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Analysis of Pine Sap Quality Based on Sieve Variations and its Effect on Economic Value

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ABSTRACT

Pine resin is one of the non-timber forest products (NTFPs) that has high economic value. However, the quality and selling value of pine resin are greatly influenced by the container media used during tapping. This study aims to analyze the effect of filter variations on the innovative tool on the quality of the resin and the resulting economic value. The method used is quantitative descriptive through field experiments and analysis of the sales value of the tapping results using two types of tools, namely traditional tools (coconut shells) and innovative tools with two levels of filters and covers. The experiment was conducted for fifteen days on two groups of pine trees that were tapped in parallel. The results showed that although the volume of resin produced was similar, the selling value of the resin from the innovative tool increased up to three times due to the cleaner quality and minimal contamination, with total income increasing from IDR 72,000 to IDR 216,000 for six trees over fifteen days. The community also responded positively to the practicality, safety, and effectiveness of the tool. This innovation contributes to increasing farmers' income and can be a strategic solution to support the efficiency of pine resin tapping by Perhutani.

Kata Kunci: Pine Resin; Collection Tools; Filter Variations; Resin Quality; Economic Value

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INTRODUCTION

Pine resin is one of the important non-timber forest products (NTFPs) that contributes significantly to both economic development and environmental sustainability. In general, the NTFP industry is characterized as labor-intensive and does not require sophisticated technology, yet it is capable of producing high-value and environmentally friendly products (Waluyo et al., 2012). Among various NTFPs, pine resin has considerable commercial value and plays an important role in supporting state revenue as well as improving the welfare of communities living around forest areas(Lempang, 2017). Therefore, the development of pine resin production and management systems remains a strategic priority in Indonesia.

In Indonesia, pine forests are widely managed by Perum Perhutani, particularly in Central Java. One of the important pine resin production areas is Wonosobo Regency, which is included in the working area of the North Kedu Forest Management Unit (KPH). This area covers 9,928.46 ha, with forest areas based on administrative boundaries reaching 8,476.53 ha or approximately 19.0% of the total area (Perhutani, 2021). Pine trees are the main commodity cultivated in this region due to their ability to produce resin that can be processed into high-value derivative products.

Pine resin is further processed into gondorukem (solid resin) and turpentine (liquid), both of which are widely used in various industries such as paper, ceramics, plastics, paint, batik, soap, pharmaceuticals, and cosmetics (Magdalena et al., 2021). Indonesia ranks third globally in pine resin production after China and Brazil (Datumawana et al., 2023). In general, fresh and clean pine resin contains approximately 60% gondorukem, 17% turpentine, and 23% water (Silitonga, 1983), and through mechanical processing (distillation), gondorukem is produced as residue while turpentine is obtained as distillate (Kasmudjo, 2010). However, despite its strong market potential, national pine resin production has not yet reached optimal levels. In 2021, pine resin processing reached only 81,788 tons or 90% of the planned RKAP target, indicating a decrease of 4% compared to 2020 due to insufficient resin supply (Perhutani, 2021).

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At the regional level, pine resin production performance also shows disparities among processing facilities. In 2021, gondorukem and turpentine production in Central Java, East Java, and West Java reached a total of 92,550 tons, contributed by eight Gondorukem and Terpentine Factories (PGT), including Sukun, Garahan, Cimanggu, Rejo Winangun, Sindangwangi, Winduaji, Paninggaran, and Sapuran (Perhutani, 2021). Among these factories, PGT Sapuran in Wonosobo Regency recorded the lowest production level, with an output of only 6,300 tons. PGT Sapuran is supplied by ten Perum Perhutani BKPH units, one of which is BKPH Kebumen located in Ngadisono, Kaliwiro. This condition indicates that pine resin productivity in this region remains relatively low compared to other production centers.

Low pine resin productivity in Indonesia is influenced by several factors. Compared to other pine-producing countries such as China, India, Portugal, and Spain, which achieve resin yields of 2.50–4.00 kg per tree per year, the average production in Indonesia remains at approximately 1.50 kg per tree per year (Perhutani, 2021). While biological factors such as species characteristics, climate, soil conditions, and altitude influence resin production (Alrasjid, H., 1983; Rahmadani, 2021; Tantra, 1983), technical factors during the tapping and collection process also play a crucial role in determining both the quantity and quality of the resin obtained.

