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EFFECTIVENESS OF PINE SAP COLLECTING TOOLS BASED ON SIEVER VARIATION IN IMPROVING THE QUALITY OF PINE SAP HARVESTING

(Efektivitas Alat Penampung Berbasis Variasi Saringan Dalam Peningkatan Kualitas Pemanenan Getah Pinus)

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ABSTRAK

Perhutani terus berupaya meningkatkan kualitas panen getah pinus melalui metode coakan dan inovasi wadah tepat di bawah tetesan getah. Akan tetapi, kualitas yang dihasilkan masih kurang optimal. Berdasarkan hal tersebut, dibuatlah wadah getah pinus berbasis saringan yang dapat meningkatkan kualitas getah pinus yang dipanen. Penelitian ini bertujuan untuk mengetahui efektivitas wadah getah pinus berdasarkan variasi saringan dan bidang miring pada talang sadap. Penelitian dilakukan dengan metode eksperimen untuk mendapatkan parameter keuntungan mekanis wadah getah pinus ekonomis yang dapat meningkatkan produktivitas kinerja alat berdasarkan konsep bidang miring. Pengujian dilakukan di laboratorium untuk merancang dan mengukur efisiensi mekanis alat, dan dilanjutkan dengan pengamatan lapangan untuk mengevaluasi kualitas dan produktivitas getah pinus yang dihasilkan. Pengumpulan data dilakukan dengan mengukur massa getah, sudut kemiringan talang, dan parameter mekanis alat secara sistematis. Hasil percobaan menunjukkan bahwa nilai parameter keuntungan mekanis terbesar terdapat pada talang sadap dengan sudut kemiringan terbesar yaitu 70°. Selain itu, alat ini dengan desain inovatif berbasis saringan dan sudut kemiringan optimal terbukti mampu meningkatkan kualitas getah dan meminimalisir pencemaran kotoran dan air. Hasil penelitian ini menunjukkan bahwa alat yang dikembangkan efektif dalam meningkatkan efisiensi pemanenan dan kualitas getah pinus, yang sejalan dengan tujuan penelitian untuk mengoptimalkan proses pengumpulan getah pinus. Alat yang dihasilkan peneliti berupa wadah berbentuk mangkuk setengah lingkaran yang dilengkapi dengan tutup yang dapat mencegah masuknya kotoran dan air hujan sehingga diperoleh getah dengan kualitas yang baik. Alat ini mampu meningkatkan kualitas getah dengan tingkat kemurnian yang lebih tinggi sekaligus menghasilkan efisiensi pemanenan hingga 25% dibandingkan dengan cara tradisional, sehingga inovasi ini berpotensi menjadi solusi efektif untuk meningkatkan produktivitas panen getah pinus secara berkelanjutan.

Kata kunci: bidang miring, wadah, kualitas, getah pinus, variasi saringan

ABSTRACT

Perhutani continues to improve the quality of pine sap harvest through the coakan method and the innovation of containers right under the sap drips. However, the quality produced is still less than optimal. Based on this, a pine sap container based on a filter was made that can improve the quality of the harvested pine sap. This study aims to determine the effectiveness of the pine sap container based on variations in filters and inclined planes on the tapping gutter. The study was conducted using an experimental method to obtain the mechanical advantage parameters of an economical pine sap container that can increase the productivity of the tool's performance based on the concept of an inclined plane. Testing was carried out in the laboratory to design and measure the mechanical efficiency of the tool, and field observations were continued to evaluate the quality and productivity of the pine sap produced. Data collection was carried out by systematically measuring the mass of sap, the angle of inclination of the gutter, and the mechanical parameters of the tool. The experiment showed that the largest mechanical advantage parameter value was found in the tapping gutter with the largest angle of inclination, namely 70°. In addition, this tool, with an innovative filter-based design and optimal angle of inclination, has been proven to improve the sap quality and minimize dirt and water pollution. The results of this study indicate that the developed tool is effective in increasing the efficiency of harvesting and the quality of pine sap, which is in line with the research objective to optimize the process of collecting pine sap. The tool produced by the researcher is a semicircular bowl-shaped container equipped with a lid that can prevent dirt and rainwater from entering so that good-quality sap is obtained. This tool can improve the quality of sap with a higher purity level while producing harvesting efficiency of up to 25% compared to traditional methods, so this innovation has the potential to be an effective solution to increase the productivity of pine sap harvests sustainably.

