# Development of Hydraulic-Based Equipment for Candlenut Oil Extraction: Design and Implementation

I P G Sopan Rahtika, I M Suarta, I K Rusmariadi, K B W Yasa
Department of Mechanical Engineering
Bali State Polytechic
Badung, Bali, Indonesia
email: putugedesopanrahtika@pnb.ac,id

**Abstract.** Indonesia possesses a remarkably diverse biodiversity that holds significant potential for enhancing the national economy. Among the traditional products commonly employed for medicinal purposes is candlenut oil. However, the current extraction process for candlenut oil relies on manual squeezing, following traditional methods. In order to enhance the productivity of small-scale candlenut oil producers, this study aims to develop a hydraulic press-based tool for extracting candlenut oil. The proposed press tool operates on the principle of utilizing pressure generated by a hydraulic jack. As pressure is applied and fluid flows from the hydraulic cylinder to the piston cylinder, the piston is pushed outward. The pressure from the hydraulic jack is transmitted through a connecting iron pipe attached to a threaded shaft, subsequently exerting pressure on the pressure plate to facilitate the pressing process for candlenut seeds. Based on data collection conducted five times to gather information with the weight of 2 kg of candlenuts, the average weight of the extracted candlenut oil was 864 grams. The average time required for this process was 14.29 minutes (14 minutes and 29 seconds), and the average weight of the remaining candlenut residue was 1.135 grams. The tool's test outcomes indicate that it can elevate candlenut oil production by 36.5%.

**Keywords:** design, extraction, hydraulic press, candlenut oil

## 1. Introduction


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Candlenut (Aleurites moluccana), native to the Maluku Islands and Malaysia, has widespread distribution from eastern Asia to the Pacific Islands. In Indonesia, candlenuts are abundant throughout the archipelago and offer promising market potential domestically and internationally. Their economic value spans from culinary enhancements to industrial resources and household items. Candlenuts find application as cooking spices, medicines, beauty products, and raw materials for various industries.

Chemically, candlenut seeds, leaves, and roots contain saponins, flavonoids, polyphenols, and fatty oils, with additional presence of tannin. These components confer laxative and medicinal properties. Despite their significance, micro-level businesses continue traditional candlenut oil production methods involving manual blending, water mixing, and hand squeezing through mesh cloth. While electricity-free, this approach presents limitations such as restricted capacity, prolonged processing time, suboptimal oil yield, and labor-intensiveness.

Addressing these constraints, this research focuses on designing a hydraulic-based candlenut extraction tool. This endeavor aims to amplify candlenut oil production efficiency and simplify pressing procedures by employing hydraulic mechanisms, enhancing processing speed compared to conventional methods. With the problem formulation centered on the design and functionality assessment of a 2 kg capacity hydraulic candlenut extraction tool, aligned with micro business production scale, the anticipated outcomes of this design endeavor are heightened micro-scale candlenut oil productivity and streamlined extraction processes. The proposed tool is expected to significantly economize time during candlenut oil extraction, fostering improved production outcomes.

## 2. Method

Candlenuts, integral to Indonesia's ecological diversity, flourish expansively across the nation and extend their presence to encompass regions in Asia and the Pacific. Investigating their historical dispersion, Rozefeld et al. [1] shed light on this aspect through an inclusive study that encompasses geographic distribution within Australia and New Zealand, as well as insights gleaned from the fossil records of Euphorbiaceae and its associated plant families.

Scholarly interest in candlenuts' applications has surged. Recent research led by Tarigan et al. undertakes a comprehensive exploration of sorption isotherms for shelled and unshelled candle nut kernels [2], alongside the study of drying characteristics of unshelled candlenut kernels [3].

The optimization of oilseed pressing methodologies has captivated researchers seeking to refine oil extraction processes. Pietsch and Eggers [4] introduced a novel high-pressure Screw Press, offering insights into its innovative features and performance evaluation. Similarly, Kütük and Dülger [5] explored the intricacies of a hybrid press system, delving into the intricacies of motion design and inverse kinematics.

The realm of innovative press system design is also exemplified by Hsieh and Tsai [6], who pursued an optimum design approach for a press system using the Stephenson-I mechanism, and Qu et al. [7], who applied Axiomatic Design theory to optimize guiding devices in Hydraulic Press columns. Engineering considerations extend to structural integrity, demonstrated by Okolie et al. [8], who analyzed the steelwork design of a 40-ton constant temperature hydraulic press.

