

## Palm Claws Pro Machine

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### Abstract

The palm oil industry has been vital to Malaysia's economy since 1848, significantly impacting both local and international markets, especially in the European Union. However, the industry struggles with the mechanization of the harvesting process. Many Malaysian farmers still rely on manual tools to lift palm fruit bunches (FFB), which can weigh up to 20 kg. This manual labor often leads to musculoskeletal disorders and injuries due to physical strain and poorly designed tools. This report introduces the Palm Claws Pro (PCP), a machine designed to lift and load fresh fruit bunches onto trucks, reducing the physical burden on workers and improving workplace safety. The project aims to create a user-friendly machine that requires minimal training, assess its safety effectiveness, and compare its performance with traditional methods. The PCP machine was meticulously designed and tested to meet ergonomic needs. The grabber can lift FFB to a height of 1.79 m without hydraulic assistance, allowing for easy transfer onto standard truck platforms. The machine's robust design can handle the weight of a 20 kg bunch without damage, thus maintaining operational reliability. Testing revealed that the PCP machine significantly reduces the time and effort needed to load FFB compared to manual methods. This efficiency improvement not only enhances productivity, lowers transportation costs, and enhances logistics in palm oil distribution. Moreover, using the PCP machine is expected to decrease absenteeism and labor turnover by reducing work-related injuries, creating a safer work environment. The Palm Claws Pro machine provides a practical solution to challenges in the palm oil industry. By alleviating physical strain on workers and increasing efficiency, the PCP machine supports a healthier workforce. Future enhancements could include a hydraulic jack for heavier loads, a handle for better mobility, and a more powerful motor for improved gripping strength.

## 1. Introduction

Palm oil has been a dominant commodity crop in Malaysia since it was introduced in 1848 and has been commercially cultivated in Kuala Selangor since 1917 [1]. It is a crucial crop for the country's economy, with the European Union being the second-largest export market after India. Palm oil is used in various products, including food, consumer goods, and energy, with about 71% of palm oil content used in food products, 24% in consumer goods, and 5% in energy consumption [1]. The cultivation of palm oil in Malaysia was introduced by the government to eradicate poverty among the rural population, and the industry has grown significantly since then.

However, the process of harvesting and transporting palm oil fruit bunches is labor-intensive and can be hazardous for farmers. Most farmers in Malaysia still use manual tools, such as the GI T Handle Spring Steel, to lift and transport the fruit bunches, which can weigh up to 70 to 80 kg [2]. This can cause musculoskeletal disorders and injuries due to improper manual handling [3]. Mechanization and robotics can help improve the efficiency and safety of the process, but the high cost of modern machinery and equipment is a significant barrier for many farmers. According to research, a bunch of fresh fruit produced from a mature tree every month can reach a weight of 20 kg, and a tree can produce 10 to 12 bunches. Therefore, on average, farmers will transfer 200 kg of fresh bunches for one tree [4].

Incorrect and improper handling methods can also cause injuries, which are 41.7% of injuries in the automotive industry due to the use of equipment [5]. There are also 12 body parts that farmers feel uncomfortable with, with four body parts showing the highest percentage of discomfort: lifting heavy objects at 83.3%, wrong body posture at 75%, bending the body at 75%, and the same frequency of movement repeatedly at 75% [6].

The process of collecting Fresh Fruit Bunches (FFB) for palm oil production involves several main stages. Harvesting begins when the palm fruits reach maturity, and skilled laborers use long poles to remove the bunches from the trees. After collection, the FFB is loaded into a truck or other transport vehicle for the journey to the processing plant. Upon arrival, the FFB undergoes initial weighing, screening, and segregation. The manufacturing process begins with the receipt of FFB at the factory, where unwanted materials are removed. After this, the FFB is sterilized to eliminate bacteria and enzymes. Threshing separates the fruit from the bunches, leading to a mixture of palm fruit and fiber. The palm fruit is then pressed to extract crude palm oil, which undergoes subsequent processes such as clarification, refining, and packaging. It is important to consider sustainability practices in the palm oil industry to address the environmental and social concerns associated with its production.

