Influence of withering time and leaf condition on physical and chemical characteristics of fig leaf tea

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Abstract. The fig leaf (Ficus carica) is a good source of bioactive compounds, especially phenolic. Fig leaf can be used for producing herbal tea. The processing of tea includes withering, rolling, oxidation, and drying. Withering is one of the major steps for tea quality. The objectives of the research were to study the effect of withering time and leaf condition on physical (color) and chemical (total phenol content, tannin content, antioxidant activity) characteristics of fig leaf tea. The fig leaves were withered in four different times (0 hours, 8 hours, 13 hours, and 18 hours). The leaf conditions were normal and rusty leaves. The results showed that withering time significantly affects the physical and chemical characteristics of fig leaf tea. The longer withering time the darker tea color, and the lower total phenol content, tannin content, and antioxidant activity of fig leaf tea infusions. Leaf condition significantly affects the tea color (L, a, b, hue). Normal leaves produce the tea with higher total phenol content, tannin content, and antioxidant activity than the rusty leaves.

1. Introduction

Fig plants (Ficus carica) is one of the plants from the Mediterranean that has high functional value in the roots, fruit, and leaves [1]. Leaves are one part of the plants that can be used easily. Leaves are an excellent source of bioactive compounds, especially phenolic compounds. The fig leaves contain phenolic components which effectively scavenge free radical DPPH. Phenolic compounds can act as antioxidants that can prevent cancer, heart disease, cataracts, asthma, and can improve immune function [2].

Today fig plants are widely cultivated in Indonesia. Fig plants grows easily in Indonesia, but because of the origin of these plants from the hot and dry Mediterranean, there are often problems with fig plants in Indonesia. Indonesia has higher humidity and rainfall compared to the Mediterranean so that it causes the leaf diseases such as leaf rust. The leaf rust is caused by the fungi, the Cerotelium fici. The characteristics of fig rusty leaves are yellow to reddish brown on the leaves [3].

In Indonesia, fig leaf is used as a material for making tea. Herbal tea is tea made not from Camellia sinensis plants but from flowers, skin, seeds, leaves, and roots of various plants. Herbal tea with various ingredients are widely developed in Indonesia, including rosella tea [4], coffee leaf tea [5], lotus flower tea [6], soursop leaf tea [7], cocoa leaf tea [8], gambir leaf tea [9], and melinjo skin tea [10].

Black tea is produced from tea leaves through several steps, namely withering, rolling, fermentation, drying, and sorting. Withering time is one of the important factors in the tea processing because it can affect the composition of the tea. The withering process is carried out as an initial step
to reduce the moisture content in the leaves so that subsequent processing takes place properly [11]. Flavor, color, and flavor-forming compounds are formed due to the polyphenol oxidation during the withering process [12]. The withering process causes biochemical reactions. The main change during withering is the breakdown of proteins into amino acids, amino acids along with carbohydrates and catechins form aromatic compounds [13].

Withering time has a significant effect on tannin content and flavor of soursop leaf tea [11]. In the processing of lotus tea, withering time affected the decrease of moisture content, antioxidant activity, tannin content, and sensory [6]. Therefore, the objectives of the research were to study the effect of withering time and leaf condition on physical (color) and chemical (total phenol content, tannin content, antioxidant activity) characteristics of fig leaf tea.

2. Material and Methods

2.1. Material

Fig leaves (Ficus carica) Green Jordan variety was obtained from fig farm in Yogyakarta. The leaves picked were the 2nd to 5th leaves with the condition of normal and rusty leaves.

2.2. Fig leaf tea processing

Fig leaves were sorted and separated based on the leaves condition (normal and rusty leaves). Then the leaves were washed and drained. Next, the leaves were withered at 28-30°C and using a fan for 0.8, 13, and 18 hours. After the withering process was complete, the withered leaves were weighed. Then the leaves were rolled manually and cut to 0.5 cm in size. Next, the leaves were oxidized at 27°C for 2 hours and dried using a cabinet dryer at 65°C for 4 hours.

2.3. Physical and chemical analysis

The analysis of color was determined by the Hunter CIE Lab system method [14]. The analysis of total phenol content and tannin content was determined by folin ciocalteu method [15], [16], and antioxidant activity was determined by the DPPH method [17].

