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Effect of fruit size, solvent and extraction methods on resin extractability of *Daemonorops* sp. (Jernang)

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**Abstract.** Dragon blood is a red color resin exuded from the fruit of rattan species of *Daemonorops* sp. The plants are mainly found in the rain forest of South-Eastern Asia, particularly Sumatera and Malaysian Peninsula. The resin has been used since ancient times in the Chinese medicines as hemostatic, antidiarrhetic, antiulcer, antimicrobial, wound healing, antitumor, anti-inflammatory, and antioxidant. It is used also as a coloring agent for ceramic industry. Besides its huge benefits, there is only little information about postharvest handling of *Daemonorops*’ fruit. This study explained the effect of solvent type, fruit size, and traditional handling methods of *Daemonorops*’ fruits in order to extract the highest amount of resin. The results showed that eluent strength had played a determining role during the resin extraction process; ranging from the strongest to the weakest was ethanol- chloroform- and hexane, consecutively. Regarding fruit sizes, the smaller the fruits; the higher the amount of extracted resin was obtained. The relationship between fruit size and extractable resin was negative exponential. Among the three types of processing methods in terms of the yield of extracted resin, the direct extraction of fruits was more pronounced compared to the other two traditional handling methods, namely the dry and the wet ones. The results highlighted that better understanding on the postharvest handling; particularly improved of extraction method is a key in the production of dragon blood resin.

1. **Introduction**

Dragon blood is known as red color resin exuded from plants. It has been used since ancient times in the Chinese medicines. The resin is used also as red color agent in the ceramic industry. Worldwide, there are four species of plants known as sources of dragon blood. They are *Croton*, *Dracaena*, *Pterocarpus* and *Daemonorops*. *Croton* is spreading in tropical and sub-tropical American continent such as Mexico, Venezuela, Ecuador, Peru and Brazil. *Dracaena* is found in the eastern Africa, Canary Islands, Madeira and Socotra. *Pterocarpus* is grown in West Indies and South America. Meanwhile, *Daemonorops* is more spreading in South East Asia, particularly on Sumatera and Malaysia Peninsula [1]. Different dragon blood sources contain different bioactive compounds, thus, their application in the traditional medicines might also vary.

The resin is harvested from the *Daemonorops* fruits. *Daemonorops*’ plants grow well in humid tropical rain forest particularly in watershed area and are known in the group of rattan belongs to the palmae family. Many local names are attributed to the fruit of *Daemonorops* such as ‘jernang’...
(Indonesia), ‘longxuejie’ (China), and ‘kirin-kakketsu’ (Japan). Out of 115 species of *Daemonorops*, only five species produce red resin as exudative from the fruits. They are *D. draco*, *D. didymophylla*, *D. draconcellus*, *D. motleyi*, and *D. micracantha* [2]. Villagers collect *Daemonorops* fruits in forest. It is difficult to get uniform size and quality of the fruits because the plants are grown uncultivated or wild in the forest. So far, all fruits are processed through dry or wet method before they are traded. Both methods produced the so called ‘intermediate product’ of dragon blood, which is usually found in the form of powder or clump depending on what kind of processing was previously applied: the dry or wet, respectively [3]. In many cases, ‘jernang’ clumps are not purely obtained from *Daemonorops* resin, but sometimes they are also mixed with other plant resin usually originated from tree plants’ based e.g. Dipterocarpaceae family.

In general, ‘dracorhodin’ and ‘dracorubin’ are known as the distinctive bioactive constituents of *Daemonorops* resin and they have been reported to possess antimicrobial, antitumor, antithrombotic, antiinflammatory and antioxidant activity [1,4]. Counter-current chromatography method combined with pH modulation, currently, has been reported to be able to purify dracorhodin with a high amount from *Daemonorops* [5]. The price of *Daemonorops* at the international market is highly determined based on the content of resin and active substance.

In order to produce dragon blood resin with good quality, therefore, harvest and postharvest handling play a crucial role. Unfortunately, many researches have been dealt with the pharmacological aspects of *Daemonorops* resin and only few have highlighted its postharvest handling. This investigation would like to complement the available information in the postharvest handling of *Daemonorops* fruit in order to produce a highly qualified dragon blood resin.