The objective of this project is to design and fabricate a machine, called Palm Claws Pro, that can lift and load fresh fruit bunches onto trucks more easily and safely. The machine should be user-friendly, reduce the risk of injury to workers, and improve the overall efficiency of the process. The expected outcomes of this project include increased productivity and efficiency in the palm oil industry, improved worker safety and reduced risk of injury, enhanced logistics and distribution efficiency, creation of an ergonomic work environment that prevents chronic musculoskeletal problems, better morale, job satisfaction, and health for workers. Overall, the Palm Claws Pro machine has the potential to revolutionize the palm oil industry by improving the safety, efficiency, and productivity of the harvesting and transportation process.

### 1.1 Available Fresh Fruit Bunches Collector Tool in Market

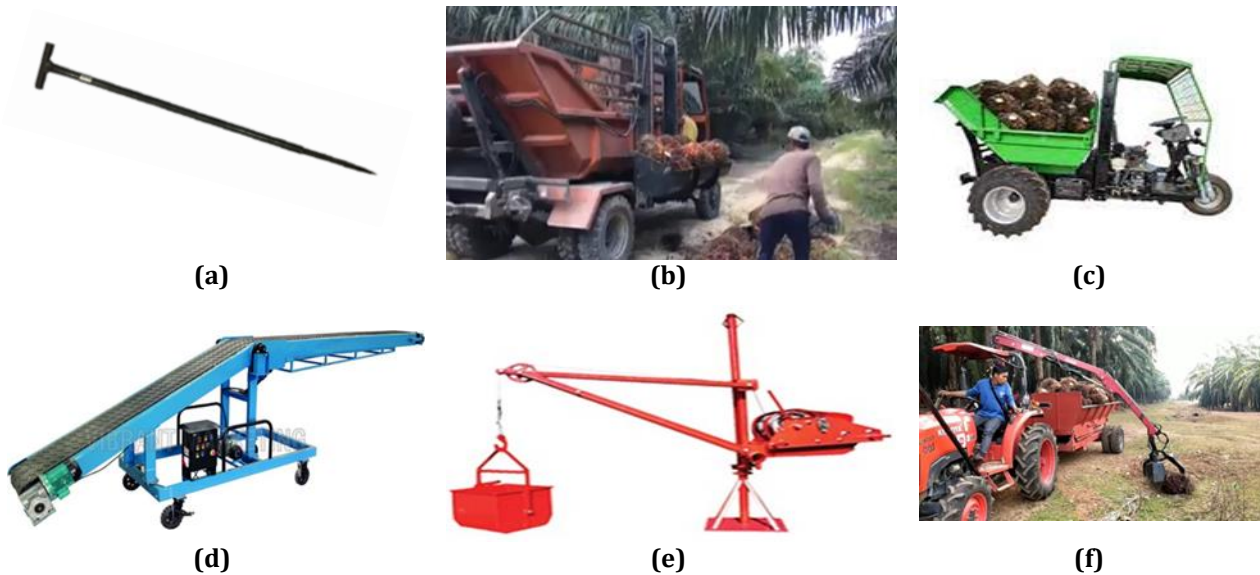
There are various methods and tools available to farmers for transporting fresh fruit bunches (FFB) from the collection area to the truck platform. One commonly used tool in oil palm plantations is the Loading Spike T, a handheld device that relies on human power. This tool, depicted in **Fig. 1(a)**, features sharp tips to pierce fruit bunches and a T-shaped structure to help lift them. Lightweight and portable, the Loading Spike T is designed for ease of use, allowing farmers to efficiently transfer fruit bunches to a truck.

Another modern tool is the side loader, shown in **Fig. 1(b)**. This machine, equipped with an excavator bucket and a hydraulic system, operates beside a transport truck. It is efficient and requires minimal space, although it can only handle small quantities of FFB and is limited to specific truck types. The side loader collects FFB manually in its bucket and then transfers them to the truck once the bucket is full [7].