Keywords: inclined plane, container, quality, pine resin, filter variation

I. INTRODUCTION

Indonesia, as a developing country with a forest area of 125,817,023 ha, has great potential in using forest products, both wood forest products and non-wood forest products (NTFPs), such as rattan, honey, fruit, mushrooms, and pine resin. Around 48.8 million people living in and around forests depend on forest products as a source of food and income, with 71.06% of villages in Indonesia interacting with forests to meet their needs (Osa, 2023; Tami, 2018). NTFPs play an important role in maintaining forest sustainability while significantly contributing to the community's economy. One of the NTFPs currently developing rapidly is pine resin which is processed into gondorukem, with high market potential and can increase added value. Wonosobo Regency, part of the Perum Kawasan KPH Perhutani, has great potential to develop pine resin as a source of long-term income if managed optimally (Ramli et al., 2023) .

Pine is a coniferous plant that has a cylindrical trunk and usually grows in highlands with a cool climate. Pine is one of the most sought-after forest products and has a fairly high selling value (Herawaty et al., 2022). Because of its rapid growth and being a pioneer plant, pine was initially used for reforestation and greening activities, according to Cahyono in Mampi (2018). Pine plants are very important because their wood can be used to make paper, furniture, matches, wall hangings, and household utensils apart from being pioneer plants,. In addition, pine trees have another specialty, namely that they can produce sap through tapping pine trees (Mukhlisa, 2020).

Tapping of pine sap according to (Ningrum, 2010) is defined as cutting, wounding, and opening the sap channels on tapped pine trees so that the sap can come out (Permatasari et al., 2018). Spraying on the tapping wound functions as a stimulant so that the sap can come out more easily from the tapping wound. According to (Ikhsan, 2019) , the process of tapping pine sap results in the formation of tapping wounds on the tree. Thus, the release of sap facilitates osmosis because it is surrounded by parenchymal tissue. If there is a wound on the tree trunk, the sap channel will open, reducing pressure on the cell walls and producing less sap. The sap will open, reducing pressure on the cell walls and producing less sap.

The tapping technique that is often used is the koakan method. The koakan method has several advantages, including easier and time-saving field work, and more affordable costs because there are no additional costs for equipment maintenance. However, this method has disadvantages, such as the sap's purity level not being good because most of the sap will be mixed with water and dirt (Woesono, HB, 2022). Tapping sap using the koakan method also cannot be done during the rainy season. Rainwater will affect the level of purity of the sap, resulting in a decrease in the quality of the sap.

The tapping gutter used is curved and open zinc so that the sap entering the container will mix with soil and water. When it rains, soil from trees, other particles, and water can enter the container with the pine sap. Then the pine sap in the container can also spill because the basic material used to hold the pine sap is very light and the installation is not sturdy enough so that it easily falls when blown by the wind or because it is hit.

In tapping using channels (drains) and open sap reservoirs, such as the koakan method and the real method, dirt in the form of pine needles, bark, and wood chips can enter the reservoir and mix with the sap. In addition, tapping sap using an open reservoir will cause the turpentine content in the sap to decrease due to evaporation or spilling water from the reservoir if there is heavy rain during tapping (Lempang, 2017).

Based on the problems described above, innovation is needed to create a container for collecting sap that is resistant to rainwater based on various types of filters, is not eroded during mining, and is not easily blown away by the wind and the right slope of the tapping channel to provide increased and good quality pine sap production. Fresh and clean pine sap usually contains 23% water, 17% turpentine, and 60% gondorukem (Silitonga, 1983). The tool's effectiveness will be seen from the slope of the tapping channel and the variety of filters in the container. The slope of the tapping channel will be analyzed using the concept of inclined plane physics. Inclined planes are usually used to overcome obstacles with relatively smaller forces when crossing longer distances (Andriani et al., 2021). By using variations in the angle of inclination, it is hoped that the appropriate size of the tapping channel can be found to channel pine sap from the tree into the container. Therefore, an experiment will be carried out to create an innovative pine sap collector and prove its effectiveness in producing quality pine sap.

