The physicochemical properties comparison of the natural coconut water and the packaging coconut water

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Abstract. The coconut water is a healthy beverage that can be used as a solvent in which a heating process can increase the solubility of the solution. The nature of coconut water easily changes in the open air. Therefore, a natural coconut water is processed into packaging coconut water. But, the packaging coconut water often contains many additional ingredients which can change the taste and nutrition of coconut water. The aim of this research was to compare the physicochemical properties between a natural coconut water (NCW) and packaging coconut water (PCW). The samples consisted of 4 groups: (1) unheating-NCW (uh-NCW), (2) heating-NCW (h-NCW), (3) unheating-PCW (uh-PCW), and (4) heating-PCW (h-PCW). The physicochemical properties were analyzed based on the UV-Vis spectrum λ = 190-790 nm, pH, turbidity, and conductivity. The NCW and PCW respectively had specific wavelengths at 229, 262 nm and 286, 296 nm. PCW had a more absorbancy than an NCW. Heating did not affect the physicochemical properties of an NCW as well as PCW. PCW had higher turbidity than NCW. The high absorbancy and turbidity in PCW were caused by the additional ingredients. All samples had pH which ranges from 5.42 - 5.49, turbidity 19.48 – 69.63 NTU, and conductivity 15.48 - 19.88 mS.

Keywords: coconut water, physicochemical properties, UV-Vis spectrum

1. Introduction
Indonesia is one of the tropical country. Coconut can grow well in the tropics [1]. So, Indonesia has a high potential for planting a very useful this plant – coconut. With a fertile soil, coconut will easily grow in many regions of Indonesia, so people can easily get the coconut fruit. The products from coconut fruit are often consumed by people around the world. One part of the coconut fruit is coconut water. Coconut water is the endosperm part, which is the liquid from immature coconut fruit. Coconut water is a healthy beverage because of its nutrition, e.g. ascorbic acid, vitamin B, calcium, sodium, potassium, copper, iron, phosphor, sulphur, chloride, or some kinds of sugar and amino acids [2]. Besides, coconut water is often consumed because it is easily obtained and also has a cheap price. Coconut water can be used to prevent or relieve dehydration, constipation, digestive disorders, fatigue, heatstroke, diarrhea, kidney stones, or urinary system infections [3].

Coconut water can be used as a component in one of the polyherbal products, EMSA (Erythropoiesis Modulatory and Stimulatory Agent) Eritin. EMSA Eritin is a polyherbal which...
consists of soybean and red rice, with coconut water as the solvent [4]. Heating with the optimal temperature (50-60 °C) can be used to increase the solubility of many components [5].

Although coconut water is sterile during in the coconut shell, coconut water is a bit difficult to be served in fresh condition for a long time due to the physicochemical change. So, there are many companies which process natural coconut water as many products, one of them is packaged coconut water [6]. The natural coconut water (NCW) and the packaging coconut water (PCW) are two kinds of coconut water. To know the basic differences from different kinds of coconut water, the physicochemical characteristic analysis is needed. Through the physicochemical characteristic, the nature of different kind of coconut water can be known, so in the further studies the compound contained in a coconut water can be known and can be applied in certain utilization. The packaging coconut water (PCW) has several physicochemical characteristic differences compare to the natural coconut water (NCW). The purpose of the coconut water processing is the longer storage time [6]. A PCW contains additional ingredients such as sodium carbonate as preservative and citric acid as acidity regulator [7]. But, those additional ingredients can change the taste and nutrition in coconut water [8].

Thus, this research is important because we can obtain information about the ability of active compounds which can be excited in certain wavelengths, whether in heating or unheating sample. From the different absorbance wavelength, it is assumed that there is component difference in coconut water. The component difference can indicate the purity of an NCW. The aim of this research was to compare the physicochemical properties between the natural coconut water (NCW) and the packaging coconut water (PCW).