Pinus merkusii Jungh. et de Vriese, the dominant pine species cultivated in Indonesia, is well adapted to various environmental conditions and is widely used for reforestation and land conservation programs (Rahmadani, 2021). This species naturally occurs in Southeast Asia and grows well at elevations between 300 and 2,000 meters above sea level (Satjapradja, 1983; Tantra, 1983). Pine trees are usually round and straight with brown to blackish bark and rough, deeply grooved and flaky bark that resembles long pieces (Evayanti, 2017; Sastrapraja, 1980). Pine trees can reach a height of 70 meters, with a branch-free trunk length of about 70% of its height (Cunningham, 2012; Lempang, 2017). Although Pinus merkusii has high resin-producing potential, the quality of resin harvested is often affected by external contamination and water content, particularly due to the use of traditional open resin collection containers and unfavorable weather conditions.

Previous studies have primarily focused on pine species characteristics, resin production potential, and processing outcomes (Alrasjid, H., 1983; Attoric, 2021; Lempang, 2017). However, limited attention has been given to technological innovation at the farmer level, especially in improving resin collection containers that are capable of maintaining resin purity under varying environmental conditions. The absence of effective, affordable, and reusable resin collection technology contributes to low resin quality, reduced selling prices, and ultimately lower income for pine farmers, particularly in regions such as Wonosobo.

Based on these conditions, this study aims to address the existing research gap by developing and evaluating an innovative pine resin collection container equipped with a filtration system. This innovation is expected to improve resin quality, enhance economic value, and provide a practical solution to support increased productivity and sustainability of pine resin production, particularly in low-performing regions such as PGT Sapuran, Wonosobo Regency.

The low productivity of pine resin is due to the fact that the containers used to collect the tapping results are still traditional, namely using coconut shells and plastic pots. The disadvantage of using coconut shells and plastic pots is that rainwater and sap become one because both containers are open. This will cause a decrease in the quality of pine resin and it is difficult to obtain premium quality, because rainwater and dirt enter. The impurities found are in the form of leftover twigs, dry pine leaves, grass, soil and gravel. This occurs during the tapping renewal. Many of the remaining trunks or cracked skins fall into the sap collection area. In addition, when the coconut shell is easily released by the wind because the binding is not strong enough with the pine tree. The pores of the shell are finally easily eroded by rain and due to the tapping process. Conditions and examples of contamination commonly found in traditional resin containers are illustrated in Figure 1.

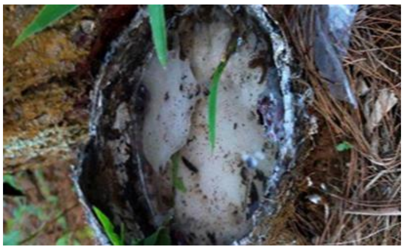

Figure 1. Coconut Shell Container

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Another use of containers is with plastic bags. Plastic bags can reduce impurities that enter the sap so that the resulting sap is cleaner compared to coconut shells (Sukadaryati, S., 2014). In addition, the cost required to buy plastic is also relatively cheaper. However, the use of plastic is only for single use and then thrown away so that it will produce a lot of plastic waste and pollute the environment because plastic is difficult to decompose. On the other hand, coconut shells can be used repeatedly and if they cannot be used again, they will not produce hazardous waste, because coconut shells or coconut shells are easily decomposed naturally. However, open containers for storing sap will greatly affect the results of pine sap and have an impact on farmers' less than optimal acquisition and reduce the economic value of the sap.

One of the supporting media for the creation of the best quality sap production is located in the sap container which is located right under the drops of sap flowing from the tapping. In addition, the slope of the tapping gutter also affects the mass of pine sap obtained so that it falls right into the container. Until now, the tapping gutter still uses curved and open zinc so that during the rainy season, the sap certainly does not fall right into the container. The sap container has an important role in improving production results because the only container and storage of sap from the tree that is the first is located in the container, the container currently used at Perum Perhutani Ngadisono, Kaliwiro is a bowl with a diameter of 8-10 cm and a height of 5-7 cm made of plastic without a cover on top and a coconut shell with an average diameter of 10 cm and a height of 6 cm so that rainwater or dirt will be very easy to enter, the sap that has been collected can also spill because the container is very light so it is very easily blown away by the wind.

