 2017).

CONCLUSION

The tea products made from cherry and leaf part of Robusta coffee originated from Songkhla, Thailand, have the potential to be established since the products have many phytochemical containment. The coffee leaves have higher polyphenol compounds and antioxidant activity than those of coffee cherries. Observation in some coffee and tea shops reported consumers’ indulgence to those products. Coffee cherry has a slightly better score than coffee leaves for aftertaste and overall qualities (the coffee cherry tea mixed with honey, lemon, and ice) as well as the consumer interest to tea product as shown by hot coffee cherry tea. Phytochemical compositions of cherry and coffee leaves are influenced by plant organs, growth stage, and species while consumer preferences of organ based tea product are determined by product quality and consumer characteristic.

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REFERENCES


Yudithia Maxiselly et al.: Phytochemical analysis of leaves and cherries coffee .................................................................

Pacific Journal of Tropical Medicine, 9(4), 366–371. https://doi.org/10.1016/j.apjtm.2016.03.014