2. Materials and Methods

2.1. Sample preparation

The samples used in this research were a natural coconut water (NCW) and a packaging coconut water (PCW). An NCW was obtained from tender coconut with age range of 6 to 8 months from Wlingi, Blitar, East Java, Indonesia. Coconut water removal method was referred to a research of Sanganamoni et al. (2017) [9]. Coconut shell was opened by using a knife. An NCW was filtered and poured into container. A PCW was obtained from PT Kalbe Farma Tbk (Hydro Coco Original product). A PCW was poured into container. There were 4 groups of samples used in this research: (1) unheating-NCW (uh-NCW), (2) heating-NCW (h-NCW), (3) unheating-PCW (uh-PCW), and (4) heating-PCW (h-PCW). Heating was carried out using laboratory electric stove, Pyrex beaker glass, and a thermometer for measuring 50 °C of heating samples. Each sample had 3 repetitions which showed the different characteristics from each coconut fruit or package. Repetition in an NCW was obtained from different coconut fruit, as well as in a PCW which was obtained from different package.

2.2. Absorbance profile measurement based on UV-Vis spectra

The absorbance profile of samples was measured by using a UV-Vis spectrophotometer (Genesys 10 UV) in wavelength range of 190-790 nm [10]. The measurement was carried out twice (duplo), then the measurement result was averaged. Spectrophotometry results data was interpreted as a line chart between wavelength (x axis) and absorbance (y axis).

2.3. pH measurement

Samples were poured into a beaker glass. The pH was measured using pH meter (Qis) by dipping the electrodes of pH meter into the sample. The button ‘Measure’ was pressed down. The pH shown on the screen was noted. The measurement was carried out twice (duplo), then the measurement result was averaged.
2.4. Turbidity measurement
Samples were poured into a sample bottle. The sample bottle was put into turbidimeter (Hach 2100Q). The menu ‘Read’ was chosen. The turbidity shown on the screen was noted. The measurement was carried out twice (duplo), then the measurement result was averaged.

2.5. Conductivity measurement
Samples were poured into a beaker glass. The conductivity was measured using conductivity meter (Extech EC600) by dipping the electrodes of conductivity meter into the sample. The button ‘CAL’ was pressed down. The conductivity shown on the screen was noted. The measurement was carried out twice (duplo), then the measurement result was averaged.

2.6. Data analysis
This research was an explorative experimental research, which the data was presented descriptively. The data of UV-Vis spectrophotometry result was presented in chart between wavelength (x axis) and absorbance (y axis). The wavelengths and absorbance of each sample was noted. The UV-Vis spectra was compared between samples. The measurement data of pH, turbidity, and conductivity from each sample was presented in table and chart.

3. Results and discussions

3.1. UV-Vis spectrophotometry result analysis
Each sample repetition had different absorbance spectrum pattern which was the typical characteristic from each sample. The peak pattern difference showed the chromophore component difference from each sample.

![Figure 1](image-url)

**Figure 1.** UV-Vis spectrophotometry result in (a) 1st repetition, (b) 2nd repetition, and (c) 3rd repetition of an NCW (unheating and heating)
each sample. Figure 1a showed that heating did not cause the great impact in absorbancy on UV-Vis spectrophotometry in 1\textsuperscript{st} repetition of the NCW. Nevertheless, there was a bit difference of absorbance in the same wavelengths from unheating and heating samples. There was a highest peak at 229 nm with absorbancy of 1,786 Å (uh-NCW) and 1,796 Å (h-NCW). Besides, there were 2 peaks which were located adjacently at 262 and 271 nm.