Along with the increasing interest of farmers in processing pine plants, various challenges are still faced beyond the issue of resin containers. Weather conditions remain one of the major factors affecting pine resin harvesting, as tapping can be conducted daily under favorable conditions but is frequently disrupted or suspended during rainfall. Prolonged unfavorable weather contributes to low and unstable income among pine farmers. In addition, low resin purity caused by water contamination directly reduces the selling price of pine resin and consequently affects farmers' income. Although these challenges are well recognized, most previous studies have primarily focused on silvicultural and cultivation aspects of pine plantations, while practical innovations in resin collection containers and filtration technologies at the farmer level remain limited. Therefore, the development of an effective, field-applicable resin filtering technology is necessary to address both quality and economic challenges faced by pine farmers. The influence of weather conditions on resin tapping activities and resin quality deterioration is shown in Figure 2.

Figure 2. Results of harvesting pine resin mixed with soil

This study aims to analyze the effect of various filtering methods on the quality and economic value of pine resin. The study was conducted through a field trial involving pine resin tappers who were asked to use filtered resin containers instead of conventional containers such as plastic bowls and coconut shells. The study also compared the sales results of both protection methods over six sales periods. Through this comparative approach, the study provides an empirical overview of the effectiveness of the filtered resin container innovation. Furthermore, the research findings are expected to contribute to addressing the deep and low competitiveness and contribution of resin processing plants, such as the Sapuran PGT in Wonosobo, which has historically had the lowest production unit compared to other factories on Java (Perhutani, 2021).

METHODS

This study employed descriptive quantitative research with a quasi-experimental field experiment approach (Creswell, 2015; Sugiyono, 2006). The quantitative approach was used to numerically describe differences in pine resin production volume and economic value, while the descriptive approach was used to

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explain the resin quality based on observable physical indicators in the field. The quasi-experimental approach was applied because the study involved the use of two types of resin collection devices.

The experiment was conducted directly in the field by installing the innovative tool on pine trees that were actively tapped in the Perhutani KPH Kedu Utara working area, especially in Wonosobo Regency, Kaliwiro District. A total of six innovative sap innovative tool were installed simultaneously with six traditional coconut shell containers as a comparison, on different pine trees that had similar physical characteristics and environmental conditions. Observations and data collection were conducted for fifteen consecutive days of tapping.

This duration was selected to capture a stable production pattern after the initial tapping adaptation period and to minimize the influence of daily fluctuations in resin flow. A fifteen-day observation period is commonly applied in field-based resin tapping studies and was considered sufficient to represent short-term variations in resin production under relatively uniform environmental conditions. The amount of sap and its selling value from both types of containers were recorded and compared, as presented in Table 1, to analyze differences in economic outcomes and resin quality based on the collection method.

Pine wood quality assessment is conducted using non-laboratory physical indicators commonly used in field practice. These indicators include: sap color, which is observed based on the level of clarity (clear–cloudy); the level of dirt, which is determined from the presence of soil particles, litter, and other visible dirt; the presence of free water, as an indication of the relative water content in the sap; and relative viscosity, observed from the consistency of the sap flow (thin–thick). These indicators are used to compare the quality of the sap produced from each treatment.

Sap volume data was recorded daily in kilograms. The economic value of the sap was determined based on the prevailing selling price at the local collector level. Data analysis was conducted quantitatively and descriptively by comparing production volume, sap quality based on physical indicators, and economic value between treatments. The percentage increase in economic value was used as the primary quantitative indicator to demonstrate differences in tapping quality.

Each tool innovation used in the experiment was equipped with a two-stage filtering system designed to enhance the purity of collected pine sap. The first filter was responsible for capturing large contaminants such as bark, leaves, and twigs. Sap that passed through the first filter would continue into the second filter, which had a higher density and served to remove finer particles and moisture. This sequential filtering ensured that the sap was clean and met high-quality standards. Additionally, each container included a rainwater drainage outlet that allowed excess water to flow out, preventing contamination and dilution of the resin during wet conditions.

