Chemical Characteristics of Cascara, Coffee Cherry Tea, Made of Various Coffee Pulp Treatments

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Abstract. Coffee cherry pulp contains caffeine, polyphenols and tannins which can cause environmental problems if discarded, but can be a potential source of antioxidants, phenolic compounds, and caffeine for functional drinks, like cascara. The chemical properties of cascara beverage from six different treatments of coffee cherry pulp were investigated. The pulp treatments were, P₁= pulp of coffee cherries which were kept in a sack for 12 hours before pulping (delayed pulping), P₂= pulp soaked in water for 12 hour, P₃= pulp left in a basket at room temperature for 12 hours, P₄= pulp/husk of dry process coffee, P₅= pulp of wet process coffee, P₆= pulp/husk of wine process coffee (prolonged dried coffee). The results show that the treatments did not affect the cascara beverage antioxidant activity which was between 53-78% DPPH inhibition. However, all treatments lowered tannin contents to about 35 mg/L, except for the P₃ and P₆ treatments. The cascara beverage caffeine content of P₁, P₂, and P₃ treatments was low, around 0.20%, and about twice of that in the P₄-P₆ treatments. Cascara beverage of P₄ contained the highest total acids and the lowest pH which was 4.18, whereas cascara tea/beverage of the wet process (P₅ treatment) had high caffeine and low tannin contents with moderate pH and total acid content.

1. Introduction
Coffee (Coffea sp.) is an agricultural commodity that has a high economic value and consider as the second most important product worldwide, after crude oil [1]. Indonesia with 1.3 million hectares of coffee plantation is recognized as the third largest coffee producer in the world after Brazil and Vietnam [2]. There are mainly 2 species of coffee produced in Indonesia, Arabica coffee (Coffea arabica L.) and Robusta (Coffea canephora). Arabica coffee is one of the main traded coffee species which comprise nearly 75% of the world's coffee production and Indonesia accounts for 10% of this amount. Whereas for Robusta world market coffee less than 25%, and Indonesia provide around 33% of that amount [3]. Coffee fruit or coffee cherry/berry consists of several parts, from the outer side to the center, the cherry compose of skin (exocarp part), pulp (mesocarp part), mucilage, parchment, silvers-kin (endocarp part), and coffee bean (endosperm). The coffee bean, also called green coffee bean, is used to produce coffee beverage after roasting. Processing of coffee fruit into coffee bean is separating the bean from the rest of the cherry parts which is a complex process and produces a mixture of wastes.

Coffee processing produces 40-45% waste which consists of skin, pulp, mucilage, and parchment. The biggest waste is the pulp with the skin which is usually considered only as pulp, account for 29.9%
Coffee pulp contains some nutrients such as 35-50% carbohydrates, 5.2-10% protein, 20-30.8% fiber, 3-10.7% minerals, 84.2% water, 4.1% sugar, 2.5% fat, 1.3% caffeine, and phenolic compounds, i.e. chlorogenic acid, flavonol, anthocyanidin, catechin, routine, tannins and ferulic acids [5,6]. Increase in coffee consumption lead to the rise of waste disposal which causes environmental problems if disposed without necessary pre-treatment because of the caffeine, polyphenols, and tannins contents [4].The use of coffee waste as animal feed also has some drawbacks due to the antinutrient components of the caffeine and tannin [1]. Fortunately, extracted caffeine, and tannin from coffee waste could be used as bioactive compounds for energy drinks and energy bars [7], whereas the polyphenols as source of antioxidants could endow health advantages.

Cascara is a beverage that has characteristics like tea but has coffee aroma. Cascara taste express as fruity, with notes from citrus and cherry, consider like watermelon and blackcurrant [10] or strawberries and raisin [11]. In general, cascara is made by drying coffee pulp in the sun for 4-5 days to generate blackish-brown color cascara. Cascara contains polyphenol compounds such as antioxidants (8.9 mmol/L) which can act as functional drinks [12].