The MT18 Mini Dump Truck, illustrated in **Fig. 1(c)**, is compact, durable, and suitable for transporting crops on unpaved roads. It can carry up to 1000 kg of goods and features wide tires to prevent slipping on muddy roads, making it popular in Southeast Asian plantations. Conveyors, like the one shown in **Fig. 1(d)**, are essential in industries for moving materials. These mobile carriers, often used in palm oil plantations, transport FFB efficiently with minimal effort. The conveyor belt is driven by a petrol motor, allowing it to move FFB weighing 20 kg to 40 kg easily [7].

The Portable Lifting Hoist, seen in **Fig. 1(e)**, is typically used for high-rise warehouse lifting but can also lift FFB into trucks [8]. It operates using a lever mechanism and an electric motor, making the process swift. However, its lack of wheels and a load limit of 136.2 kg means multiple repetitions are needed for large quantities. Lastly, the Crane Grabber, depicted in **Fig. 1(f)**, is a simple crane with a hydraulic system, designed for agricultural use. It can lift up to 180 kg to a height of 3.5 m and rotate 360°. While efficient, it requires a tractor to operate and skilled personnel to manage, limiting its flexibility [9].

In summary, the various tools and machinery available for transporting FFB in oil palm plantations range from manual devices to advanced hydraulic systems, each with their own advantages and limitations. These tools aim to improve productivity and reduce the physical strain on farmers [9].