The UV-Vis spectrophotometry chart in 2\textsuperscript{nd} repetition of the NCW also had a highest peak and 2 peaks which were adjacent (Figure 1b). But, the differences between unheating and heating sample of the NCW were greater in 2\textsuperscript{nd} repetition. The differences were at 244 nm as a ‘valley’ of the chart, and at 262 and 268 nm as the adjacent peaks. From those wavelengths, it is known that heating caused the decreasing of absorbance in 2\textsuperscript{nd} repetition of the NCW.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{UV-Vis spectrophotometry result in (a) 1\textsuperscript{st} repetition, (b) 2\textsuperscript{nd} repetition, and (c) 3\textsuperscript{rd} repetition of an PCW (unheating and heating)}
\end{figure}
The characteristic of 3rd repetition of the NCW was a bit different from 1st and 2nd repetition, because the 3rd repetition of the NCW only had 2 peaks at 232 and 262 nm. The absorbance of the sample after heating was a bit increased. There was no significant difference between the UV-Vis spectrophotometry chart of unheating and heating sample (Figure 1c).

The 6 peaks in 1st repetition of uh-PCW were located at 229, 244, 262, 271, 286, and 296 nm, while the peaks of h-PCW were located at 229, 247, 262, 274, 283, and 296 nm. The chart between unheating and heating sample was obviously different only at the last peak. Overall, the absorbance of 1st repetition of a PCW was increased after heating (Figure 2a).

The 6 peaks in 2nd repetition of a PCW (unheating and heating) were located at 229, 247, 262, 271, 286, and 296 nm. The difference between unheating and heating sample was obviously different only at the 2nd peak (247 nm). Overall, the absorbance of 2nd repetition of a PCW was decreased after heating (Figure 2b).

The UV-Vis spectrophotometry chart from unheating and heating sample of 3rd repetition of a PCW is difficult to distinguish. The 6 peaks in 3rd repetition of uh-PCW were located at 229, 241, 262, 274, 286, and 296 nm, while the peaks of h-PCW were located at h-PCW were located in 229, 244, 262, 271, 286, and 296 nm. Overall, the absorbance of 3rd repetition of a PCW was increased after heating, except for the 4th peak (Figure 2c).

Both hyperchromic (absorbance increasing in peak) and hypochromic (absorbance decreasing in peak) occurred in the research of Aljamali (2015) [11]. Absorbance is a ratio between the incoming light intensity with absorbed light intensity. Absorbance depends on substance concentration in a solution. The higher the substance level, the higher the absorbance in a solution [12].

There are 2 groups which affect the absorbance spectrum of the molecules, i.e. chromophores and auxochromes. Chromophores are functional group which cause molecules to absorb energy from ultraviolet or visible light radiation. Chromophores are affected by another group called auxochromes. Auxochromes are attached to chromphores and affect the color intensity of the molecules [13].

A PCW had the different UV-Vis spectrum characteristic from an NCW. An NCW had 2 to 4 peaks in UV-Vis spectrophotometry, while a PCW had 6 peaks. An NCW had typical absorbance spectrum pattern, which consisted of 1 or 2 peaks with higher absorbance and other 1 or 2 peaks with lower absorbance, both was separated with a ‘valley’ of the spectrum. The 6 peaks in a PCW’s UV-Vis spectrum had the similar shape and were adjacent each other. The more amount of peaks could be caused by additional ingredients, so there would be more chromophore components which could form peak. A PCW contains sodium carbonate as preservative and citric acid as acidity regulator [7].

| Table 1. Peak data tabulation of UV-Vis spectrophotometry |
|---------------------------------------------------------|
| Sample | Repetition | Wavelength (nm) |
|        |            | 229 | 232 | 241 | 244 | 247 | 262 | 268 | 271 | 274 | 283 | 286 | 296 |
| uh-NCW | 1st        | +   | +   |     |     |     | +   |     | +   |     | +   |     |     |     |
|        | 2nd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
|        | 3rd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
| h-NCW  | 1st        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
|        | 2nd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
|        | 3rd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
| uh-PCW | 1st        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
|        | 2nd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
|        | 3rd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
| h-PCW  | 1st        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
|        | 2nd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |
|        | 3rd        | +   |     | +   |     |     | +   |     | +   |     | +   |     |     |     |

Data tabulation of UV-Vis spectrophotometry peak appearance from all samples showed in Table 1. The specific wavelengths of an NCW were 229 and 262 nm, while the specific wavelengths of a PCW were 286 and 296 nm. Peak appearance and typical UV-Vis spectrum pattern of an NCW can be used to know the purity of a PCW. A PCW had peaks in 229 and 262 nm which indicated that a PCW had an NCW components. The peaks in 286 and 296 nm indicated that a PCW had other components.
besides an NCW. The other components might be the additional ingredients such as the preservative and acidity regulator.