The purpose of this study is to design and develop an innovative filter-based pine resin collector, taking into account the optimal slope of the tapping gutter and the variation of filters on the container, improve the quality and productivity of the pine resin produced. This study also aims to test the effectiveness of the tool in reducing dirt and rainwater pollution and increasing the purity of the pine resin obtained.

II. METHODS

The type of research used in this study is experimental research. The experiment aims to determine the effect of gutter slope treatment on the quality of the sap produced by controlling the factors that influence it (Sugiyono, 2011).

Research Flow Chart

Experiments and field observations were conducted in the laboratory (Jaedun, A., 2011). The laboratory experiments were conducted to design a pine resin container with a closed channel and various filters, while the field observations were to test the tool's effectiveness in producing quality pine resin. The research stages are in accordance with the flow diagram in Figure 2.

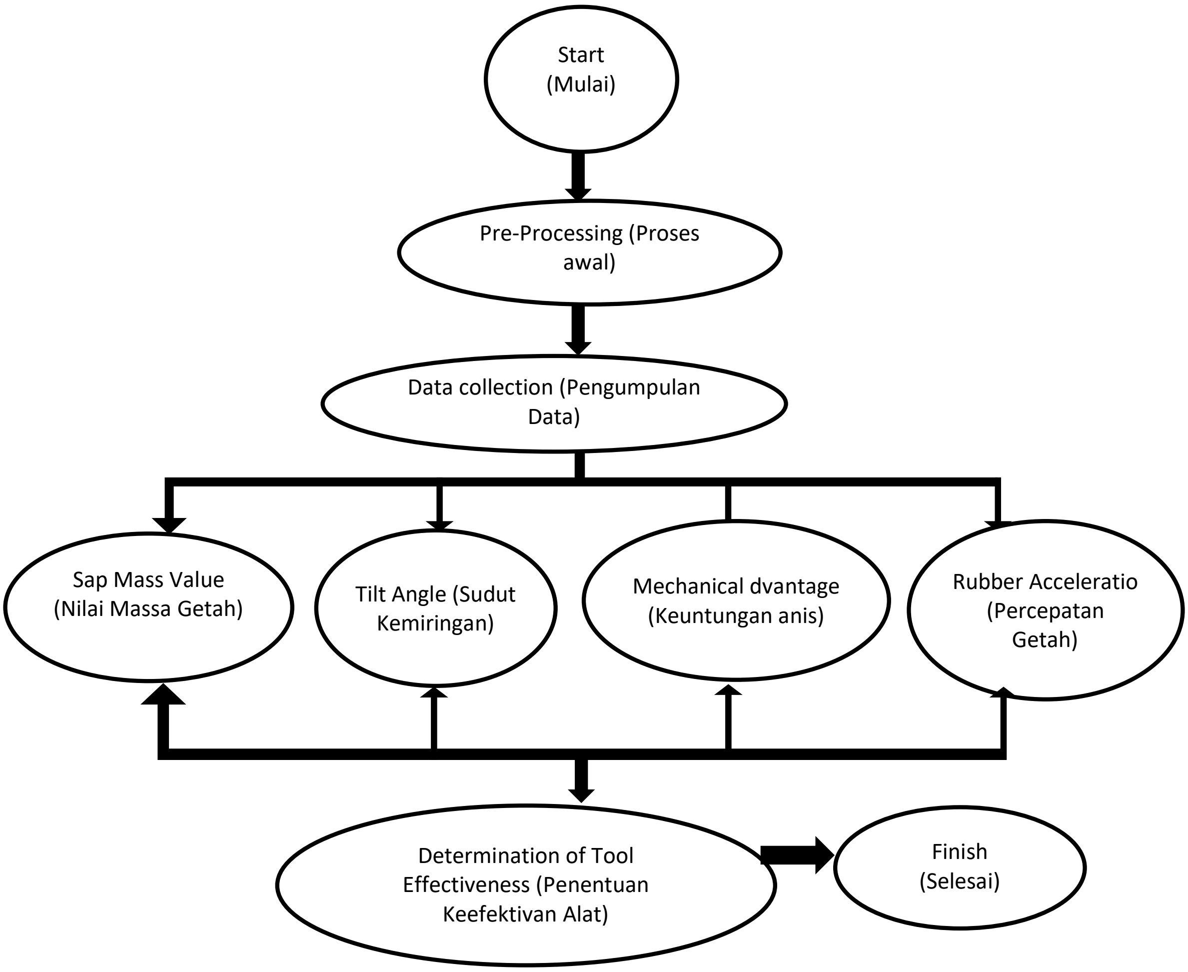

Figure 1. Research Flow Diagram
Gambar 1. Diagram Alir Penelitian

Pre-Processing

The pre-processing process here is the installation of various filter-based pine resin collection equipment for data collection, with the following stages.

a. Install 3 devices on 3 different trees;
b. Install a tapping line for each tool with 3 different slope variables; from 50°, 55°, and 70°;
c. Measure the angle of the gutter in relation to the container containing the pine resin;
d. Tree felling or dredging is carried out for 15 days with a plowing interval of 3 days;
e. Weigh the mass of pine resin with a digital scale with an accuracy of 0.01 grams;
f. Find the mechanical advantage by finding the height of the container to the tap and the size of the tap to the top of the container hole;
g. Calculate the acceleration of the flow of pine resin through the tapping channel to the storage tank;

Data analysis