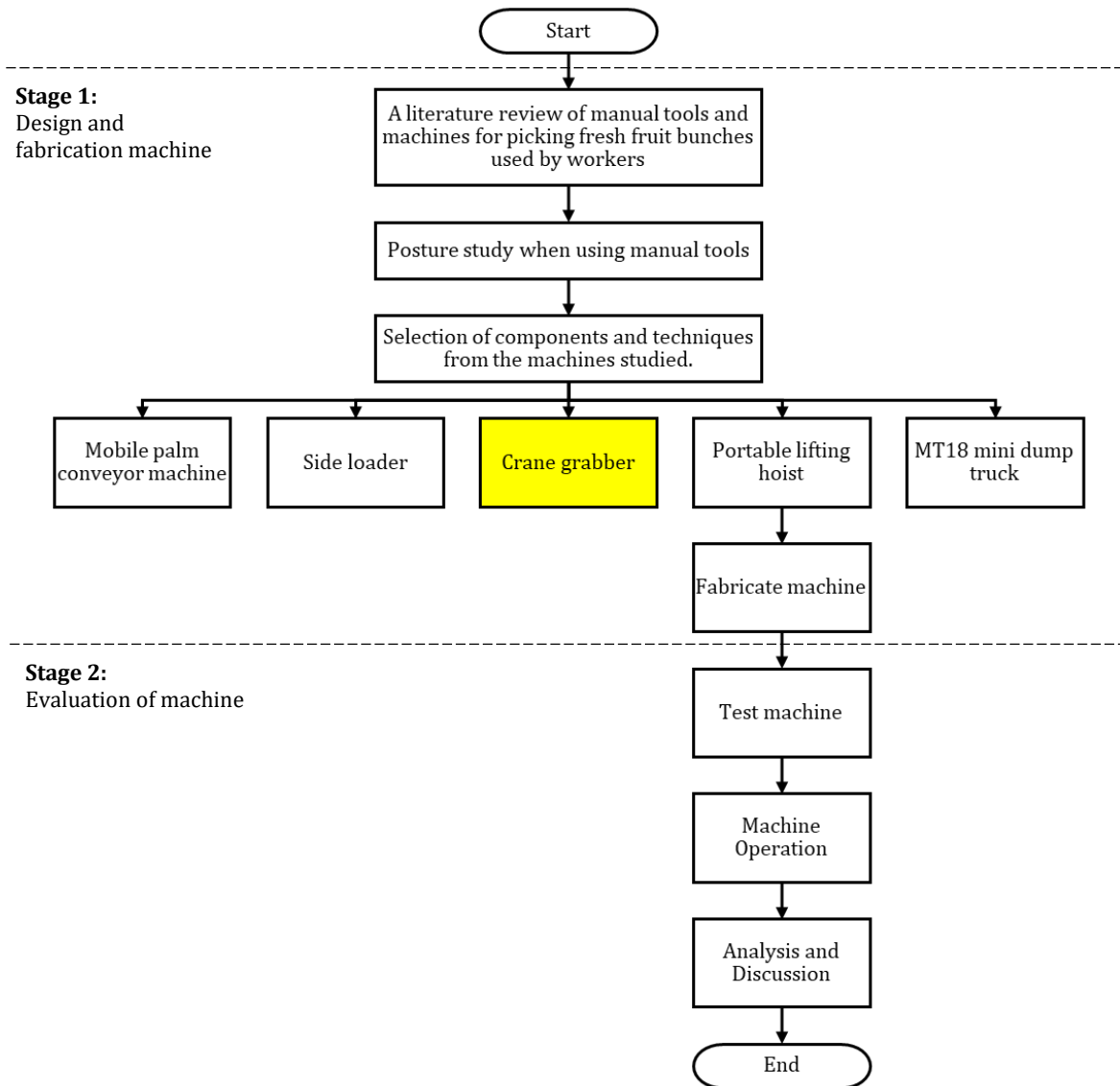


**Fig. 1** Available FFB collector tool (a) Loading Spike T; (b) Side Loader; (c) MT18 Mini Dump Truck; (d) Mobile Palm Conveyor Machine; (e) Portable Lifting Hoist; (f) Crane Grabber

## 2. Methodology

A flow chart is to depict the sequence of operations that occur until the project is completed. A flow chart as shown in **Fig. 2** will be drawn in the early stages of the project. Stage 1 is the process of design and fabrication of Palm Claws Pro Machine. From a review of previous and available manual tools and machines for picking fresh fruit bunches (FBB) available in market, three product preliminary designs were sketched. Then, the advantages and disadvantages of each selected product design will be filtered to choose the product with the best concept. Posture study when using manual tools is taken as consideration in design product. After making the product selection, the project will continue with the choice of materials such as hydraulic jack, wheelbarrow tire, bolt and nut, bearing, grabber, platform, and motor. This is to choose the most appropriate material to produce the product. Crane grabber concept is chosen as a technique to lift the FBB. The claw will be installed in the machine as it works to grab and release FBB into the truck.

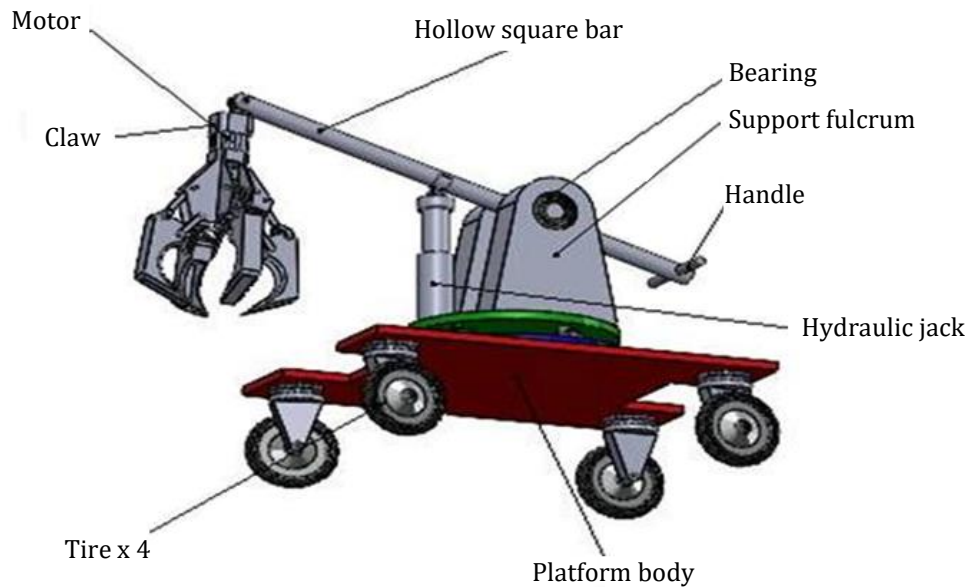
Stage 2 is a process after fabrication of Palm Claws Pro Machine. This machine needs to be tested to find out the strength and effectiveness to cope with the load imposed. The main purpose of the test carried out on the palms Claws Pro (PCP) machine is to identify the effectiveness of the machine for workers, to study the load carried when using traditional tools compared to the machine and the difference in the time of lifting fresh bunches.