Peak area difference indicates the chromophore group difference in each sample so it generates the difference of ability in absorbing UV light [14]. A molecule or ion can absorb radiation in ultraviolet or visible light area if the radiation can cause the electron transition in compound. Electron transition occurs when the electron moves from an orbital to another orbital with different energy level. The energy carried by light can move the electron from lower energy orbital (ground state orbital) to higher energy orbital (excited state orbital or antibonding orbital) [13]. Peak formation in wavelengths of 230 - 300 nm is caused by the electron transition from $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ orbital, respectively. Peak formation in wavelength of 268 nm is caused by the electron transition in $\pi \rightarrow \pi^*$ orbital [15].

![UV-Vis spectrophotometry result of all (a) unheating and (b) heating samples](image)

**Figure 3.** UV-Vis spectrophotometry result of all (a) unheating and (b) heating samples

All samples had high absorbance in UV area and constant low absorbance (below 0.5 Å) in visible light area. It is possibly caused by coconut water which was a colorless sample, so it cannot absorb energy in visible light area [11]. Figure 3 showed that the absorbance of a PCW decreased significantly (below 0.5 Å) near 400 nm, while the absorbance of an NCW decreased significantly (below 0.5 Å, but lower than a PCW) near 300 nm. It possibly occurred because an NCW had more water component than a PCW. A PCW had more additional ingredients so its absorbance was higher than an NCW. This result could be confirmed with turbidity measurement result which showed that a PCW had higher turbidity than an NCW. A PCW ‘Hydro Coco’ has total calories of 60 kcal. This product contains no protein or fat (0 g). A PCW ‘Hydro Coco’ has carbohydrate content of 16 g, sodium content of 100 mg, and potassium content of 360 mg [16]. An NCW has total calories of 17.4 kcal. Water content of an NCW is 95.5%. An NCW has fat content less than 0.1% and protein content of 0.1%. The carbohydrate content of an NCW is 4%. An NCW also contains amino acids, minerals, and vitamins [17].

3.2. pH, turbidity, and conductivity analysis

The pH measurement result showed that all samples had pH which was not much different from each other. The pH of all samples ranged from 5.42 to 5.49 (Table 2). That result is not much different with [18] which stated that coconut water has acid pH with range of 5-5.4. Water with more free hydrogen ion ($H^+$) will be acidic, while water with more free hydroxyl ion (OH$^-$) will be alkaline [19]. Temperature did not affect the pH measurement result. It is proved from the pH of the samples which was not changed after heating. Temperature does not cause dissociation in weak acid or base [20].

Turbidity is a parameter to measure the light intensity which is spread by suspended particles. The suspended particles block the light through water [19]. Turbidity measurement result was highly varied. Turbidity of all samples ranged from 19.48 to 69.63 NTU. A PCW had higher turbidity than an NCW (heating or unheating) (Figure 4). The high turbidity is possibly caused by sodium carbonate as
preservative and citric acid as acidity regulator [7]. Turbidity of all samples decreased after heating, except for 3rd repetition of NCW and PCW, so it is known that heating slightly decreased the turbidity of coconut water. Heating might cause the insoluble substances (suspended particles) of coconut water to be slightly soluble.