RESULTS AND DISCUSSIONS

Pine resin is one of the export commodities that plays an important role in supporting local and national economies, particularly through non-timber forest product (NTFP) trade. As a result, various innovations are required, not only in resin processing but also in resin collection and storage systems to maintain product quality. According to (Bina, 2014), Perum Perhutani is one of the world's largest producers of gondorukem and turpentine, ranking third in the global market after China and Brazil. Indonesia produces approximately 900,000 tons of pine resin annually, with 50,000–60,000 tons traded in the global market, while China dominates production with approximately 800,000 tons per year (Bina, 2012). Indonesian pine resin products have been exported to several countries, including the United States, India, South Korea, and European markets (Sukadaryati, 2014).. However, the quality and quantity of pine resin are not determined solely by market demand, but are also strongly influenced by environmental variables such as rainfall, humidity, and temperature, which affect resin flow and contamination during the tapping and collection process. Under unfavorable environmental conditions, particularly during the rainy season, resin quality may decline due to increased water content and impurity levels, thereby reducing its market value.

In this study, we developed an innovative design for a semicircular pine sap container, made of aluminum and equipped with a lid and two types of filters inside. This tool is also equipped with a closed tapping gutter made of iron plate, which is designed to increase productivity and effectiveness of its use. This semicircular aluminum container greatly facilitates the process of collecting pine sap. The available cover functions as a protector, keeping the sap clean from dirt from the tree and the surrounding environment. With various types

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of filters used, we ensure that the collected sap is truly clean. The closed tapping gutter made of iron plate plays an important role in protecting the sap from dirt that may fall from the tree, while the belt used to attach the pine sap container ensures that the tree is not injured during the sap collection process. In addition, this pine sap container is also equipped with a channel for rainwater to drain out. The structural design and functional components of the filter-based pine resin innovative tool are illustrated in Figure 3.

Figure 3. Innovation of Pine Sap Container Tools Based on Filter Variations

This tool innovation is the result of the development of Mody Lempang's research, which utilizes a closed sap container and a tapping channel as the sap entrance. This approach aims to maximize the quality of the sap obtained and reduce the water content, because turpentine will be more easily separated from water (Lempang, 2017). In addition, with a small sap entrance and a very tight container, dirt will have difficulty entering the container. In contrast to Mody Lempang's research in 2017, Perhutani in Kaliwiro only uses the koakan method to obtain sap because this method is more economical and efficient in terms of time. This research provides innovation in the development of the tool created by Mody Lempang by adding various types of filters to the closed container, as shown in Figure 4.

Figure 4. Sieves with different diameters

The implementation of a two-stage filtration system in the tool innovation proved to be effective in improving resin quality. Based on field observations, resin collected using the filter-based container appeared clearer in color and more homogeneous in texture compared to resin collected using traditional coconut shell containers. The filtered resin showed fewer visible impurities such as bark fragments, soil particles, and insects, which are commonly found in traditional collection methods. These qualitative differences are visually presented in Figure 5.

(Rubber From Coconut Shell) (Rubber Products Rubber Placeholders)
Figure 5. Comparison of Pine Sap Harvest Results

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Based on preliminary research conducted during the development of this tool, the resulting pine resin exhibits superior quality compared to traditional methods. This improved quality is primarily influenced by the implementation of a two-stage filtration system, where large contaminants such as bark and leaf fragments are retained by the first filter, while finer particles and excess air are filtered by the second, higher-density filter. Physically, the resin quality is observed through indicators of clearer color, more homogeneous texture, and lower levels of impurities compared to sap collected using open containers. Furthermore, the closed container design and rainwater drainage contribute to reducing air content due to mixing with rainwater, especially during the rainy season, thus maintaining the purity of the sap.