**Fig. 2** Fabrication and evaluation of Palm Claws Pro Machine

## 2.1 Product Design and Operation

**Fig. 3** shows the technical drawing of the Palms Claws Pro machine. The machine had been designed with exact size and dimension using Solidwork Software. This palms Claws Pro machine helps unload fresh palms bunches by placing them near the stack of fresh palms bunches, this is to facilitate the process of unloading fresh palms bunches from the ground into the transport truck. First, lower the machine's claws towards the fresh fruit bunches of palms. Then the motor switch is pressed to activate the motor, this motor works to control the claws that will grab fresh fruit bunches of palms. When the new bunch of palms is finished being gripped, by using the lever on the hydraulic pump, the user needs to pump the lever until the hydraulic support rod pushes the claws rod up. As a result, the claw rod will bring fresh bunches of palms oil high from the ground and remain above. After that, the top of this machine has to be turned towards the truck platform to allow fresh fruit bunches of palms to be brought into the truck. When the fresh fruit bunches of palms are in the desired position, the user needs to press the motor switch again so that the claws can release the fresh fruit bunches of palms onto the truck platform.



**Fig. 3** Fabrication and evaluation of Palm Claws Pro Machine

## 2.2 Main Component Palm Claws Pro Machine

The selection of materials for these components is grounded in considerations of sustainability, corrosion resistance, strength, and durability, ensuring the machine performs efficiently under the demanding conditions of palm oil plantations.

**Table 1** List of main components with materials

No.	Main Components	Materials	Function
1	Hydraulic Jack	Steel	to generate force and lift heavy objects.
2	Tire	Cast iron, ductile steel, phenolic, nylon and polyurethana	to facilitate the movement of the machine from one place to another.
3	Bearing	Stainless steel	to prevent friction between components that move in rotation, the machine lifts bunches of fresh fruit.
4	Claw	Steel	It consists of four claws that will grip fresh fruit bunches of palms strongly.
5	Body Frame	Hollow Steel	strong and able to withstand the weight applied to it.

**Table 1** presents a list of the main components of a machine, detailing the materials chosen for each and their respective functions. Each component has its own reason for choosing the mentioned materials.

**Hydraulic Jack (steel):** Steel is chosen for the hydraulic jack due to its excellent strength and durability. The primary function of the hydraulic jack is to generate force and lift heavy objects, which necessitates a material that can withstand substantial stress and pressure. Steel's high tensile strength ensures it can endure the heavy loads involved in lifting palm oil bunches. Additionally, steel is highly durable, offering a long lifespan with minimal maintenance. From a sustainability perspective, steel is also a recyclable material, contributing to the reduction of environmental impact [10].

**Tire (cast iron, ductile steel, phenolic, nylon, and polyurethane):** The tire is constructed from a combination of cast iron, ductile steel, phenolic, nylon, and polyurethane. This diverse mix of materials ensures the tire can facilitate the movement of the machine from one place to another efficiently. Cast iron and ductile steel provide the necessary strength and durability to support the machine's weight and withstand rough terrains. Phenolic and nylon contribute to the tire's resilience and wear resistance, ensuring smooth operation over time. Polyurethane adds a layer of flexibility and shock absorption, enhancing the wheel's performance on uneven surfaces. These materials are chosen for their longevity and reduced environmental impact, as they minimize the need for frequent replacements.

**Bearing (stainless steel):** Stainless steel is selected for the bearing due to its superior corrosion resistance, strength, and durability. Bearings play a critical role in reducing friction between rotating components, which is essential for the smooth operation of the machine as it lifts fresh fruit bunches. Stainless steel's resistance to rust

and corrosion ensures that the bearings maintain their functionality over extended periods, even in the harsh, humid conditions of palm oil plantations. The material's strength ensures it can withstand the mechanical stress of continuous operation, contributing to the overall durability and sustainability of the machine.