Conductivity measurement result was highly varied in all samples (Table 2). Conductivity ranged from 15.48 to 19.88 mS. The increasing or decreasing of conductivity was not significant, so there was a bit difference of conductivity between heating and unheating samples. Heating did not affect the conductivity of coconut water. Conductivity is used to measure the ion concentration in a solution [21]. Conductivity shows the amount of soluble salt in coconut water. The soluble salt concentration associated with plant capacity in absorbing nutrition from soil [22]. Conductivity is measured in electrolyte solution. Electrolyte is a substance that contains ion, i.e. ionic salt solution or ionized substance in solution. The ion formed in a solution plays a role in conducting electricity. Some electrolyte such as acid, base, or salt can be weak or strong [23]. Coconut water is a weak electrolyte. Weak electrolyte is a substance which is not fully ionized in solution. Weak electrolyte solution can conduct electricity, but not as easy as strong electrolyte because weak electrolyte has less ions which bring the charge from one electrode to another electrode [23].

| Parameter | 1st Repetition | 2nd Repetition | 3rd Repetition | Average |
|-----------|----------------|----------------|----------------|---------|
| **uh-NCW** | | | | |
| pH | 5.64 | 5.55 | 5.07 | 5.42 ± 0.30 |
| Turbidity | 17.35 | 22.25 | 18.85 | 19.48 ± 2.51 |
| Conductivity | 10.28 | 23.95 | 23.30 | 19.18 ± 7.71 |
| **h-NCW** | | | | |
| pH | 5.63 | 5.55 | 5.11 | 5.43 ± 0.28 |
| Turbidity | 17.05 | 20.60 | 30.50 | 22.72 ± 6.97 |
| Conductivity | 10.09 | 23.80 | 25.75 | 19.88 ± 8.53 |
| **uh-PCW** | | | | |
| pH | 5.55 | 5.55 | 5.37 | 5.49 ± 0.10 |
| Turbidity | 68.50 | 72.95 | 67.45 | 69.63 ± 2.92 |
| Conductivity | 11.84 | 9.51 | 25.10 | 15.48 ± 8.41 |
| **h-PCW** | | | | |
| pH | 5.54 | 5.49 | 5.43 | 5.49 ± 0.06 |
| Turbidity | 67.50 | 69.75 | 69.50 | 68.92 ± 1.23 |
| Conductivity | 11.44 | 10.05 | 25.15 | 15.55 ± 8.35 |

Temperature increasing of liquid causes the decreasing of viscosity, because the increasing of molecular thermal energy causes the increasing of molecule mobility and intermolecular spacing, which those can decrease the flow resistance. When the viscosity is decreased, the Total Soluble Solids (TSS) will also be decreased. The solids contained in coconut water mostly are soluble solids such as sugar. The decreasing of solids amount occurs along with the decreasing of activation energy in coconut water. Lower energy is needed to decrease the potential energy barrier in soluble solids [24]. Those indicated that higher temperature can increase the solubility of coconut water. The optimal heating temperature to increase the solubility of some ingredients ranges between 50 to 60 °C [5].
4. Conclusions
An NCW had different UV-Vis spectra characteristic from a PCW. An NCW had 2-4 peaks, while a PCW had 6 peaks in UV-Vis spectra. The marker wavelengths of an NCW were 229 and 262 nm, while the marker wavelengths of a PCW were 286 and 296 nm. The absorbance and turbidity of a PCW were higher than NCW. Heating did not affect the physicochemical properties of an NCW as well as a PCW.

5. Future studies
Based on the UV-Vis spectrophotometry result, a PCW has different UV-Vis spectra characteristics from an NCW, so HPLC test should be carried out with a purpose of giving the knowledge of compound content in coconut water with different treatment. Besides, organoleptic test also should be carried out to knowing the taste difference between coconut water with different treatment. Through organoleptic test, it can be proved that there is taste change in a PCW compare to an NCW. A PCW is expected to have a similar physicochemical characteristic with an NCW, so it can give profit to consumer, both in aspect of nutrition or economy.

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