The data processing and analysis process with three variables, namely the rubber mass value, the angle of inclination of the tapping gutter, and the mechanical advantage of the inclined plane are used as follows.

a. Latex Mass Value

The way to determine the mass value of the sap is as follows:

1) Remove the tapping gutter from the tree trunk;
2) Take a container filled with pine resin;
3) Spoon the pine resin into a container and weigh it;
4) Record the results of weighing the pine resin;
5) Mass analysis with the equation:

$$m = m \pm \Delta m \text{ ....(1)}$$

Here, $m$is the mass of pine resin measured, and $\Delta m$is the brightness in the measurement due to the precision of the instrument (± 0.01 grams in this study). This equation follows the principles of error analysis as described in Taylor (1997), Introduction to Error Analysis.

b. Large value of the slope angle

The angle of inclination of the tapping gutter is analyzed using the equation:

$$\Sigma F_x = m.a$$

$$w \sin\theta - f.g = m.a \text{(frictional force is neglected)}$$

$$m.g \sin\theta = m.a$$

$$\sin\theta = \frac{m.a}{m.g}$$

$$\sin\theta = \frac{a}{g}$$

$$\theta = arc \sin\frac{a}{g} \dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

Mechanical Advantage Value

The way to determine the mechanical advantage value is as follows:

1) Measure the height of the container to the end of the gutter or to the tree support using a ruler;
2) Measure the length of the gutter to the collector hole;
3) Measure the angle of the gutter to the container;
4) Find the mechanical advantage with the equation $KM = s\ h$, where s is the slope of the tapping gutter from the tree trunk to the hole in the top of the container lid, while h is the height of the tree trunk to the hole in the top of the container lid.
5) Record the results of the mechanical advantage measurements using the equation:

$$KM = (km \pm \Delta km) \quad (3)$$

Research Tool Design

The innovative design of the filter-based pine resin collector used in this study includes: a tapping gutter, container, lid, filter, and belt.