**Claw (steel):** The claw, which grips the fresh fruit bunches of palms, is made of steel. Steel is ideal for this component because of its high strength and ability to maintain a firm grip on heavy loads without deforming. The claw's primary function is to securely hold the fruit bunches, which requires a material that can handle significant force and pressure. Steel's durability ensures that the claws can repeatedly perform their task without significant wear or failure. Additionally, steel's recyclability supports sustainable manufacturing practices.

**Body Frame (hollow steel):** Hollow steel is used for the body frame due to its combination of strength and reduced weight. The body frame needs to be strong enough to support the entire machine and the loads it carries, but also light enough to facilitate movement and operation. Hollow steel provides the necessary structural integrity while minimizing the overall weight of the machine. This balance enhances the machine's efficiency and maneuverability. Furthermore, like solid steel, hollow steel is recyclable, contributing to the machine's sustainability by allowing for the reuse of materials at the end of its lifecycle.

### 2.3 Evaluation on Palm Claws Pro Machine

First, the load capacity test is conducted to ensure the model can bear the maximum load of 10 kg without damage. This test involves gradually placing a load up to 20 kg on the model. At each stage, any changes or signs of material fatigue are observed and recorded. Parameters examined include structural strength, deformation, and component integrity. This test is crucial to ensure the model has sufficient durability to handle the required load during operation.

Next, the lifting height test is conducted to ensure the model can lift FFB to a height of 1.75 m. In this test, the model is operated to lift a 20 kg load to the specified height. The lifting height is measured to ensure the model can reach and maintain that height. Parameters examined include the performance of the lifting mechanism, stability during lifting, and the maximum height achievable. This test ensures the model can meet the required lifting height specifications.

Finally, the stability test is conducted to ensure the model remains stable when lifting loads and operating on uneven terrain. This test involves testing the model with the maximum load on various inclines and surfaces. The tendency of the model to tip over or lose balance is observed. Parameters examined include balance points, load distribution, and the model's response to changes in surface conditions. This test is crucial to ensure the model is safe to use under various conditions.

### 2.4 Sustainability and Environmental

Environmental sustainability involves responsible interaction with the environment to prevent the depletion of natural resources and ensure long-term ecological quality. In the context of *sema*, it refers to the sustainable rate of resource harvesting, which is renewable, reducing pollution and increasing renewable resources, as well as can be extended forever. The Palms Claw Pro (PCP) Machine exemplifies an environmentally friendly approach, operating through a combination of manual and motorized functions. The motor is powered by electricity, eliminating smoke emissions that could harm the environment. In contrast, a petrol-powered generator releases smoke, contributing to ozone layer depletion, air pollution, and haze. The PCP Machine significantly reduces the risks of environmental pollution. Its components are designed for reuse in various applications; for instance, the wheelbarrow tires can serve as tires for other machines, and the durable hollow iron frame can be repurposed for different inventions. This practice aligns with the 3R concept—reduce, reuse, and recycle. Adhering to this concept is essential for minimizing waste and litter on Earth, promoting the reuse of materials that still have utility, and recycling recyclable items to foster ecosystem stability.

## 3. Result and Discussion

Several tests need to be conducted to determine whether the objectives of the study are met or not. The success of this product can be determined based on the objective of the project's fabrication, which is that this machine will be taken to the oil palm plantation as the purpose of the testing and analyzing process. To meet the first objective, 8 fresh fruit bunches (FFB) of different weights and sizes will be tried to be lifted using the machine that has been built to analyze the force against the grabber. For the second objective, the FFB will be placed on the floor. Then, the FFB will be lifted by hand to simulate the usual method of transporting the FFB on a truck. Finally, the third objective will be researched by studying the researcher's body posture while using the machine and do not use machines.