Cascara is considered a new beverage for the United States and Indonesia. However, this drink has long existed in other regions. Farmers from Yemen and Ethiopia actually dried coffee pulp and processed it into beer [13]. Cascara drink in Yemen are called qishr which has long been known by Yemenis before the existence of tea drinks. Farmers in Ethiopia and Yemen also mix spices such as ginger, nutmeg and cinnamon in cascara and known as "hashara". South America, especially El Salvador and Bolivia, apparently has been exporting cascara for a long time. They sell dried coffee cherries pulp to various regions of the world. Cascara has also been known for a long time, although there has not been much scientific research done.

The Gayo Highlands in Central Aceh District is one of the main Arabica coffee producing regions in Indonesia. However, unfortunately, so far, the coffee pulp has not been used optimally. Small amount of the pulp has been used directly as natural fertilizer by some farmers. Most of it is left to accumulate and rot, causing a very sharp odor and disturbing to the surrounding environment.

Scientific studies on making cascara from Gayo Arabica pulp have never been done. Gayo Arabica coffee has known for its world superiority characteristics. It is suspected that cascara produced from Gayo coffee will also have superior characteristics. However, it is known that the processing of Arabica coffee in the Gayo Highlands is quite diverse [14], including the delay of milling/pulping due to the late handling of coffee fruits after harvesting. Furthermore, the composition of dried skin, pulp, and parchment, known as coffee husk [1] may determine by varieties, geographical location, growing conditions, and the maturity of harvested coffee fruit [7,15,16]. These factors may affect the quality of the pulp and cascara produced. Therefore, the objectives of this research are to study the process of producing cascara from diverse coffee pulp sources and analyze the quality of cascara produced.

In general, the purpose of this study is to utilize Gayo Arabica coffee pulp waste and transform it into economically valuable product. Specifically, this research aims to study the cascara production from various Gayo Arabica coffee pulps obtained from farmers who process coffee cherry into coffee bean in various ways, and analyze its correlation to the chemical quality of the cascara produced.

2. Materials and methods
The samples were originated and collected from the Gayo Highlands in Central Aceh District, which is famous as the main producer region of Arabica coffee in Indonesia. On the highland regions with an elevation over 800 m above sea level, the coffee is widely known as Gayo coffee.

2.1. Preparation of cascara from the coffee cherry pulp
In general, the cascara was made based on [17] with some modifications. Six different treatments of Gayo Arabica coffee pulp were prepared (Table 1). The coffee pulps consist of skin and pulp, whereas coffee husk compose of skin, pulp and parchment. Depending on the process of obtaining the coffee beans, the cascara can be produced from the coffee pulps or coffee husk. Treatments P1, P2, P3, and P5 utilize coffee pulps, whereas treatments P4 and P6 use coffee husk for the cascara production. In
treatments P1, P2, P3, and P5, the cascara produced by drying the coffee pulps for about four days or until the pulp was brittle which can be snapped apart by fingers. Dried cascara for treatment P4 and P6 were obtained directly from farmers after hulling (separating the husk from the coffee beans) dried coffee cherry.

Table 1. Six different treatments applied to the coffee cherry prior to the production of cascara.