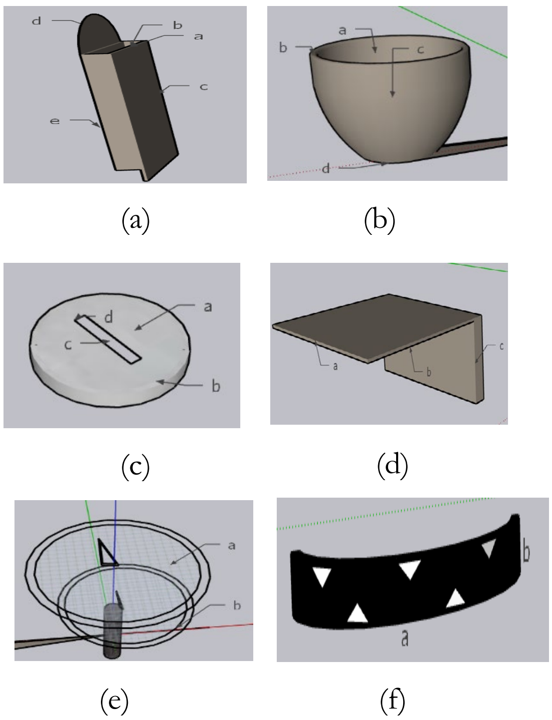

Figure 2. a. Tapper gutter, b. Container, c. Cover, d. Strainer, e. Filter, f. Belt

Gambar 2. a. Talang Sadap, b. Wadah, c. Tutup, d. Payung, e. Saringan, F. Sabuk

Research Variables

The variables in this study consist of independent variables, dependent variables, and control variables.

a. Independent Variables
   It is expected that the independent variables changed in this study can produce good quality sap. In this study, the independent variables used are the angle of the tapping channel to the tree (θ), the height of the container to the tree hole (h), the slope of the tapping channel from the tree hole to the top of the container hole (s).
b. Dependent Variable
   The dependent variable is a parameter of the quality of the innovation of the tool produced as an influence of the independent variable. In this study, the dependent variables used are mechanical advantage (KM), the mass of pine resin produced (m), and the volume of water collected (v).
c. Control Variables
   Control variables are needed so that the research results are in accordance with expectations. The control variables are controlled so that the influence of the independent variable on the dependent variable is not influenced by external factors that are not studied. In this study, the control variables used were valves, rubber containers, belts, lids, and tapping gutters.

Research Place

The location of the research and data collection was carried out at the FITK UNSIQ Laboratory and the effectiveness test of the tool was carried out in the pine forest of the Forest Management Unit Agency (BKPH) of Perum Perhutani Kebumen Ngadisono, Kaliwiro District, Wonosobo Regency.

III. RESULTS AND DISCUSSION

An innovative tool for collecting pine sap is made in the form of a semicircular bowl-shaped container with a lid with holes in the lid at varying distances. The tapping gutter used is made of an iron plate. The tapping gutter is connected from the tree trunk to the container at different angles. Various filters, as well as belts, tie the container to the tree. The tool's effectiveness is proven by the amount of pine sap produced by the koakan method with innovative filter variations so that the sap produced is of good quality. The feasibility of the tool is seen from the mechanical advantages and productivity compared to previous pine sap collectors.

The working principle of this tool is to complement the shortcomings of the previous pine resin container, namely: 1) installing a belt that is already attached to the tool on a pine tree, so as not to injure the tree; 2) installing a tapping gutter on each tool with three different slope variations and on three different trees; 3) measuring the angle of the tapping gutter to the pine resin container; 4) Tree scraping or dredging is carried out within 15 days with a scraping range of once every 3 days. The results of the study are presented in Table 1.

