Fruit identification and effect of starch isolation methods on color attributes of Cilacap bread fruit’s starch

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Abstract. Utilization of Cilacap breadfruit as a food source is very important for supporting local food diversification. The objectives of this study were to identify the Cilacap breadfruit based on morphology identification method and to evaluate the effects of starch isolation methods on color properties of its starch. The results showed that the morphological identification of Cilacap breadfruit was round - slightly oval, and the brownish green white spots-colored was shown on the ripe stage of fruit at the tree. The average weight of Cilacap breadfruit was 1.506 kg, and the yield of starch was 11.08\%. The fruit identification was determined by LIPI Bogor Indonesia, of which confirmed that Cilacap breadfruit used in this study was a species of \textit{Artocarpus altilis} (Parkinson ex. F.A. Zorn) Fosberg (Moraceae family). Starch isolation by using sediment separation extraction method after three-time decantation was shown as a better method than the non-separation isolation method. Color attributes of starch by using sediment separation extraction method gave a value of $L^* = 94.113$, $a^* = 5.253$ and $b^* = -1.506$ for the white bottom sediment, while the brown color of the upper sediment gave $L^* = 87.587$, $a^* = 5.063$ and $b^* = 1.956$.

1. Introduction
Breadfruit plants are tropical plants producing quite a lot of breadfruit, an average of 200-300 fruits per tree at harvest time \cite{1,2} with a fruit’s weight of about 150-200 kg \cite{3}. This breadfruit is a high carbohydrate-producing fruit \cite{4,5}, low in fat \cite{6}, a good source of vitamins and minerals \cite{1,5}, but its utilization is not yet popular compared to other carbohydrate sources such as cassava, banana or corn. Breadfruit plant distribution in Indonesia is very broad so that many fruit variations are found according to local origin, one of which is Cilacap breadfruit \cite{7}. Breadfruit which becomes the object of this research is ripe-at-tree Cilacap breadfruit. Cilacap breadfruit is one of the breadfruit varieties cultivated in Cilacap district, Central Java, Indonesia since 1980-1995, and has spread to several other...
regions in Indonesia. The superiority of Cilacap breadfruit is its large, fast-growing fruit, and its ability to grow under extensive ecological conditions, compared to other varieties growing in Java [8]. Cilacap breadfruit is also called bali breadfruit because its peel tends to be smooth and hairless. Since breadfruit has broad distribution and morphology differences due to differences in regional origin, it is significant to identify morphology in Cilacap breadfruit, especially ready-to-harvest breadfruit as used for research, including physical attributes from outside. In order to ensure that Cilacap breadfruit belongs to the *Artocarpus altilis* species, (Parkinson) Forsberg and obtain scientific clarity that can be accounted for, it is necessary to conduct identification using the identification key by experts. To extend shelf life and expand its utilization, breadfruit can be processed into flour or starch [2,9]. In this case, starch is more beneficial because of its wider use in food and pharmaceutical industries [4,10].

Color is one of the determining factors in starch application in food systems [11]. In food applications, white breadfruit starch without the addition of chemicals is preferred by consumers, but the constraints faced are during processing if there is a lot of air contact which will consequently produce a brownish starch [2,12]. Therefore, it is necessary to modify the starch isolation process with natural extraction methods (without the addition of chemicals) but produce white starch. Subsequently, the starch is tested for color using a Chromameter CR-400, Konica Minolta Optics, Inc.

### 2. Experimental

The main materials of this research were ripe-at-tree Cilacap breadfruit harvested from the people’s gardens in Jetis sub-village Klepu village Ceper district Klaten Central Java, unripe fruits, leaves, flower beds, root shoots, distilled water, clean water, ice cubes. Tools include styrofoam box sized 42x31x26 cm, ice box sized 50x40x34 cm, extraction equipment: Knife, 6-liter-volume pan, 2.5-liter-volume pan, Muslim cloth, 30x30x3 cm stainless steel pan, cabinet dryer, grinding machine Disk Mill Model FFC-23A, Speed 5800 rpm, serial number 6367, made in Republic of China, Chromameter CR-400, Konica Minolta Optics, Inc.