2. Materials and Methods

2.1. Materials

Materials used in this investigation were rattan fruits - known as *jernang* in the local language. The fruits were bought from a local trader, who acts as a middleman collecting rattan fruits from different areas in the forest of Aceh Province, Indonesia. The rattan fruits were usually harvested by the community, who live surrounding the forest and this kind of activity has been served as part of their livelihood strategy. The rattan fruits applied in this investigation were grouped in the genus *Daemonorops draco* Willd. Blume, which is indigenous from the Sumatran rain forests and whose resin has been exported and worldwide known as ‘dragon blood’.

The bulk fresh rattan fruits consisted of different sizes was classified visually based on its size into very small, small, medium and large. Fifty fruits as representative from each size were measured in their diameter and elongation by using calipers.

2.2. Methods

2.2.1. Traditional Postharvest Handling Method. Raw dragon blood resin was produced using wet or dry process in the postharvest handling method according to the traditional practice in local community of Aceh Province, Indonesia. In the wet process, fresh rattan fruits were ground manually in a basket and the resin was washed with water. The wet resin was collected after sedimentation overnight. The sediment was collected and then dried by air. The sediment would be agglomerated and formed as big as a fist. In the dry process, fresh rattan fruits were dried under shadow before processing for 2 – 3 days. The dry fruits were manually grounded. Then, the red powder was sieved through an 80-mesh screen and collected. Dragon Blood Extraction

Sample in the form of fresh fruit or intermediate product of dragon blood with a weight of 50 grams was soaked in the solvent and stirred slowly in a 250 ml beaker glass. The red solution containing dragon blood resin was filtered and collected. The filtering procedure was replicated until no more resin extracted from the sample indicated by pale red color of the solution. The solution was collected and dried in an oven with a temperature of 50° C in order to produce dragon blood resin. Yield was calculated as percentage [%] of dragon blood resin extracted from the weight of fresh fruits.
2.2.2. Experiments. Experiments aiming to get higher yield were conducted according to completely randomized design with one factor and three replications. There were three kinds of groups of experiments. The first experiment should determine which solvent could accumulate higher yields as there were three kinds of solvents with different polarity employed, namely: ethanol 96%, chloroform and \textit{n}-hexane. In the second one investigated which fruit size was suitable in order to obtain high yield. The last one was to compare the yield of dragon blood’s intermediate products based on two different methods: i) direct extraction of fresh fruits, or ii) common extraction methods applied in the local community: the wet or dry process. The second and the third experiment employed ethanol 96% as solvent.

2.2.3. Statistical Analysis. Data were analyzed using SAS software university edition. Analyses of variance (ANOVA) was employed using generalize linear model and with the Tukey post-hoc test.

3. Results and Discussion

3.1. Effect of Solvent Polarity on Extraction Yield

Figure 1 presents the effect of solvent on the extraction yield of dragon blood resin. The highest yield was gained by chloroform, which resulted 13.91 g resin per 100 g \textit{Daemonorops} fruits. Then it was followed by ethanol with a yield of 11.18 g resin per 100 g fruits. Chloroform has polarity index (PI) of 4.81 grouped into non-polar solvent and ethanol with PI of 24.55 belonged to semi-polar solvent. The lowest yield of 0.64 g resin per 100 g fruits was presented by hexane although it is still also classified as non-polar solvent with a PI of 1.88. Water classified as a kind of strong polar solvent with PI of 80.10, however, there was no yield collected, as the resin was not soluble in water.

![Figure 1](image)

**Figure 1.** Effect of solvent on the extraction yield of dragon blood resin

This result was supported by \cite{4} stated that the dragon blood resin was soluble in ethyl acetate and methanol and less soluble in hexane. Ethyl acetate is non-polar and methanol is semi-polar solvent. Following the solubility principle of “like dissolves like” \cite{6}, this result indicated that dragon blood resin contains non-polar and semi-polar substances.