| Treatment (P)                          | Remarks                                                                 |
|---------------------------------------|-------------------------------------------------------------------------|
| P1= pulp from coffee cherries which   | The coffee cherry was picked up at morning, kept in an organic sack overnight for about 12 hours, and further processed for pulping the next day. |
| were kept in a sack for 12 hours       |                                                                         |
| before pulping (delayed pulping)       |                                                                         |
| P2= pulp soaked in water for 12 hours  | The coffee cherry was picked up at morning, and further processed for pulping in the afternoon. The cherry pulp was then soaked in water for 12 hours before it was dried. |
| P3= pulp left in a basket at room      | The cherry was picked up at morning, and further processed for pulping in the afternoon. Afterwards, the cherry pulp was put in an opened wooden basket and left for 12 hours at room temperature (T= 25°C). |
| temperature for 12 hours              |                                                                         |
| P4= pulp/husk from dry process        | The cherry pulp/husk consists of skin, pulp, and parchment, was obtained from the natural dry process derived from the local farmer. The coffee cherry is sun dried followed by removing the husk in de-hulling process. |
| coffee                                 |                                                                         |
| P5= pulp from wet process coffee      | The cherry pulp was originated directly from the wet process derived from the local farmer. The ripened coffee cherry is separated from the unripe cherry in water, then the pulp of ripened cherry removed by using pulper. |
| P6= pulp/husk from wine process       | The cherry pulp/husk was obtained from the wine process. In general, the wine process emphasized an intense selection of high quality of coffee cherry (size, shape, and weight), special fermentation conducted in an aerobic container for one month, drying, and de-hulling. |
| coffee (prolonged dried coffee)       |                                                                         |

2.2. Preparation of cascara tea/beverage
Cascara beverage was prepared by weighing 65.6 g dried cascara which was then added with 1,000 ml 90°C of hot water and kept for 6.5 minutes brewing, then filtered. The filtrate, the cascara beverage/tea, was used for chemical analysis.

2.3. Cascara tea analysis and data analysis
The cascara tea further employed in the chemical analyses, i.e. caffeine and tannin content by using spectrophotometer [18], antioxidant by using DPPH assay [19], pH by using pH meter, and total acid content [20]. There are three replications for each treatment, therefore total 18 samples analyzed. Collected data were statistically analyzed using ANOVA and Duncan test.

3. Result and Discussion

3.1. Caffeine content of cascara tea/beverage
The caffeine content of cascara tea was in the range between 0.14 – 0.45%, with an average of 0.29% (Figure 1). The caffeine contents were relatively comparable with the caffeine (0.458%) of coffee husk reported by [16]. However, the results were low compared to [12] who reported 226.4 mg/L caffeine in
the extracted cascara. [12] utilized smaller cascara particle size and longer extraction time (total 45 minutes) in preparing the cascara infusion. The P5 and P6 treatments had higher caffeine content compared to other treatments. This inferred that coffee pulps of P1, P2, P3, and P4 treatments might have accelerated and longer fermentation process which had led to the lowering of the caffeine content. According to [21], coffee fruits that left in sacks or buckets have lower caffeine content due to rapid fermentation process. The longer the fermentation process, the lower the caffeine content. The caffeine degradation process might begin after 12-36 hours of fermentation [22].

![Figure 1. The caffeine content of cascara tea of various pulp treatments.](image1)

### 3.2. Tannin content of cascara tea/beverage

Table 2 shows tannin content of the cascara tea range from 28.5 – 76 mg/L with an average of 47.2 mg/L. Tannin content of 28.4 mg/L or 5.68% had been found by [23] who extracted dried coffee pulp using ethanol. Whereas [16] reported that coffee husk from several studies had tannin content of 4.5-5% dry matter. Tannin is a secondary metabolite compound found in some plants. Tannins are able to bind to proteins so that proteins in plants can be resistant to degradation by the protease enzyme. Tannin levels affect the tea color. The darker the color of cascara tea, the lower the tannin content [24].

![Figure 2. The tannin content of cascara tea of various pulp treatments.](image2)

Washing and immersing coffee cherry or coffee pulp prior to the drying process in cascara production might lower the tannin content, since the tannin of the coffee dissolve and discarded in water.
Furthermore, according to [16], the fermentation process in water involving pre-immersion of coffee pulp prior to the employment in the main coffee processing had a strong effect in lowering the tannin content. Figure 2 shows that the tannin content of cascara tea from treatment P2 and P5 were significantly low (< 30 mg/L) compared to that of other treatments. The pulp of P2 treatment was soaked in water for 12 hours before sun dried, while the coffee cherry of P5 was immersed in water to separate the unripe coffee fruits. According to [18], although tannin is anti-nutritional factors [1], small amounts of its consumption can benefit the body, the maximum limit is 560 mg / kg body weight per day.