Table 1. Results of Tree Sap Collection
Tabel 1. Hasil Pengumpulan Getah Pohon

No.	Rubber Collection (Pengumpulan Getah)	Mass of Sieve Sap 1 (gram) - Tree 1 (Massa Getah Saringan 1 Pohon 1)	Mass of Sap Sieve 2 (grams) - Tree 1 (Massa Getah Saringan 2 Pohon 1)	Mass of Sieve Sap 1 (grams) - Tree 2 (Massa Getah Saringan 1 Pohon 2)	Mass of Sap Sieve 2 (grams) - Tree 2 (Massa Getah Saringan 2 Pohon 2)	Mass of Sieve Sap 1 (gram) - Tree 3 (Massa Getah Saringan 1 Pohon 3)	Mass of Sieve Sap 2 (grams) - Tree 3 (Massa Getah Saringan 2 Pohon 3)
1	1	2.130 ± 0.005	4 ± 0.005	5 ± 0.005	26 ± 0.005	6.950 ± 0.005	39 ± 0.005
2	2	3.100 ± 0.005	7 ± 0.005	3 ± 0.005	7 ± 0.005	7 ± 0.005	20 ± 0.005
3	3	1,530 ± 0.005	8 ± 0.005	3 ± 0.005	9 ± 0.005	1,900 ± 0.005	17.3 ± 0.005
4	4	0.790 ± 0.005	1.440 ± 0.005	3 ± 0.005	1 ± 0.005	0.970 ± 0.005	1.100 ± 0.005
5	5	-	1.210 ± 0.005	0 ± 0.005	0 ± 0.005	0.890 ± 0.005	1.210 ± 0.005

Table 1 shows the productivity of the tool based on the amount of pine resin produced. Pine resin collection is carried out every 3 days. Table 1 shows that the first to fifth collection, both tree 1, tree 2, and tree 3, show that sieve 2 produces more sap mass than sieve 1. This is because the sap in sieve 2 is thicker, while in sieve 1 the sap tends to be thinner and is still often mixed with ants or other dirt that is thrown away during the cleaning of the sap.

When viewed from the average mass of sap produced, tree 1 sieve 1 and 2 produced sap of 1.51 grams and 3.48 grams, tree 2 produced sap of 3.2 grams and 10 grams, and tree 3 produced sap of 3.76 grams and 15.72 grams. This difference is influenced by the diameter of the three trees. Tree 1 has a diameter of 86 cm, tree 2 has a diameter of 96 cm, and tree 3 has the largest diameter of 106 cm. Trees with larger diameters produce more sap than trees with smaller diameters. As explained by Rahmadani (2021), tree diameter plays an important role in pine sap production. In addition, tree age also has an effect (Sukardayanti, 2014), although in this study the difference in age was not too significant because trees 1 and 2 were 13 years old, while tree 3 was 14 years old.

Seasonal conditions also affect pine resin production. The first, second, and third resin collections are carried out in the dry season, where hot temperatures and high light intensity support greater sap flow. Conversely, in the fourth and fifth resin collections carried out in the rainy season, sap production decreases. This is caused by rainwater washing the sap before it enters the tapping channel and cold temperatures causing the sap to clot and have difficulty flowing.

Traditional pine resin extraction using coconut shells produces a higher yield. The first extraction produced 15.78 grams, the second extraction produced 11.5 grams, and the third extraction produced 7 grams. However, the fourth and fifth extractions produced 0 grams. The high production in the initial extraction was caused by the sap mixed with dirt such as ants and twigs. This shows that traditional pine resin extraction can produce more sap initially, but the quality of the sap produced is lower. This high yield is because the sap produced is still mixed with dirt such as animals, twigs, fallen wood from farmers' harvests, and various other dirt that can easily enter the sap container. This greatly affects the quality of the harvested sap, figure 3.


(a) (b)

Figure 3. (a) Palm sap from a container with a filter; (b) Palm sap with a coconut shell container
Gambar 3. Getah Pinus dari Wadah yang ada Saringannya; (b) Getah Pinus dengan Wadah Batok Kelapa

This filter-based sap container has a lid that can protect the pine sap from dirt that can affect the purity of the sap produced. The gutter is also made closed so that dirt does not easily enter. Inside the container there is also a filter to filter dirt that may still enter through the gutter. Thus, the pine sap produced using this filter-based sap container has a significant difference compared to the pine sap produced using ordinary tools, namely coconut shells without a lid. This filter-based pine sap container is effective in improving the quality of pine sap.

In addition to internal factors (tree age and tree diameter) and external factors (weather), tool treatment also affects the harvesting of the resulting sap. The angle of inclination when placing the tapping channel also affects the amount of pine sap produced. Tables 4 and 5 show the data on the results of the slope on the acceleration of sap movement, as well as its mechanical advantage.