Advancements extend to hydraulic pressing techniques. Willems et al. [9] conducted experimental determinations and modeling of yield and pressing rates for hydraulic pressing of oilseeds. Concurrently, Vidal et al. [10] elevated the nutritional value of cold-pressed oilseed cakes through extrusion cooking. Additionally, Santoso et al. [11] explored the influence of process parameters on rubber seed oil extraction using a Hydraulic Press.

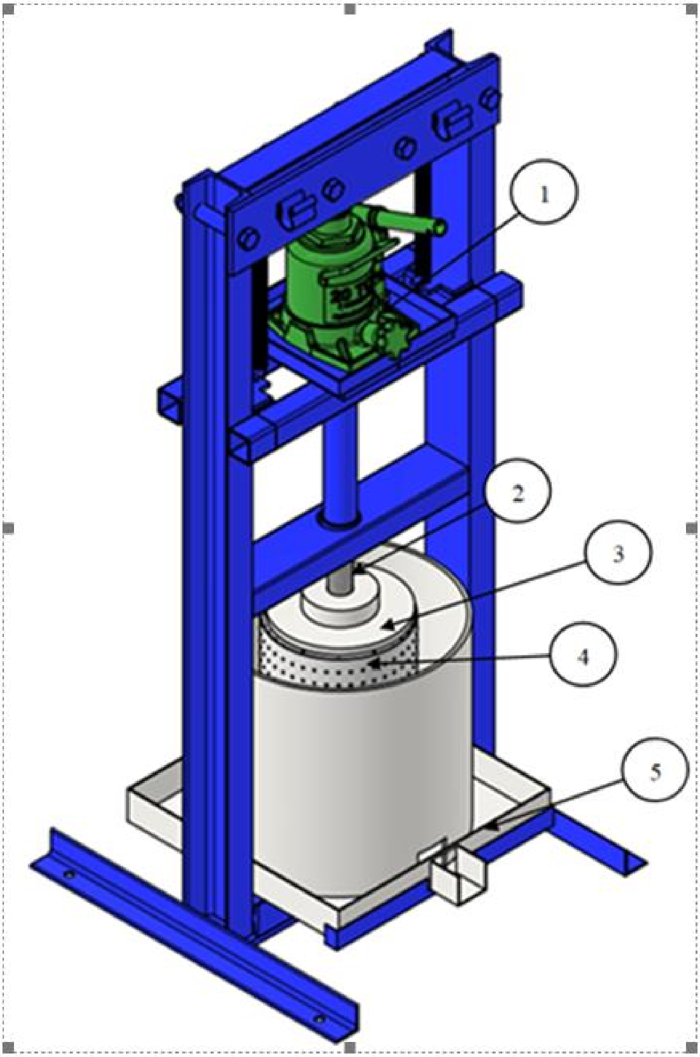


**Fig. 1.** The designed pressing equipment.

These diverse research endeavors collectively illuminate the multifaceted dimensions of oilseed pressing, spanning innovative design methodologies and comprehensive process parameter studies. This research contributes to the broader understanding of oil extraction techniques, while our current endeavor further explores hydraulic system applications in designing a press tool for candlenuts.

This research can be categorized as design development research. It follows a mechanical design process, which is a systematic approach to conceiving, creating, and refining mechanical systems and components. This process involves iterations starting from problem identification, continuing through conceptualization, detailed design, testing, and optimization. Functional requirements, material selection, structural integrity, and manufacturability are all considered during the design process to develop efficient and reliable mechanical solutions. By utilizing engineering science calculations and adhering to established engineering standards, this process ensures that designs meet performance criteria, safety standards, and cost-effectiveness. Prior to this research, we have also conducted studies related to design type research, such as the development of a wind harvester [12] and a cocoa bean sorter [13].

**Fig. 2.** The photo of finished equipment.

To begin the process, the candlenut flesh intended for pressing is enveloped within a mesh cloth and subsequently introduced into the pressing tube. Positioned atop the jack is a steel retainer that aids in the pressing operation. As the hydraulic jack is activated, the threaded axle connected to the presser is rotated. This rotation causes the presser to come into contact with the candlenut seeds earmarked for pressing, signifying their readiness for the pressing phase.