### 3.1 Working Principle of Palm Claws Pro Machine

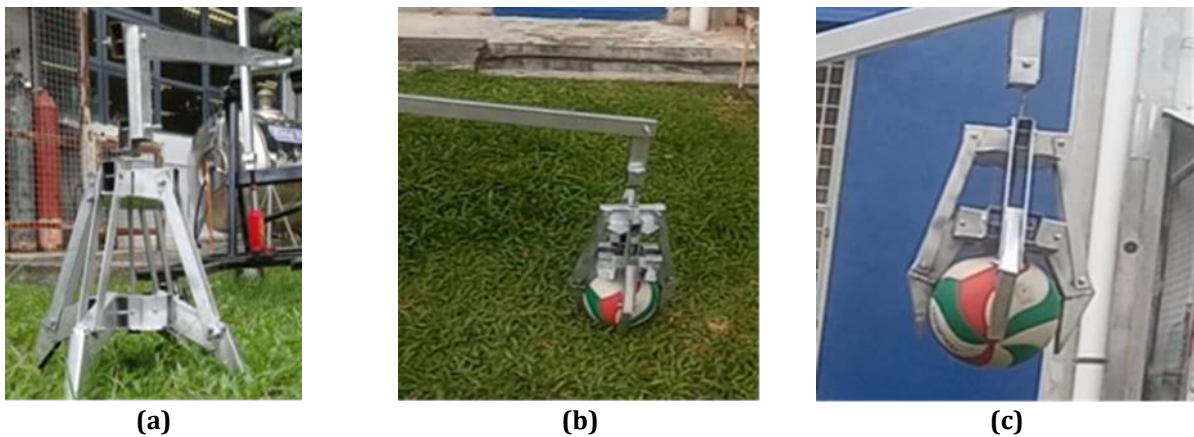
**Fig. 4** shows the prototype of Palm Claws Pro machine that has been fabricated. First, take the machine to the oil palm plantation and transport it to the pile of fresh bunches of palm oil. Adjust the claws according to the position of the fresh fruit bunches of palms. Using the claws, grab the fresh fruit bunches of palms and tighten the nut on the claws using a spanner until it is manually tight. Pump the hydraulic pump lever until the fresh fruit bunches of palm claws are raised to the height of the truck platform. Loosen the nut to release the fresh bunches of palm oil onto the truck platform. Repeat the same steps with another bunch of fresh fruit bunches of palms.



**Fig. 4** Palm Claws Pro Machine

### 3.2 Mechanism Of Claws Machine

Grabber claws, also known as grippers, use two or more fingers (jaws) to enclose and hold an object. They work by bringing the fingers together from opposite sides to grasp the item, driven by mechanisms like pneumatic, hydraulic, or electric actuators. Pneumatic actuators use compressed air to move the fingers, hydraulic actuators use pressurized fluid for higher force applications, and electric actuators use motors for precise control. The fingers can be hard, made from metal or plastic for rigid objects, or soft, made from materials like silicone for handling delicate items. Robot claws are used in many industries, such as manufacturing, logistics, healthcare, and food processing, due to their versatility and ability to handle different shapes and materials with a firm but gentle grip [11]. From this mechanism **Fig. 5(a)** shows that the grabber being set to grab the test subject on the ground. Before the test started, the grabber machine being ensured to ensure the process of grabbing the test subject. **Fig. 5(b)** shows the grabber had successfully grabbed the ball that being the test subject in this test. The grabber managed to grab the ball tightly. **Fig. 5(c)** shows that the grabber managed to lift up the ball in the air without the ball being fell to the ground. This indicates that the grabber mechanism works very well to grab and hold the test subject successfully.



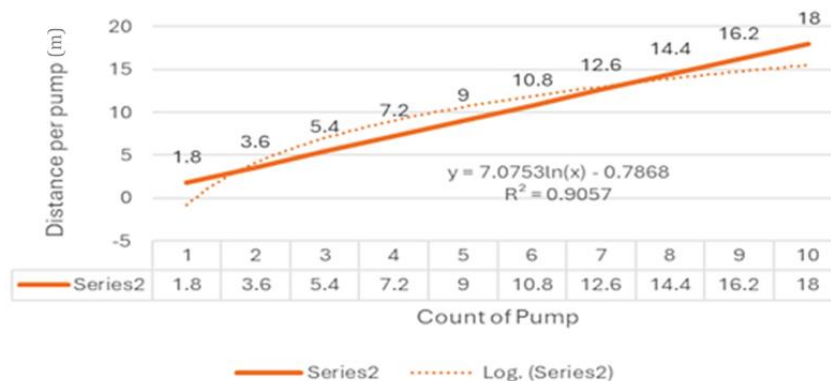
**Fig. 5** Mechanism of claws machine (a) Grabber being opened to reach FFB on the ground; (b) Grabber grabbing a ball; (c) Grabber lifting a ball up in the air

### 3.3 Experimental Result

Based on the tests conducted on this machine, it has been confirmed that it is generally capable of supporting the average weight of a palm oil bunch. The machine demonstrates excellent mobility, easily transitioning from paved roads to uneven terrain without experiencing any dislocation or instability. This adaptability ensures reliable performance across various field conditions, enhancing its usability in diverse environments.