Table 2. Results of calculating the acceleration of pine resin entering the container
Tabel 2. Hasil perhitungan percepatan getah pinus yang masuk ke dalam wadah

No.	Types of Trees (Jenis Pohon)	Tilt Angle (Sudut Kemiringan)	Acceleration (m/s^2) (Percepatan)
1.	Tree 1	70°	9.4
2.	Tree 2	55°	8.2
3.	Tree 3	50°	7.7

Table 3. Results of Mechanical Advantage Value Calculation
Tabel 3. Hasil Perhitungan Nilai Keuntungan Mekanik

No.	Types of Trees (Jenis Pohon)	The angle of inclination of the gutter to the container (θ) (Sudut kemiringan talang terhadap wadah)	Slope or length of the tapping gutter (cm) (Kemiringan atau panjang talang sadap)	Height of container relative to tree trunk (h) (cm) (Tinggi wadah terhadap lodang pohon)	Mechanical advantage (MC) (Km ±Δ km) (Keuntungan mekanis)
1.	Tree 1	70°	10	10.16	0.98 0 ± 0.05
2.	Tree 2	55°	10	10.44	0.96 0 ± 0.05
3.	Tree 3	50°	10	11.98	0.83 0 ± 0.05

The acceleration value of pine sap entering the container is influenced by the angle of inclination of the tapping gutter to the tree trunk. At an angle of inclination of 70°, the acceleration value is calculated as 9.4 m/s. At an angle of inclination of 55o , the acceleration value is calculated as 8.2 m/s. At an angle of inclination of 50o , the acceleration value is calculated as 7.7 m/s. In theory, the greater the angle of inclination, the greater the acceleration of pine sap entering the container (Douglas Giancoli, 2014). This angle of inclination will affect the time. For the same type of tree, both age and diameter of the tree, the gutter installed with an angle of inclination of 70o will produce sap in a relatively faster time.Based on Table 5 mechanical advantage of the angle of inclination, the greater the angle of inclination, the greater the mechanical advantage of the inclined plane in the form of a tapping gutter on pine resin. This is because in the equation of the mechanical advantage value on the inclined plane, namely km = w / F = (mg sin θ) / (ma) = (g sin θ) / a = s / h the value of the mechanical advantage on the inclined plane is directly proportional to the sine of the angle of inclination. So the greater the angle of inclination and the height between the container and the tree trunk, the greater the mechanical advantage.

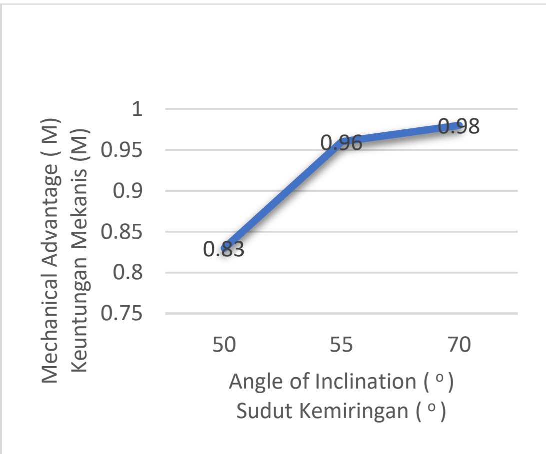

Figure 4. Graph of mechanical advantage values
Gambar 4. Grafik Nilai Keuntungan Mekanik

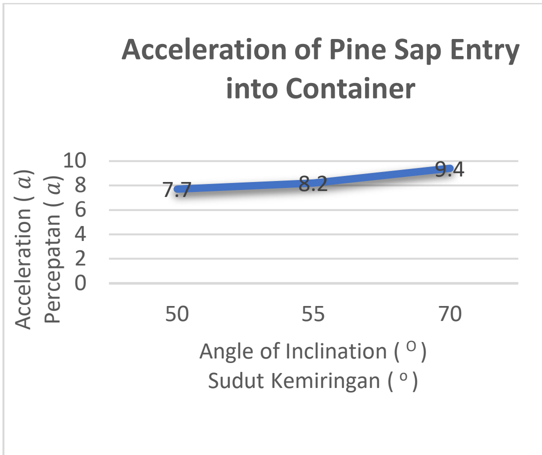

Figure 5. Graph of the acceleration of the entry of pine resin into the container.
Gambar 5. Grafik Percepatan Getah Pinus Masuk ke Wadah

The greater the angle of entry of the tapping channel, the greater the acceleration of the pine resin entering the container. This is because in the slope angle analysis equation, namely θ = arc sin 〖 a / g 〗 , it can be seen that the slope angle is directly proportional to the acceleration.