The outer attribute observation used 9 ripe breadfruits picked from the garden. Outward appearance was observed, including the shape, measurement: length and width, peel color, weight of the fruit with stalks before peeling, weight of edible parts and starch yield after isolation. Starch yield was calculated as described by Akanbi et al [13]. The data obtained is presented in Table.

The fruit identification process is the same as the plant identification process, which is through the search for plant materials employing the identification key, by sending identification materials in the form of root shoots, leaves, flower beds and breadfruit inserted in the styrofoam box, with ice cubes in between the sidelines of the materials and boxes tightly closed. Next, the styrofoam box was inserted in a sealed ice box and sent to LIPI, part of the Bogor Botanical Garden Plant Conservation Center.

The isolation process method Extraction non-Separation (EnS) of sediment is a standard starch isolation procedure that is commonly carried out by many researchers, namely without the separation process after decantation. Starch isolation in this study was carried out through a wet extraction process as described by Nwokocha and Williams [4] with the following modifications: breadfruit starch was isolated from ripe breadfruit. The extraction process was repeated 3 times, each replication consisted of 3 breadfruits. 9 breadfruits were washed, soaked in clean water to avoid browning due to contact with air, sliced into 8 parts, weighed and wet-milled with a grinding machine Disk Mill Model FFC-23A, Speed 5800 rpm, serial number 6367, made in Republic of China. The fruit pulp produced was then weighed, mixed with distilled water with slurry and aquades ratio: 1: 2, and squeezed using Muslim cloth. The filtrate left in the cloth was stored on top while the milk starch passing from the juice was collected in a 6-liter pan. The breadfruit sediment was once again added with aqauadest with a volume of 1: 2, filtered and stored in the same pan of the first juice of starch. The starch milk was deposited for 4 hours, the supernatant was poured (decanted). The sediment was then added with aqauadest by ratio 1: 2, deposited again for 4 hours and the supernatant was poured (decanted). This total process was carried out 3 times. After the third decantation, the starch sediment was stored on a 30x30x3 cm stainlees steelepans and dried in a cabinet dryer at 60° C for 2 days, each for 7 hours.
Starch isolation method Extraction with Separation (EwS) of sediment is a modification of the Cilacap breadfruit extraction process to obtain white starch. The process modification started after 3 decantation processes as the procedure above. After the third decantation, the sediment in the pan was added more aquadest by ratio 1:1, the container in the form of the pan was tilted and allowed to settle for 2 hours. The clear upper liquid was carefully separated, then the sediment was left for another 10 minutes. The Upper Extraction Sediment (UES) in the form of slurry was rocked to separate the brown upper sediment with white starch sediment below it. The slurry-shaped upper starch sediment was poured in a stainless steel pan, then dried. The Bottom Extraction Sediment (BES) which was completely precipitated and could not be poured, was taken using a spoon quickly and placed on another stainless steel pan, immediately dried in a cabinet dryer at 60°C for two days, respectively 7 hours. After drying, the starch was milled, then sifted with mesh 100. Then, each starch was stored in an airtight container labeled according to its type, then stored in a refrigerator at 4°C.

Starch color analysis used Chomameter CR-400 (Konica Minolta Optics, Inc.) based on the Hunter scale. The color results were in the form of numbers from the component L*(light = brightness)value ranged from 0 (black) to 100 (white), the value of a*(green-red) ranged from -80 (green) to +100 (red), and the value of b*(blue-yellow) ranged from -80 (blue) to +70 (yellow)[17] which can be read and recorded. Each sample was repeated 3 times.

All data were shown as mean ± SD. The results of color analysis with different extraction methods were analyzed by One Way ANOVA using the SPSS version 20.0 program, with a significance level of α = 5% (p<0.05) was conducted.

