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Article

Mass Transfer Coefficient Study of Cherry (*Muntingia calabura L.*) Leaves Alkaloids Extraction Using Ethanol

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Abstract

Cherry (*Muntingia calabura L.*) leaves have been acknowledged for their potential as a rich source of various components including alkaloid, flavonoid, tannin, saponin, triterpenes, and polyphenol. Alkaloids play diverse roles in medical science. Isolated alkaloids from plants are already widely used in traditional medicine. Obtaining alkaloids from the leaves required an extraction process using organic solvent. This study aimed to evaluate the mass transfer coefficient for the extraction of alkaloids from cherry leaves using ethanol as a solvent. Dried cherry leaves were contacted with 96% ethanol at different temperatures and contact times. The extraction temperature ranged from 60, 65, 70, 75, and 80°C while the contact time varied from 30, 60, 90, 120, and 150 minutes. The extraction process was conducted with a mixing speed of 440 rpm. With the increasing contact time and extraction temperature, there was a corresponding increase in alkaloid concentrations. The optimal extraction conditions were achieved at 75°C with an extraction time of 150 minutes, resulting in an alkaloid content of 0.6486 gr/ml. The mass transfer coefficient under these extraction process conditions was 1.7923 hour^{-1}. These data are crucial for the design and scale-up of extractors to achieve optimal results.

Keywords: Alkaloids, Cherry leaves, Ethanol, Extraction

1. Introduction

Alkaloids are primarily found in nature on plants, fungi, and other organisms in the form of organic compounds containing nitrogen. It can be found in many forms of compounds neither essential nor toxic for life. For example, alkaloids in many spices are used in cuisine, but it also found as toxins in batrachotoxin [1].

Alkaloids has various function, especially in medical science. Several alkaloids are found on plants already isolated to proceed as antibacterial, antiviral, cancer treatment, antitumor, analgesic, antihypertensive, and antiproliferation [2], [3]. With these broad benefits, it is necessary to isolate alkaloids in other potential plants.

Muntingia calabura L., known as cherry or "*kersen*" in Indonesia', is one of the species that comes from Mungiaceae family. This plant is easily found in Indonesia but still rarely used whereas it contains many useful compounds. Every part of this plant could be proceeded and used for many purposes. Cherry leaves contain flavonoids, tannin, saponin, triterpenes, polyphenols, and steroids [4]–[7]. With these compounds, cherry leaves have anti-bacterial [8], anti-inflammatory [9], and anti-oxidant [10].

There were several methods to isolate natural compounds from plants. The maceration process is a simple extraction method that is suitable for thermolabile compounds. This method takes a long duration and low efficiency. The most widely used method for extracting the natural compound is solvent extraction. It takes several steps, the solvent penetrates into the solid matrix, and then it dissolves the solute. The solute is transported out from the solid matrix by diffusion process then it is collected. Many factors can influence the extraction process, such as extraction solvent, raw material particle size, temperature, time, the ratio of solid-liquid, and solvent concentration [11], [12].

The most common alkaloids extraction method is using solvent. The efficiency of this method relates to the solvent type, solvent dosage, the solid particle size, and the operation condition. Several solvents used in alkaloid extraction were pure water, acid water-organic solvent, alcohol, and alkaline [13]. The suitable solvent used in the extraction process is organic solvent, such as ethanol [14], [15].

The mass transfer between the solvent and the alkaloid on the sample needs to be evaluated to know the effectiveness of the extraction process. The mass transfer process can be determined using the mass transfer coefficient (K_{La}). The value of K_{La} in solid-liquid extraction is determined by the mass transfer velocity of solute from solid surface to solvent [16]. Mass transfer coefficient influenced by the solid particle size. Smaller particle size would increase the penetration rate of the solvent to the solid particle and the diffusion of the solutes. But if the particle size is too fine, the filtration process would be difficult [11].

A previous study on anthocyanin extraction was performed on red dadap flowers. The extraction process was done using ethanol and hydrochloric acid solution at 550^{o}C and 440 rpm stirring speed, giving a mass transfer coefficient of 0.01162 sec^{-1}. Meanwhile, in the extraction process using ethanol and citric acid mixture, a mass transfer coefficient of 0.00629 sec^{-1} was obtained [17].