Pine sap collector tool based on filter effectively improves the quality of harvested pine sap. This tool has the advantage that the sap produced has good purity in terms of cleanliness and the tool material is durable and does not rust easily so it can be used for a long time. The design of the container in the form of a half circle made of iron makes it easy to collect sap. The closed container and equipped with various filters are very helpful in keeping the harvested sap clean. The tapping gutter that is made closed and installed at a certain angle speeds up the entry of sap into the container. And the belt used to tie the tool to the tree does not injure the tree. This tool is very effective and efficient so that it can be mass-produced to help pine farmers.

The analysis results shown in Figure 4 show that the greater the angle of inclination of the tapping gutter, the higher the mechanical advantage obtained. This mechanical advantage is directly proportional to the sine of the angle of inclination, which means that a larger angle of inclination optimizes the flow of pine sap into the container, thereby increasing harvesting efficiency. This shows that with the right angle of inclination, the tool can accelerate the process of removing pine sap, thereby increasing the overall productivity of the tool. This finding is in line with research (Ikhsan , 2019), which shows that the optimal angle of inclination in the traditional method produces faster sap flow compared to the horizontal method. In addition, this method is proven to be more efficient than the koakan technique on stands with low slopes, which often experience dirt and water accumulation in the tapping channel.

Figure 5 shows a graph of the acceleration of pine resin flow into the container which increases with the increasing angle of the tapping channel. At an angle of 70°, the acceleration of the resin flow reaches the highest value, which is 9.4 m/s^2, which indicates that the channel with a steeper slope accelerates the movement of pine resin into the container, thus producing resin in a shorter time. This finding further strengthens the effectiveness of the tool design that allows faster and more efficient pine resin collection. This is in line with the research of Permatasari et al. (2018), which shows that the flow of resin in the traditional tapping method is often obstructed in flat channels, thus taking longer. The steep-angle channel technique also shows advantages over the horizontal collection method in areas with high humidity, where resin tends to clump and inhibit flow.

CONCLUSION

Based on the tools that have been made and the experiments that have been carried out, it can be concluded that: 1) The design of this pine sap container is a semicircular container made of aluminum with various types of filters in it and a tapping gutter made of iron plate. 2) The purity of the sap produced is better because it has gone through a direct filtering process and mechanical advantage parameters with varying slope planes and filter variations. 3) The greatest mechanical advantage value is with the slope of the tapping gutter angle on the type 3 container, namely with a slope angle of 700 and with the second filter variation on container 3. 4) The feasibility of the design is seen from the productivity aspect as seen from the amount of sap produced, the tree that produces the most sap is the type 3 tree with a tree age of ±13 years, a tree diameter of 106 cm and a tapping gutter slope of 70 degrees.

Based on the tools that have been made and the experiments that have been conducted, it can be concluded that 1) The tapping channel slope angle of 70° produces the highest sap mass (15.72 grams) with optimal flow acceleration (9.4 m/s^2) compared to other angles, making it the best slope angle for pine sap production. 2) This innovative tool, with a closed container design and various filters, is able to significantly improve the quality of sap by reducing contamination from dirt, wood chips, and rainwater, especially during the rainy season. 3) The combination of the optimal slope angle (70°) and the innovation of this tool provides the best solution to increase the productivity and quality of pine sap. 4) This research provides a real contribution to the management of Non-Timber Forest Products (NTFPs) in Indonesia. It has the potential to be adopted more widely in other areas to support more productive and sustainable forest management.

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