3.2. Effect of Fruit Size on Extraction Yield

The influence of fruit size on extraction yield of dragon blood resin is presented in Figure 2. Fruit size is presented as hundred fruits weight (HFW) in grams. The bigger the HFW value is, then the bigger the size of \textit{Daemonorops}’ fruits is. Statistically, there was no significant difference by the extraction
yield of very small and small *Daemonorops*’ fruits. Extraction yield of small fruits reached 13.6 g dragon blood resin per 100 g fruits, while extraction yield of big fruits was only 4.4 g resin per 100 g fruits. This result indicated that the smaller the fruit size is, the more resin is contained.

It might be related to the plant stage and second the total surface area of fruits where small fruits have larger total surface area per weight unit than big fruit. The younger the plants are, the better the performance of the cells from physiologically and biochemically. Moreover, small fruits reached 1,466 square millimeters while big fruit was only 487 square millimeters per hundred fruits. During fruit development, the dragon blood resin exuded and covered the surface area of fruits. It explained, why smaller fruits contained more resin. This result provided an indication that dragon blood resin has exuded since the initiation of fruits even when the fruit size was still small. While the fruit size was increasing during the growth stage, there was no or less resin exudation probably produced.

Figure 2. Effect of fruit size on extraction yield of dragon blood resin in relation with surface area of *Daemonorops* fruits

3.3. Effect of Postharvest Processing on Extraction Yield

The traditional processing method is commonly practiced among the *Daemonorops* fruit collector. The collector, mostly, needs to go deep to the forest in order to find *Daemonorops* plants before they harvest the fruits. Sometimes, it takes up to seven days in the forest before they could have back again to the village. The fresh fruit is susceptible to rot. Fungi grow easily and could damage the quality. The fresh fruits can be held without quality deterioration for 4 days. After that, the fresh fruit shall be dried or processed through a wet or dry method. The product of wet or dry process in the form of resin clump or powder has longer shelf life based on the information from local trader. Figure 3 shows the effect of traditional processing method on the extraction yield of dragon blood resin.

Figure 3 indicates that ethanol extraction of fresh fruits or direct extraction resulted the highest yield of dragon blood resin. Direct extraction produced 11.18 g resin per 100 g fresh fruit. Regarding the both common applied extraction by the community; either dry or wet process did not produce so high amount compared to the direct extraction method. The dry process had resulted half of the direct method or yielded only 5.38 g resin, while wet process had the lowest yield, namely only 2.82 g resin per 100 g fresh fruit. This result indicated that huge amount of resin losses occurred during the both traditional processes, which finally leads to economic loss.
Figure 3. Effect of processing method on the extraction yield of dragon blood resin

This research provided basic information on the better postharvest handling of *Daemonorops* fruit in terms of getting high yield of dragon blood resin. This is the first publication informing that there was a negative relation between the size and resin yield, meaning that small and young *Daemonorops* fruits were indicated with higher content of dragon blood resin. Thus, this result would recommend local villager to better harvest small and young fruit rather than waiting until the fruit becoming bigger and ripe. However, it still remains question about the quality of the resin.

The application of traditional process of *Daemonorops* fruit should be further considered because of high resin losses. It was shown that resin losses up to 50 and 75 percent in the dry and wet process, respectively (Figure 3). During dry process, the whole fruit was ground using traditional tools like hammer and conducted manually. The resin on fruit surface was detached in the form of fine dust and coloring the surrounding area. While in the wet process, resin could be possibly lost during the process of grounding and washing. In order to reduce losses, extraction of dragon blood resin should be done direct from fresh or dried fruit by applying chemical solvent, preferably by employing non-or semi-polar solvent (figure 1). For long storage at the middlemen- or collector-level, drying of *Daemonorops* fruits should be an option. The next step of research investigation could be in the area of its long-time storage and how to maintain the level of moisture in order to avoid quality deterioration due to fungi growth.

Selection of solvent was crucial in extraction of dragon blood resin in order to obtain maximum yield. Chloroform and ethanol as well as ethyl acetate and methanol [4] was solvent with a polarity ranging from 4 up to 30. Within this range, it was shown that the dragon blood resin has good solubility and therefore, led to higher extraction yield.

4. Conclusions
Extraction yield of dragon blood resin could be increased by harvesting young and small *Daemonorops* fruits, instead of medium and large size fruits by using solvent with polarity range of 4 – 30 and direct extraction of fruits without postharvest processing should be further encouraged in order to obtain higher yield.

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