Furthermore, the grabber component of the machine has been proven to reach a height of up to 1.79 m without the need for the hydraulic pump. This is particularly advantageous since the typical height of a truck platform is at least 0.85 m, meaning the machine can efficiently transfer the fruit bunches to the truck without additional hydraulic assistance. This capability not only simplifies the operation but also increases the efficiency of the loading process.

The graph of count pump vs distance per pump in **Fig. 6** shows the relationship between the number of pump activations (Count of Pump) and the resulting distance per pump (distance per pump). As the count of pumps increases from 1 to 10, the distance achieved per pump also increases, following a logarithmic trend. The graph "Count Pump vs Distance Per Pump" demonstrates a logarithmic relationship between pump activations and distance achieved, with a strong correlation ( $R^2 = 0.9057$ ), indicating that while each pump increases distance, the rate of increase diminishes with successive pumps, highlighting a positive yet decelerating growth pattern. This suggests that while each additional pump contributes to an increase in distance, the rate of increase diminishes slightly with each successive pump, illustrating a positive but decelerating growth pattern. The Palm Claws Pro (PCP) Machine not only improves operational efficiency but also enhances worker safety and comfort. Several improvements can be made to the PCP machine, including upgrading to a hydraulic jack that can lift loads higher, adding a handle to the machine's frame for easier movement, and replacing the motor with a more powerful one to strengthen its grip on the fruit bunches, making the unloading process more efficient and ergonomic for workers.



**Fig. 6** Graph of count pump versus distance per pump

### 4. Conclusion and Recommendation

In conclusion, the Palm Claws Pro (PCP) machine has successfully demonstrated significant advancements in both operational efficiency and worker safety. The PCP machine is specifically designed to lift and load Fresh Fruit Bunches (FFB) into trucks, thereby reducing the physical strain on workers and minimizing the risk of injuries, such as back pain, associated with traditional lifting methods. By mechanizing the FFB handling process, this solution allows workers to perform tasks without pain, thereby improving overall comfort and productivity. Moreover, the machine incorporates safety features that ensure each component is securely connected and capable of withstanding the forces and loads encountered during operation. Analysis indicates a strong correlation between pump activations and distance achieved, suggesting that while each activation increases the distance moved, the rate of increase diminishes over time, reflecting a positive yet decelerating growth pattern. To further enhance the PCP machine, several improvements are proposed, including upgrading to a more powerful hydraulic jack for higher lifting capabilities, adding handles for easier maneuverability, and replacing the motor with a stronger variant to improve grip on the FFB. These modifications will not only streamline the unloading process but also contribute to a more ergonomic working environment. In addition to its operational benefits, the PCP machine is designed with environmental sustainability in mind. It relies on an electric power source, significantly reducing carbon emissions compared to traditional methods. Constructed from environmentally friendly materials, such as stainless steel, and utilizing reusable components, this machine minimizes material waste and pollution during its production and operation. Overall, the Palm Claws Pro (PCP) machine stands as a testament to the commitment to enhancing worker safety and comfort while promoting environmental sustainability in palm oil harvesting operations.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Izzul Hafiz Maz Azri; **data collection:** Muhammad Adam Abdullah, Muhammad Noor Azamuddin Noor Azam; **analysis and interpretation of results:** Muhammad Adam Abdullah, Izzul Hafiz Maz Azri, Muhammad Noor Azmuddin Noor Azam; **draft manuscript preparation:** Hafsa Mohammad Noor, Muhammad Adam Abdullah, Izzul Hafiz Maz Azri, Muhammad Noor Azmuddin Noor Azam. All authors reviewed the results and approved the final version of the manuscript.

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