3.3. Antioxidant activity of cascara tea/beverage
The antioxidant activity was measured as percent inhibition which is in cascara tea was found to be in the range of 53-78% inhibition, with an average of 68%. The ANOVA test showed that the treatments had no significant effects (P > 0.05) on the antioxidant activity. Antioxidant activity analyzed by [4, 25] show that the coffee pulps free radical scavenging activity range from 7.5-70.2%. The disparity might be due to the difference in the extraction solvent used, where they utilized a variety of alcohol solvents instead of hot water as in this study. The disagreement might be also due to the variance in the type or treatment of the coffee pulps. Furthermore, [12] concluded that the different variety of coffee cherry and type of processing resulted in significantly different contents of phenolic compounds and caffeine. Antioxidant activity relates to the content of phenolic compounds, the higher the phenolic compounds found in the coffee cherry, the higher the activity of antioxidants [24].

3.4. pH of cascara tea/beverage
The pH of cascara beverages range 4.18–5.63, with an average of 5.05. The lowest pH was performed by P4 or cherry pulp obtained from the dry process (Figure 3). The pH-value of 4.18 of the P4 treatment was performed as the lowest value, which is quite different from others. It is assumed that coffee dry process which involved a longer drying period, up to six days caused the sugar contained in the beans to have a longer fermentation period, compared to other treatments. Lactic acid, ethanol, butyric acid, and propionate were also formed during the sugar degradation process that was parallely occurred during natural fermentation applied in tea [24]. Such condition would lead to a more acidic condition, and finally tea’s sourness. Furthermore, the formation and composition of aliphatic acid would also lead to lower acidity in many foods.

![Figure 3. pH of cascara tea of various pulp treatments.](image)

3.5. Total acid content of cascara tea/beverage
The total acid contents of the cascara tea were in the range of 0.41 – 2.02% with an average of 0.85% (Figure 4). The dried coffee husk obtained from the natural dry process or P4 resulted in the highest total acid of cascara tea, with 2.02% total acid which was significantly different from others. This result
is in accordance with the pH results, that the higher the total amount of acid produced in cascara tea, the lower the pH value. Such tendency might be affected due to the drying process, in which directly drying fresh coffee cherry was applied in the coffee dry process of treatment P4. The fresh coffee cherry was dried for 7 days without removing the pulp. This might positively support the forming higher amount of aliphatic acids. Such result was in line with the result of pH of the cascara tea. According to [24], direct drying method employed in coffee dry process (like in P4) was a slower drying period, up to 7 days which had affected the coffee husk appearance, with more wrinkled and darker outer skin, which led to the more sour taste in cascara tea as a direct result of longer fermentation time.

![Figure 4. Total acids of cascara tea of various pulp treatments.](image)

4. Conclusion

Caffeine contents of cascara tea were affected by treatments of coffee pulp/husk in which treatments with longer fermentation process (such as in P1, P2, P3, and P4 treatments) had lower caffeine content. The tannin content of the cascara tea ranges from 28.5 – 76 mg/L with an average of 47.2 mg/L. Washing and immersing coffee cherry or coffee pulp prior to the drying process in cascara production might lower the tannin content (to < 30mg/L), since the tannin of the coffee dissolve and discarded in water. The treatments had no significant effects (P > 0.05) on the cascara tea antioxidant activity which had an average of 68% inhibition. The lowest pH of 4.8 and the highest tannin content of 2.02% were performed by P4 treatment in which the husk obtained from the dry process. Bioactive component and content of cascara depend on the variety of coffee cherry and type of cherry processing. In Aceh District of Indonesia, cascara tea can be further explored and prospected as trade commodity, beside the best known Gayo coffee beans, concerning the existence of huge plantation of the Arabica coffee. Among the assessed treatments, cascara tea/beverage of the wet process (P5 treatment) had high caffeine and low tannin contents with moderate pH and total acid content.

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