This study purposed to evaluate the mass balance coefficient in the extraction process of cherry leaves with ethanol as solvent. The extraction processes differed in contact time and temperature process.

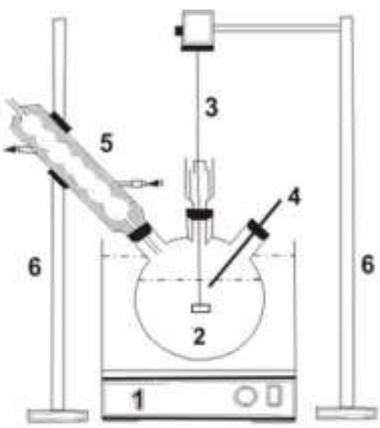
2. Material and Method

2.1 Material

In this experiment, the primary materials were cherry leaves and ethanol. The cherry leaves were obtained from the cherry plants around Surabaya. The solvent for the extraction process, ethanol, was used with 96% purity.

2.2 Method

The cherry leaves were prepared by drying under sunlight and crushed became powder. Then, 20 gr of cherry leaves powder was extracted using 200 ml of 96% ethanol. The extraction process was carried out using an extraction equipment set that consisted of three-neck flask, stirrer, thermometer, condenser, and water bath. The extraction processes were varied from 30, 60, 90,120, and 150 minutes while the mixing speed was 440 rpm. The extraction processes were carried out at different temperatures from 60, 65, 70, 75, and 80^{o}C. After the extraction process, the mixture was filtered using filter paper.



1. Water bath
2. Three neck flask
3. Electrical stirrer
4. Thermometer
5. Condenser
6. Statif

Fig. 1. Extraction Equipment

The filtrate was analyzed using UV-Vis spectrophotometer and calculated using equations 1 and 2 where C is alkaloid concentration, A is absorbance, λ is wave length, MW is molecular weight, DF is dilution factor, E is molar absorptivity, and L is cuvette width.

$$C = A/\lambda \quad (1)$$

$$C = (A \times MW \times DF)/(E \times L) \quad (2)$$

The mass transfer coefficient (K_{La}) for solid-liquid extraction is determined by the mass transfer velocity of solute from the solid surface into the solvent. It was calculated using the following equations [18]:

$$N = d(CV)/dt = K_{La}.V_L(C_S - C) \quad (3)$$

$$K_{La}.dt = dC/(C_S - C) \quad (4)$$

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Eq. 4 is integrated with t limited from 0 to t and the concentration from 0 to C_s, so the equation becomes:

$$\ln\{C_s/(C_s - C)\} = K_{La}.t \quad (5)$$

3. Results and Discussion

3.1 Correlation between alkaloid content and extraction temperature

From Fig. 2, it could be seen that alkaloid content and extraction temperature were directly proportional. With higher extraction temperatures, a higher alkaloid content was produced. At a temperature 75^{o}C, the level continued to increase from 30 to 150 minutes statically because at 75^{o}C close to the ethanol boiling point. The alkaloid content at this level obtained was 0.6426 gr/ml. At 80^{o}C the alkaloid content decreased to 0.6411 gr/ml because the boiling point of the ethanol was close to 80^{o}C and there was a possibility that the solvent evaporated.

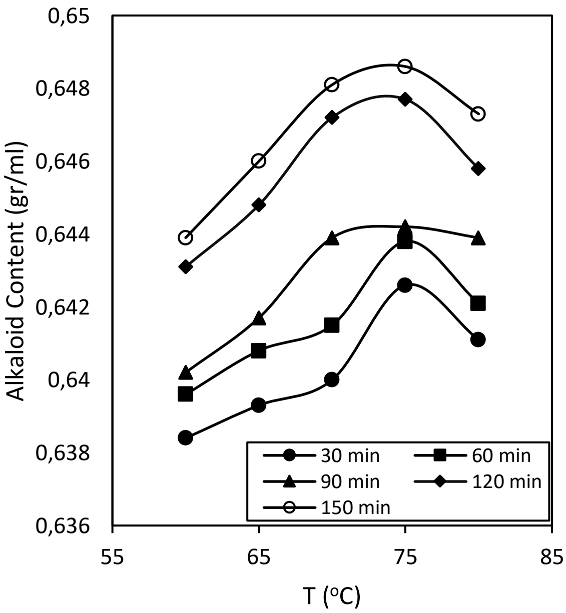

Fig. 2. Correlation between alkaloid content and extraction temperature at various times