The construction of the tool is illustrated in Fig. 1. The operational principle of this press tool revolves around generating pressure through a hydraulic jack. The application of pressure prompts the flow of fluid from the hydraulic cylinder to the piston cylinder, facilitating the outward movement of the piston. During the pressing process, the pressure exerted by the hydraulic jack is transmitted to a connecting iron pipe, which in turn is linked to an axle. This transmission of force results in the activation of the pressure plate, initiating the pressing process for the candlenut kernels. The photo of the final constructed design can be shown on Fig. 2.

**TABLE I.** TEST RESULTS OF 2 KG CANDLENUTS USING TRADITIONAL METHOD

| No | From 2 kg of candlenuts | | | |
|---|---|---|---|---|
| | ***Oil(g)*** | ***Residue(g)*** | ***Time(h:m)*** | ***Percentage*** |
| 1 | 439 | 1561 | 2:45 | 22 |
| 2 | 355 | 1645 | 2:25 | 18 |
| 3 | 399 | 1601 | 2:36 | 20 |
| 4 | 439 | 1561 | 2:50 | 22 |
| 5 | 399 | 1601 | 2:30 | 20 |
| Average | 406 | 1594 | 2:37 | 20 |

Employing the jack lever, the hydraulic jack is actuated, causing the piston rod to extend and the jack itself to descend. As a result, the pressure plate engages with the candlenuts within the reservoir tube, prompting the release of oil from the candlenuts. Upon completion of the pressing process in accordance with the desired pressure level, the jack's bottom valve is turned to the left. This action facilitates the retraction of the jack piston, returning the jack to its elevated position. Subsequently, the pressure plate is rotated to the left until it regains its initial upper position, thereby allowing for the extraction of the remaining candlenut residues resulting from the pressing process.

This hydraulic-based candlenut extraction device utilizes hydraulic force to actuate the presser in an up-and-down motion as a key component of the pressing mechanism. The process of designing and constructing this hydraulic press-based candlenut extraction tool commences with the design planning and the procurement of materials. The framework of this device incorporates materials such as L-shaped iron with dimensions of 40 x 40 x 4 mm, UNP iron with dimensions of 80 x 42 x 5 mm, WF steel with dimensions of 100 x 50 x 5.5 cm, hollow iron with dimensions of 40 x 40 x 3 mm and 80 x 40 x 1.2 mm, plates with dimensions of 210 x 210 x 3 mm, iron plates with dimensions of 480 x 100 x 8.55 mm, 380 x 100 x 8.55 mm, 480 x 95 x 10 mm, and 210 x 95 x 10 mm. Additionally, stainless steel plates with dimensions of 320 x Ø 198 x 2 mm, 320 x Ø 340 x 1.2 mm, and 380 x 380 x 2 mm, iron pipes with dimensions of 280 x Ø 43 x 3 mm, threaded rods with dimensions of 400 x M 32 mm, presser with dimensions of Ø 190 x 10 mm, embossing tool with dimensions of Ø 46 x 9 mm, embossing tool housing with dimensions of Ø 99 x 27 mm, wire springs with a diameter of Ø 3 mm, and a 5-ton hydraulic jack.

## 3. Result and Discussion

The assembly process was carried out in accordance with the prescribed steps. All necessary components, both fabricated and procured, were prepared. The assembly commenced by affixing the retaining plate to the frame, securing it with bolts, rings, and nuts. Subsequently, the counterbalance for the hydraulic jack was installed onto the frame, accompanied by the attachment of springs to the jack's hook and the frame. Further assembly involved the welding of a threaded shaft to the bossing housing and the pressure plate onto the nut welded to the connecting iron pipe on the hydraulic jack's counterbalance. The integration of the pressing tube, temporary storage tube, and temporary storage box onto the welded base plate completed the assembly of these components onto the frame. The hydraulic jack was then mounted onto its designated base, ensuring proper alignment with the iron pipe previously welded to the frame for balance during usage or the extraction process. Following these assembly steps, a comprehensive mechanical testing procedure was executed to validate the functionality of the candlenut extraction tool.

The equipment testing procedure was meticulously conducted with the following steps. A total of 2 kilograms of candlenuts were weighed and enveloped in filtering cloth before being inserted into the pressing tube. The pressing process involved two iterations, with the hydraulic jack being pumped using the lever until the pressure plate effectively pressed the candlenuts, resulting in the extraction of oil. After each pressing cycle, the oil valve was carefully released to restore the jack to its initial position. The process was executed with precision, ensuring that the candlenuts were effectively pressed. Following the extractions, the collected extracts were accurately measured using a graduated cylinder, and the residue's weight was ascertained. These procedures were adhered to, ensuring the reliability and precision of the test outcomes.