3. Result and Discussion

The shape of Cilacap breadfruit is mostly round and slightly oval, with green peel color when still unripe and when it is ripe, it turns brown with white spots. The length of Cilacap breadfruit is around 13.5-17 cm, width 13.23-17.18 cm, weight before peeling 1.62-1.58 kg, weight of the edible part 1.33-1.25 kg, and starch yield 9.9-13.16%. The average value of external attributes is shown in Table 1.

| Sample       | Attribute components               |
|--------------|-----------------------------------|
| Cilacap Breadfruit |                    |
| 1. Shape     | Round and slightly oval           |
| 2. Peel Color| Brownish green with white spots   |
| 3. Length    | 15.36±1.76 cm                    |
| 4. Width     | 14.89±2.05 cm                    |
| 5. Weight    | 1.51±0.07 kg                     |
| 6. Weight of edible parts | 1.25±0.08 kg |
| 7. Starch yield | 11.08±1.80 %                   |

Breadfruit varies in shape, size and surface texture. Most breadfruit is round or slightly oval 0.25-6 kg in weight, about 9-20 cm in length and 10-20 cm in diameter [6]. Breadfruit is harvested when the tree is ripe which is marked by dark green peel, smooth surface and the presence of latex stains on the peel of the fruit [1]. The most reliable characteristics of ready-to-harvest fruits are the presence of green skin color intensity to brown and the presence of latex stains on the peel surface of the fruit [14]. The fruit used in this study has these characteristics. The presence of latex on the fruit surface is due to the central part of the fruit having a vascular bundle with many latex tubes [6]. Starch yield of each researcher varies, namely 9.60% [15], 14.26-18.5% [13]. The variation in yield of breadfruit starch depends on the level of fruit maturity, variety, differences in climate and agronomic conditions, and the extraction process, namely decantation and purification during starch isolation [13].

The results of analysis undertaken by LIPI, Bogor Botanical Gardens Plant Conservation Center show that bald Cilacap breadfruit is confirmed as a species of Artocarpus altilis (Parkinson ex. F.A. Zorn) Forsberg, Moraceae family. This is in accordance with the study of Sari et al [15] that breadfruit...
samples for their research, the results of identification by Bogoriensi Herbarium belong to the same type as those used in this study.

The analysis of starch color attributes with two methods is presented in Table 2. EwS breadfruit starch color having the highest L value is BES sample, which is 94.11, the second is EnS sample of 88.64, the last is UES sample with L value 87.59. L values range from 0 (black) - 100 (white) [16,17]. The greater the value of L approaches 100, the more white the starch color. This shows that the starch isolated by extraction with separation results in bottom sediment (BES sample) having the whitest color.

| Sample code based on Starch isolation method | L*       | a*       | b*       |
|---------------------------------------------|----------|----------|----------|
| 1. EnS                                       | 88.64±0.19 | 5.48±0.05 | 3.27±0.27 |
| 2. EwS :                                    |          |          |          |
| 2.1. UES                                    | 87.59±2.19 | 5.06±0.40 | 1.95±1.05 |
| 2.2. BES                                    | 94.11±0.35 | 5.25±0.39 | -1.50±0.42 |

Table 2. Color attributes of Cilacap breadfruit starch.

Description: Numbers followed by different letters show very different (p ≤ 0.05). EnS = Extraction non-Separation; EwS = Extraction with Separation; UES = Upper Extraction Sediment; BES = Bottom Extraction Sediment.