3. Result and Discussion

3.1. Physical Characteristics

3.1.1. Color

| Table 1. L* value of fig leaf tea infusions under the different withering time and leaf condition |
|-----------------------------------------------|
| Withering time (hours) | Leaf condition | L* value | Average |
|------------------------|----------------|----------|---------|
|                        | Normal          | Rusty    |         |
| 0                      | 56.117 ± 0.200  | 55.125 ± 0.400 | 55.621 ± 0.600 |
| 8                      | 54.972 ± 0.150  | 54.762 ± 0.219 | 54.867 ± 0.210 |
| 13                     | 54.352 ± 0.186  | 53.228 ± 0.327 | 53.790 ± 0.639 |
| 18                     | 52.175 ± 0.107  | 50.895 ± 0.347 | 51.535 ± 0.712 |
| Average                | 54.404 ± 1.473  | 53.503 ± 1.729 |

Note: Different notations in the same row and column show a significant difference at 0.05.

According to Table 1, leaf condition significantly affected the L* value of fig leaf tea infusions. The L* value rusty leaves were lower than normal leaves. The L* value were 54.404 and 53.503 for normal and rusty leaves respectively. It means rusty leaves produce a darker color on fig leaf tea infusions. Rusty leaves have brownish spots, are more withered, and look dull. Rusty leaves cause infection in the leaves. The structure of the damaged leaves causes chlorophyll in the leaves degraded easily [18]. Chlorophyll in leaves is degraded into blackish feofitin compounds so that rusty leaves look darker.
The L* value under the different withering time was various, between 51.535 to 55.621 (Table 1). Withering time significantly affected the L* value of fig leaf tea infusions. The longer withering time, the lower L* value. The same result in lotus flower tea [6] and in kakao leaf tea [8] that showing the longer withering time the lower L* value. During withering, the leaves contact with oxygen. In black tea processing, the longer withering time, the lower tea’s lightness [19].

3.1.1.2. a* value and b* value. Notation a is the chromatic mixture of red and green while notation b is the chromatic mixture of blue yellow [10].

| Table 2. a* value of fig leaf tea infusions under the different withering time and leaf condition |
|---------------------------------------------------------------|
| Withering time (hours) | Leaf condition | Normal | Rusty | Average |
|------------------------|----------------|--------|-------|---------|
| 0                      |                | 1.230 ± 0.044 | 0.827 ± 0.027 | 1.028 ± 0.213 |
| 8                      |                | 1.323 ± 0.039 | 1.213 ± 0.062 | 1.268 ± 0.076 |
| 13                     |                | 1.685 ± 0.019 | 1.918 ± 0.052 | 1.802 ± 0.127 |
| 18                     |                | 2.462 ± 0.019 | 2.420 ± 0.051 | 2.441 ± 0.043 |
| **Average**            |                | **1.675 ± 0.496** | **1.595 ± 0.632** |        |

Note: Different notations in the same row and column show a significant difference at 0.05.

| Table 3. b* value of fig leaf tea infusions under the different withering time and leaf condition |
|---------------------------------------------------------------|
| Withering time (hours) | Leaf condition | Normal | Rusty | Average |
|------------------------|----------------|--------|-------|---------|
| 0                      |                | 15.043 ± 0.055 | 11.877 ± 0.100 | 13.460 ± 1.655 |
| 8                      |                | 16.093 ± 0.085 | 15.650 ± 0.099 | 15.872 ± 0.248 |
| 13                     |                | 22.478 ± 0.077 | 16.833 ± 0.145 | 19.656 ± 2.950 |
| 18                     |                | 24.165 ± 0.172 | 21.882 ± 0.118 | 23.023 ± 1.201 |
| **Average**            |                | **19.445 ± 4.026** | **16.560 ± 3.655** |        |

Note: Different notations in the same row and column show a significant difference at 0.05.

According to Table 2 and Table 3, the leaves condition significantly affected the value of a* and b* fig leaf tea infusions. The a* value were 1.675 and 1.595 for normal and rusty leaves respectively, while the b* value were 19.445 and 16.560 for normal and rusty leaves respectively. Rusty leaves had lower a* value than normal leaves, it means rusty leaves produce a lower intensity of red on fig leaf tea infusions. Rusty leaves also have a lower b* value than normal leaves. It means rusty leaves produce a lower yellow intensity in the fig leaf tea infusions. In the rusty leaves, photosynthesis process is disrupted by spots that cover the leaf surface from the entry of sunlight, thereby reducing the ability to synthesize organic matter [18]. One of the photosynthetic organic compounds is a phenol. Tannin is one of the phenol components. Tannin oxidation in the leaves tea by polyphenoloxidase enzyme allows the change of catechins to theaflavins and thearubigin. Theaflavins play a yellow color, while thearubigin plays a brownish red color [13]. Low tannins in rusty leaves form a small amount of thearubigin and also theaflavin, so it has a lower a* value and b* value.