The testing process was conducted five times, employing both traditional methods and the hydraulic-based candlenut extraction tool. The results obtained through the traditional method are presented in Table 1, while those acquired using the extraction tool are outlined in Table 2.

**TABLE II.** TEST RESULTS OF 2 KG CANDLENUTS USING TOOL

| **No** | **From 2 kg of candlenuts** | | | |
|---|---|---|---|---|
| | ***Oil(g)*** | ***Residue(g)*** | ***Time(m)*** | ***Percentage*** |
| 1 | 830 | 1170 | 15.00 | 42 |
| 2 | 914 | 1086 | 14.20 | 46 |
| 3 | 874 | 1126 | 13.49 | 44 |
| 4 | 830 | 1170 | 14.35 | 42 |
| 5 | 874 | 1126 | 14.40 | 44 |

| No | From 2 kg of candlenuts | | | |
|---|---|---|---|---|
| | ***Oil(g)*** | ***Residue(g)*** | ***Time(m)*** | ***Percentage*** |
| Average | 864 | 1136 | 14.29 | 43 |

Utilizing the traditional method for data collection, with 2 kg of candlenuts, the average extracted candlenut weight was 406 grams, the time required was 2.37 hours (2 hours and 37 minutes), and the average weight of candlenut residue was 1.595 grams.

Conversely, employing the extraction tool for data collection, and performing the procedure five times with 2 kg of candlenuts, the average extracted candlenut weight was 864 grams, the average extraction time was 14.29 minutes (14 minutes and 29 seconds), and the average weight of the candlenut residue was, as depicted in the graph above, 1136 grams. This is based on the weight of the initial 2000-gram candlenut raw material.

The results of the testing hydraulic-based candlenut extraction tool indicate an increase in candlenut oil production by 36.5%. This improvement is attributed to the advancements in the design and functionality of the extraction equipment.

The comprehensive mechanical testing of the hydraulic-based candlenut extraction tool have yielded highly promising results. The substantial increase in oil yield, accompanied by significantly reduced processing times, underscores the tool's potential to improve candlenut oil production. This innovative equipment opens new horizons for the candlenut industry, enhancing efficiency and, ultimately, contributing to the overall prosperity of small-scale candlenut oil producers. These findings underscore the transformative potential of modern mechanical design and technology in addressing long-standing challenges in traditional production processes.

# 4. Conclusion

Based on the results of designing the hydraulic-based candlenut extraction tool, the following conclusions can be drawn:

The hydraulic-based candlenut extraction tool employs a hydraulic jack press system for the candlenut pressing process. The design dimensions of this hydraulic-based extraction tool are 480 x 80 x 1150 mm. The components utilized in the design include a hydraulic jack with a 5-ton capacity, a spring made of Ø 3 mm steel wire, a hydraulic jack counterweight constructed from hollow iron measuring 165 x 40 x 490 mm, a hydraulic jack base created from iron plate sized 210 x 210 x 23 mm, a threaded shaft made of Ø M 32 mm steel, a connecting iron pipe constructed from iron pipe sized 280 x Ø 43 x 3 mm, a presser made from Ø 190 x 10 mm steel, a bossing housing fashioned from ST-60 iron sized 27 x Ø 99 mm, and a bossing made from iron sized 9 x Ø 46 mm. The pressurizing cylinder is fabricated from stainless steel plate measuring 320 x Ø 198 x 2 mm, the temporary storage cylinder employs stainless steel plate sized 320 x Ø 340 x 1.2 mm, and the interim storage box is constructed from stainless steel plate sized 380 x 380 x 2 mm.

From the data collected using the hydraulic-based candlenut extraction tool, and performing the procedure five times with 2 kg of candlenuts, the average extracted candlenut weight was 864 grams, the average extraction time was 14.29 minutes (14 minutes and 29 seconds), and the average weight of the candlenut residue was 1.135 grams. The results from testing the hydraulic-based candlenut extraction tool show an increase in candlenut oil production by 36.5%. This improvement is attributed to the advancements in the design and functionality of the extraction equipment.

For further research, it is recommended to redesign the tool using pressing methods that align with the evolving production capacities of industry.

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