3.2 Correlation between mass transfer coefficient and extraction temperature

The mass transfer coefficient values were obtained from the correlation in eq. 5. The gradient of the linear line showed the mass transfer coefficient for every extraction temperature (Fig. 3). All temperatures showed a positive gradient with R square value of more than 0.9. The value of $\ln C_S/(C_S - C)$ proportional to the mass transfer coefficient. The temperature of the extraction process influenced the value of the mass transfer coefficient. With higher temperatures, the mass transfer would be increased. But at 80^{o}C, the mass transfer coefficient slightly decreased. That indicated the mass transfer of the solute and solvent optimum at 75^{o}C.

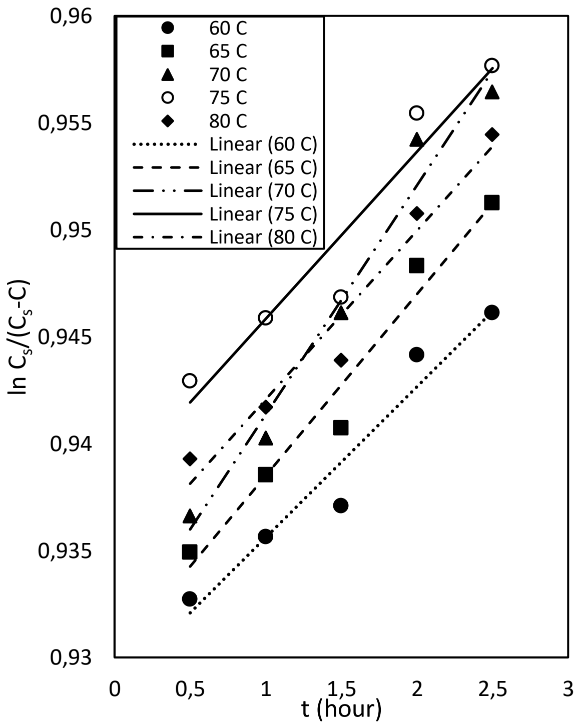

Fig. 3. Correlation between ln $C_s/(C_s$-C) and extraction time on various temperature

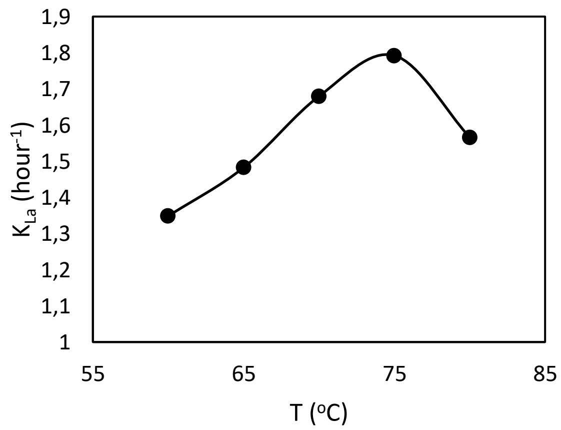

Fig. 4. Correlation between mass transfer coefficient and extraction temperature

Fig. 4 indicates the extraction process at higher temperatures resulted in higher mass transfer. The optimum mass transfer was obtained

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at 75°C where the mass transfer was 1.7923 hour^{-1}. While at 80°C, the mass transfer coefficient was decreased due to the temperature being relatively close to the solvent boiling point. This condition would lead to a higher solvent evaporate rate. So, the amount of solvent in contact with the solid material would decrease.

4. Conclusions

Alkaloid content on cherry leaves was extracted using ethanol as a solvent in varied conditions. The optimum extraction temperature and contact time condition were achieved at 75°C and 150 minutes, respectively. The mass transfer coefficient of this alkaloid extraction was 1.7923 hour^{-1}. With a temperature over 75°C, the mass transfer process would be decreased due to the effectivity of the solvent limited by the boiling point.

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