The effectiveness of this filtration-based sap collection device was further confirmed through laboratory observations, which showed that the filtered sap had a higher purity level and met the raw material criteria for premium-grade processing. To assess the practical and economic benefits of using this device, field trials were conducted comparing six filter-based sap collection devices and six traditional coconut shell containers. The test results, summarized in Table 1, show that the volume of sap produced by both methods was relatively similar, at 3 kg per tree. However, the sap collected using the filter-based device had a selling price three times higher than that of the sap collected from the traditional container. This indicates an increase in economic value of approximately 200%, derived not from increased production volume, but from improved sap quality based on physical indicators and purity.

When compared to previous studies, such as (Lempang, 2017), who also used a closed resin collection system to reduce water content and external contamination, this study adds an important advancement through the integration of double-layer filtration. Meanwhile, (Sukadaryati, 2014) found that although plastic bags could reduce contamination compared to coconut shells, they contributed to environmental waste and were less durable. In contrast, the tool developed in this research is reusable, environmentally friendly, and provides higher quality sap without generating plastic waste. Therefore, this innovation not only offers technical advantages in quality control but also addresses environmental and economic sustainability.

The results of the pine sap harvest produced from each of these collector tools are summarized in table 1 below.

Table 1. Pine Sap Harvest Data

Description	Coconut Shell	Pine Sap Collector Tool
Number of Trees	6 trees	6 trees
Tapping Time	15 days	15 days
Sap Yield per Tree	3 kg	3 kg
Total Sap Yield (6 Trees)	18 kg	18 kg
Price per Kilogram	Rp 4.000	Rp 12.000
Total Income	Rp 72.000	Rp 216.000
Income Difference		Rp 144.000 higher

Based on the data above, the amount and quality of sap produced from each tapping method are the same, which is 3 kg per tree for 15 days. However, the striking difference lies in the selling value of the sap which is influenced by the type of container used. Sap collected using a pine sap container based on a variety of filters has a selling price three times higher than sap collected using coconut shells. This is most likely due to the cleaner quality of the sap and minimal contamination when using special tools. The innovative container is designed with a closed lid and two-stage filtration system, which prevents the entry of rainwater, insects, twigs, and soil particles—contaminants commonly found in traditional methods such as using coconut shells. As a result, the sap harvested is clearer and classified as higher grade, making it more valuable in the market. Clean sap can be processed more efficiently into derivative products such as gondorukem and turpentine, which are priced higher due to their purity and ease of refining.

In terms of income, the use of special containers generates a total income of IDR 216,000 for six trees over fifteen days, while coconut shells only produce IDR 72,000 under the same conditions. Thus, there is a net income difference of IDR 144,000, representing a threefold increase. This indicates that the economic gain is not from volume, but from quality enhancement which directly affects pricing.

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These findings align with the study by (Lempang, 2017), who found that closed and well-filtered containers resulted in higher-grade sap with lower moisture content, leading to higher market prices. Likewise, (Sukadaryati, 2014) observed that unfiltered sap, especially when collected in open containers, was prone to contamination and often rejected by collectors or priced lower due to additional processing costs. By using technology to control quality at the point of collection, farmers reduce post-harvest losses and improve selling power, which contributes to increased income and sustainability in resin production.

The results of this study provide a significant contribution to increasing the income of pine resin farmers in Indonesia through the exploitation of Non-Timber Forest Products (NTFPs), especially for Perhutani BKPH in an effort to improve the quality of the harvested pine resin. The performance of the tool used is very effective, with a container design equipped with a lid to protect against large dirt and two filters of different sizes to filter small dirt that may enter the container. The shape of the container which resembles a semicircular bowl makes it easier to collect sap, and is equipped with a filter that can be lifted when collecting sap. However, this tool has a drawback in the installation process, which is slightly longer than the previous tool. Therefore, it is advisable to understand how to install the tool properly and correctly, and ensure that the tool is installed properly and not tilted.

CONCLUSION

This study concluded that the use of a filter-based pine resin collection device can improve the quality of the resin and its economic value compared to traditional collection methods. The higher level of resin purity achieved through the filtering system significantly increased the selling price, up to threefold. Furthermore, positive responses from pine resin tappers regarding its durability, effectiveness, safety, and ease of use and maintenance indicate that this device is feasible for field use. Overall, these findings indicate that the innovative filter-based resin collection device has significant potential to increase the productivity and income of pine farmers while supporting the sustainability of non-timber forest products in Indonesia.

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