The a* value and b* value under the different withering time was various, between 1.028 to 2.441 (Table 2) for a* value and between 13.460 to 23.023 (Table 3) for b* value. Withering time significantly affected the a* value and b* value of fig leaf tea infusions. The longer withering time, the higher a* value. It means the infusions color was more redness. The longer withering time, the higher b* value. It means the infusions color was more yellowness. Catechin oxidation in the leaves tea by polyphenoloxidase enzymes allows the change of catechins to theaflavins and thearubigin. The longer catechin oxidation in the withering process causes the color changes to more brownish. Thearubigin plays a brownish red color [13]. A high a* value is associated with high levels of thearubigin in the infusions [21]. Theaflavins play a yellow color [13]. High b* values are associated with high levels of theaflavins in the infusions [21].
3.1.1.3. °Hue

Table 4. °Hue of fig leaf tea infusions under the different withering time and leaf condition

| Withering time (hours) | Leaf condition | Average |
|------------------------|----------------|---------|
|                        | Normal         | Rusty   |         |
| 0                      | 85.326 ± 0.171 | 86.018 ± 0.121 | 85.672 ± 0.388 |
| 8                      | 85.300 ± 0.143 | 85.568 ± 0.203 | 85.433 ± 0.218 |
| 13                     | 85.713 ± 0.056 | 83.497 ± 0.220 | 84.605 ± 1.167 |
| 18                     | 84.183 ± 0.068 | 83.589 ± 0.151 | 83.936 ± 0.281 |
| Average                | 85.130± ± 0.594 | 84.693 ± 1.150 |         |

Note: Different notations in the same row and column show a significant difference at 0.05

According to Table 4, leaf condition significantly affected the value of the hue of fig leaf tea infusions. The °Hue value were 85.130 and 84.693 for normal and rusty leaves respectively. Tea infusions with a lower °Hue has a greater intensity of red color and a smaller intensity of yellow. Rusty leaves have a lower hue value than normal leaves because chlorophyll in rusty leaves is more easily degraded due to damaged leaf structure. In the processing of black tea, the enzymatic oxidation process causes the green chlorophyll to decompose into black feotitin [13].

Withering time significantly affected the °Hue value. The longer the withering time the lower °Hue value. A high °Hue value indicates the intensity of red is getting smaller and the intensity of yellow is getting bigger. The °Hue value under the different withering time was various, between 85.672 to 83.936 (Table 4). In this range of values, the color of the fig leaf tea infusions is yellow red [22]. The same result in lotus flower tea [6] that showed the longer withering time the lower °Hue value.

3.2. Chemical Characteristics

3.2.1. Total phenol content

Table 5. Total Phenol Content of fig leaf tea infusions under the different withering time and leaf condition

| Withering time (hours) | Leaf condition | Average |
|------------------------|----------------|---------|
|                        | Normal         | Rusty   |         |
| 0                      | 1.494 ± 0.023  | 1.076 ± 0.009 | 1.285 ± 0.219 |
| 8                      | 1.486 ± 0.018  | 1.070 ± 0.018 | 1.278 ± 0.218 |
| 13                     | 1.315 ± 0.014  | 1.042 ± 0.020 | 1.179 ± 0.143 |
| 18                     | 1.241 ± 0.012  | 0.709 ± 0.012 | 0.975 ± 0.278 |
| Average                | 1.384± ± 0.113 | 0.975 ± 0.158 |         |

Note: Different notations in the same row and column show a significant difference at 0.05

According to Table 5, the leaves condition significantly affected the total phenol content of fig leaf tea infusions. The total phenol content was 1.384% and 0.975% for normal and rusty leaves respectively. Rusty leaves have a lower total phenol content compared to normal leaves. It is due to the Cerotelium fici which attack the leaves results in the appearance of spots that can cover part of the leaf surface so that the sunlight cannot enter. Thus the photosynthesis process on the leaf surfaces is disrupted, thereby reducing the ability to synthesize organic materials [18]. One of the photosynthetic organic material is a phenol.