This starch is produced without the addition of bleaching chemicals. EnS and UES starch samples are darker (brownish). Starch color is an important factor in acceptance by consumers, since color is one of the important quality components in starch application in various food systems [11,18]. Wheat-based food products, wheat color play an important role in the quality of products, i.e. yellow is the choice of durum wheat pasta, but is not preferred for white bread or noodle products [18]. Nevertheless, the making of breadfruit flour or starch has a problem that is the occurrence of browning reaction during processing, which starts when stripping the skin due to oxidation due to contact with air [2]. To avoid this, in this study, after being peeled, the fruit was immediately soaked in a tub of clean water with the aim of avoiding the peeled fruit in direct contact with air. In addition, breadfruit which is processed into flour or starch quickly turns brown because breadfruit contains polyphenols or phenolic compounds [6,12] and phenolase enzymes causing brown color [12]. Polyphenol compounds reacting with oxygen from the air form polyphenol oxidase which triggers browning of the material in the form of starch. Phenolase enzymes that react with oxygen cause enzymatic browning [2]. Such browning process may also occur in EnS and UES samples, while BES is protected from browning because it does not have direct contact with air. Meanwhile, the use of heating with radio frequency uses 6 kW, 27.12 MHz electromagnetic energy on potato starch is to deactivate the polyphenol oxidase and lipoxygenase enzymes which trigger browning and produce L* 67.72 ± 0.14 [19]. As a comparison, several studies on starch color from various plant sources can be seen in Table 3. To obtain white breadfruit starch color, some researchers added 0.08% NaOH solution and soaked peeled fruit for 45 minutes to produce breadfruit starch with an L* value 74.9 [12], whereas Nwokocha & Williams [4] added 0.3% NaOH to the extraction of breadfruit, and Olatunde et al [17] added a 0.5 g/L citric acid solution to extraction of banana starch with a value of L* 81.23 for Honduran variety banana and 64.74 for plantain, but in this study, extraction without the addition of chemicals produces the highest L* value of 94.11 ± 0.349. In order to standardize, the highest Hunter scale was measured on a standard white tile, L* 97.63; a* 0.78 and b* 0.25 [20]. The higher the L* value means the color of Cilacap breadfruit starch is getting brighter [21]. The value of a* of breadfruit starch in this study for all starch samples is not significantly different, while the value of b* has a difference between the EwS sample and the BES and UES sample with BES. The EnS sample has the highest b* value (3.272in average) followed by UES (1.95in average) as a representation of yellowish color, while the BES sample gives a little blue color because the value of b* is negative (-1.50in average). Cilacap breadfruit starch color in this study has better color attributes compared to the breadfruit starch color.
of the research result Lubis et al [12], cassava starch [22, 23], sweet potato starch, taro starch [23], sago starch [23], and starch potatoes [19].

From Table 3, it is known that in addition to enzyme inactivation and NaOH addition, differences in color measuring instruments are likely to cause differences in results for the L*, a* and b* scales. This is evident in the study [24], i.e. several samples of wheat flour using Chromameter CR-210 Minolta and Chromameter II reflectance Minolta, produces different values of L*, a* and b*. In this study, breadfruit starch without NaOH addition and measured with chromameter CR-400 Minolta produces a value of L* 94.11.

Table 3. Starch color from various plant sources

| Type of Starch       | Hunter Scale | Researcher  | Measuring Instrument                  |
|----------------------|--------------|-------------|----------------------------------------|
|                      | L*           | a*          | b*                                    |
| Breadfruit starch     | 73.30-74.9   | -           | 6.64±0.45                             |
| a. Casava starch      | 82.22±1.74   | 2.37±0.14   |                                        |
| b. Casava starch      | 68.95        | 4.21        | -2.64                                 |
| Sweet Potato starch   | 65.91        | 3.96        | -0.69                                 |
| Taro starch           | 67.20        | 4.32        | -2.23                                 |
| a. Sago starch        | 65.01        | 4.49        | -0.22                                 |
| b. Sago starch        | 86.33        | 1.66        | 7.68                                  |
| Potato starch         | 67.72±0.14   | 5.75±0.53   | 39.68±1.13                            |
|                      | 81.23        | 3.37        | -3.59                                 |
| a. Honduras variety   | 64.74        | 3.29        | -7.00                                 |
| b. Plantain           |              |             |                                       |

4. Conclusion

Cilacap breadfruit has been confirmed as a species of Artocarpus altillis (Parkinson ex. FA Zorn) Forsberg, Moraceae family, with a mostly round and slightly oval shape, the brownish green white spots-colored was shown on the ripe stage of fruit at the tree, ±15.36cm in length, ±14.89cm in width, ±1.51 kg in weight, edible parts ±1.25 kg and starch yield ± 11.08%. To obtain white starch breadfruit, Extraction with Separation (EwS) after three-time decantation is better method than Extraction non Separation (EnS), and without the addition of chemicals. Starch isolation extraction method with separation after three-time decantation is a modification process which can produce white bottom starch sediment (BES sample) (L* 94.11) and brownish upper sediment (UES sample) (L* 87.59).
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