The total phenol content under the different withering time was various, between 0.975% to 1.285% (Table 5). Withering time significantly affected the total phenol content of fig leaf tea infusions. The longer withering time the lower total phenol content. The longer withering time, the more compounds in the leaves undergo biochemical changes [10] so that the total phenol content decreased. Phenols have volatile properties, are easily oxidized, sensitive to light and oxygen. The longer withering time, the more phenol oxidized and forming brown pigmen and the lightness was reduced [20].
3.2.2. Tannin content

Table 6. Tannin content of fig leaf tea infusions under the different withering time and leaf condition

| Withering time (hours) | Leaf condition | Average |
|-----------------------|----------------|---------|
|                       | Normal         | Rusty   |         |
| 0                     | 0.208 ± 0.001  | 0.201 ± 0.001 | 0.205± ± 0.004 |
| 8                     | 0.200 ± 0.001  | 0.197 ± 0.001 | 0.198± ± 0.002 |
| 13                    | 0.198 ± 0.001  | 0.173 ± 0.002 | 0.186± ± 0.013 |
| 18                    | 0.186 ± 0.002  | 0.165 ± 0.001 | 0.175± ± 0.011 |
| Average               | 0.198± ± 0.008 | 0.184± ± 0.016 |         |

Note: Different notations in the same row and column show a significant difference at 0.05

According to Table 6, the leaves condition significantly affected the tannin content of fig leaf tea infusions. The tannin content was 0.198% and 0.184% for normal and rusty leaves respectively. Same with total phenol content, in the rusty leaves the tannin content also lower than in the normal leaves. It is due to the Cerotelium ficl which attack the leaves results in the appearance of spots that can cover part of the leaf surface so that the sunlight cannot enter. Thus the photosynthesis process on the leaf surfaces is disrupted, thereby reducing the ability to synthesize organic materials [18]. Tannins are one of the phenol components [13].

The tannin content under the different withering time was various, between 0.175% to 0.205% (Table 6). Withering time significantly affected the tannin content of fig leaf tea infusions. The longer withering time the lower tannin content. The same result with tannin content in the lotus flower tea, tannin content decreased because the tannin slightly oxidized during the withering process[6]. The content of catechins decreases during withering in the tea processing. The catechins are converted into theaflavins and thearubigin to produce a distinctive flavor [13].

3.2.3. Antioxidant activity

Table 7. Antioxidant activity of fig leaf tea infusions under the different withering time and leaf condition

| Withering time (hours) | Leaf condition | Average |
|-----------------------|----------------|---------|
|                       | Normal         | Rusty   |         |
| 0                     | 89.066 ± 0.198 | 86.048 ± 0.146 | 87.575± ± 1.566 |
| 8                     | 87.930 ± 0.109 | 83.547 ± 0.284 | 85.738± ± 2.298 |
| 13                    | 87.256 ± 0.145 | 75.364 ± 0.335 | 81.310± ± 6.215 |
| 18                    | 68.016 ± 0.239 | 62.513 ± 0.191 | 65.264± ± 2.881 |
| Average               | 83.067± ± 8.903 | 76.877± ± 9.391 |         |

Note: Different notations in the same row and column show a significant difference at 0.05

According to Table 7, the leaves condition significantly affected the antioxidant activity of fig leaf tea infusions. The antioxidant activity was 83.067% and 76.877% for normal and rusty leaves respectively. Rusty leaves have lower antioxidant activity when compared to normal leaves. Antioxidant activity in the fig leaves is strongly influenced by phenol content [2]. Antioxidant properties are caused by phenolic compounds. Phenolics compounds have function as antioxidants because of their ability to stabilize free radicals by giving hydrogen atoms [23]. Besides, tannins has activity as antioxidants [24], so that phenol and tannin content affect the antioxidant activity. Rusty leaves have a lower phenol and tannin content than normal leaves. So the lower the phenol and tannin content, the lower the antioxidant activity.

The antioxidant activity under the different withering time was ranged between 65.264% to 87.575% (Table 7). Withering time significantly affected the antioxidant activity of fig leaf tea infusions. The longer withering time the lower antioxidant activity. It is associate with total phenol content and tannin content. The longer withering time, the lower total phenol content and tannin content (Table 5 and Table 6).
4. Conclusions

Withering time and leaf condition significantly affect the physical and chemical characteristics of fig leaf tea. The longer withering time the darker of fig leaf tea infusions color and the lower total phenol content, tannin content, and antioxidant activity of fig leaf tea infusions. Leaf condition significantly affects the tea color (L*, a*, b*, hue) of fig leaf tea infusions. Rusty leaves produce fig leaf tea infusions with a dark/old/brownish color. Normal leaves produce fig leaf tea infusions with higher total phenolic content, tannin content, and antioxidant activity than the rusty leaves. From these parameters, normal leaves that are withered for 8 hours produce the best fig leaf tea.

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