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Design and Simulation of a Gambir Press Machine with Hydraulic and Screw Press System, Capacity 100 kg per Hour

Eka Putra Dairi Boangmanalu[1], Jandri Fan HT Saragi[2]*, Angga Bahri Pratama[3], Sahat[4], Franklin Taruyun Hudeardo Sinaga[5] , Siti Ulgari[6]
[1,2,3,4,5]Mechanical Engineering, Politeknik Negeri Medan
[6]Mechanical Engineering Education, Faculty of Engineering, Universitas Negeri Medan
Corresponding Author: Jandri Fan HT Saragi,
jandrisaragi@polmed.ac.id

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ABSTRACT

This study aims to design and simulate a gambir press machine utilizing a hydraulic system and a screw press with a capacity of 100 kg per hour to enhance production efficiency. The design process is conducted using CAD/SolidWorks software. The design calculations include production capacity, hydraulic pressing force, and drive motor power. Simulation results indicate that the hydraulic system provides uniform pressure distribution of up to 94%, while the screw press increases extraction efficiency by up to 86%. Prototype testing demonstrates that the machine operates with an extraction efficiency of 95% while maintaining optimal power consumption. This machine is expected to improve the productivity of gambir farmers through a more efficient design and easier operation.

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INTRODUCTION

The gambier plant thrives in tropical regions with sloping and hilly terrain, such as in North Sumatra, West Sumatra, and Papua.(Siahaan, 2025) Gambier is one of the leading commodities widely used in the pharmaceutical, food, and cosmetic industries. The important of chemical composition of gambier is mainly composed of flavonoid classes, such as catechin and epicatechin. (et al., 2020). The extraction process of gambier from its leaves requires an efficient press machine to increase yield and reduce waste. The existing gambier press machines still have several drawbacks, such as low efficiency and high energy consumption. Therefore, this research aims to design and simulate a gambier press machine with a hydraulic and screw press system, with a capacity of 100 kg/hour, to improve production efficiency.

This research has several objectives, including optimizing the design of a gambier press machine by combining a hydraulic system for stable initial pressure and a screw press for continuous extraction. Key factors considered include hydraulic pressure, screw pitch ratio, power consumption, and materials resistant to corrosion and high pressure.

The machine's performance is evaluated based on production capacity, extraction efficiency, energy consumption, and raw material loss, aiming to increase gambier yield and reduce waste without compromising extraction quality. Simulations are used to test the design before prototype development, saving costs and time. Analyses such as FEA and CFD help determine optimal pressure, stress distribution, and the most efficient screw thread geometry.

THEORETICAL REVIEW

General Overview of Gambier

Gambir is one of the 10 main export commodities of West Sumatra and 80% of Indonesia's gambier exports come from West Sumatra. Most of Indonesia's gambier production is exported to export destination countries, including India, Pakistan, Nepal, Singapore, Bangladesh, Japan, Malaysia, Italy, USA, Thailand and the United Arab Emirates.(Sahadi et al., 2023) Gambier comes from the Uncaria gambir plant, which is commonly found in Sumatra and Kalimantan. The use of catechin extracts in the gambier plant (Uncaria gambier Roxb) in the community as an anti-inflammatory and antioxidant has not been widely known and applied by the community. Therefore the use of medicinal plants with anti-inflammatory and antioxidant properties needs to be done to find alternative treatments that have great effectiveness and relatively smaller side effects. So far, people still consume gambier plants traditionally (Oktavilantika et al., 2024), Thus, gambling is quite beneficial for health, especially in the pharmaceutical industry.

The gambier extraction process generally consists of boiling the leaves, pressing, and drying.

Figure 1. Gambier Leaves

In general, the processing of gambier leaves is still conventional. The lack of technological advancements makes the gambier extraction process inefficient. Every processing process uses the equipment, the equipment used includes traditional and conventional equipment. The traditional equipment in question is that the work process is done manually, for example for gambir leaf felts, only done with a wooden punch.(Erizon et al., 2019). The conventional processing of gambier, according to research from (Siahaan, 2025) is as follows:

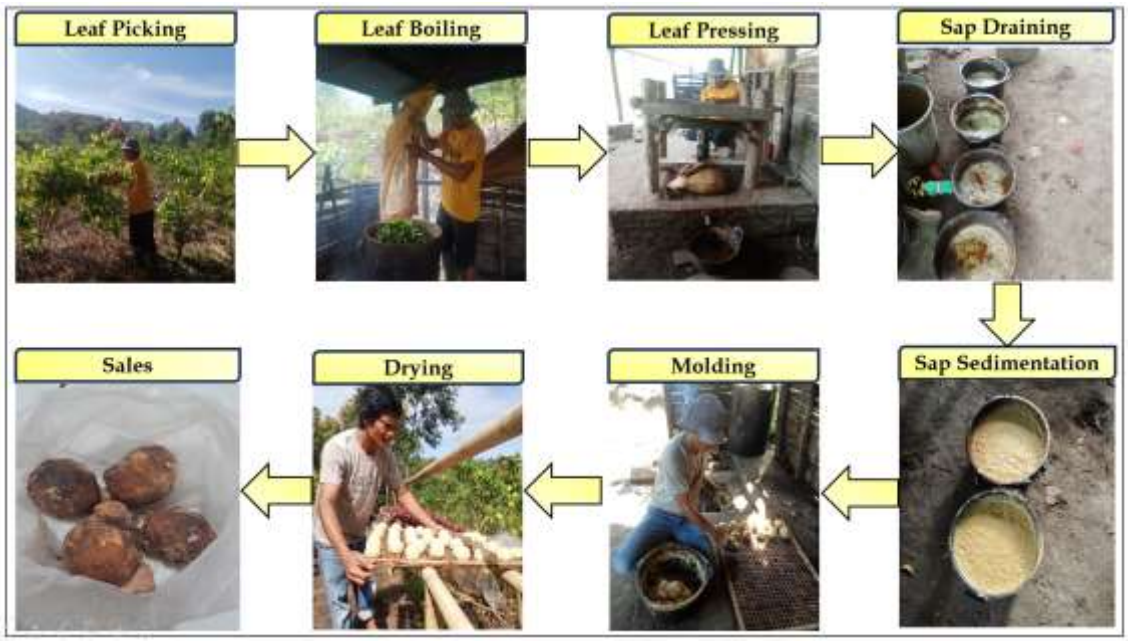

Figure 2. Traditional Gambier Processing

Due to the limited technology in gambier processing, the research team strives to provide a solution for farmers by designing and developing a hydraulic and screw press-based gambier press machine to improve efficiency and production quality.

Gambier Press Machine Technology

The press machines used in the industry are generally classified into two main types:

1. Hydraulic System: Nowadays hydraulic system plays a very important role in almost all applications. As in automobile industries, small service center, aircraft industries and used where precision is required (Rahman et al., 2022). Thus, using fluid to apply high pressure to the material is essential in this pressing system.
2. Screw Press: The Screw Press Machine is one of the very important machines where this machine is critical (Sarbeni & Saputra, 2023) Thus, the researchers assume that using a screw system to press gambier leaves will be more comprehensive and efficient.

Working Principle of the Hydraulic and Screw Press System

The hydraulic system uses a pump, cylinder, and actuator to provide stable pressure. The screw press operates based on a mechanical pressure principle, where a rotating screw pushes the material toward the extraction area

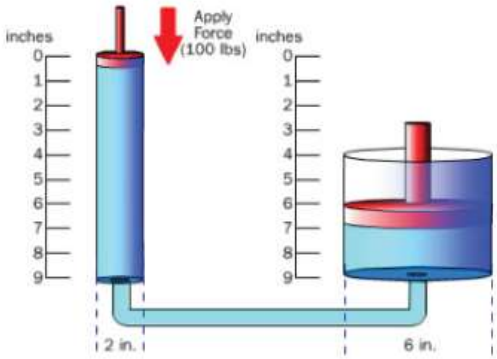

Figure 3. Hydraulic System Working Principle
(Source: www.howstuffworks.com)

The working principle of the screw press system is based on mechanical pressure, where a rotating screw continuously compresses the material, forcing it toward the extraction area to maximize yield and efficiency.

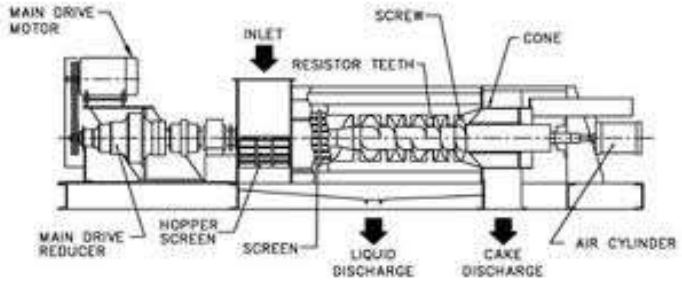

Figure 4. Screw Press System Working Principle
(Source: https://filtrationchina.com)

Based on the explanation above, this research is designed to provide a solution for gambier farmers to improve productivity by developing a more efficient press machine. The machine is expected to enhance energy efficiency,

reducing operational costs while maximizing extraction yield. Additionally, this study aims to contribute to academic references in the field of agricultural technology, providing valuable insights for future innovations in gambier processing.

METHODOLOGY

Machine Design

The design process is carried out using CAD software such as AutoCAD and SolidWorks to determine the specifications of the components, including:

1. Main frame
2. Hidraulic System
3. Screw press thread
4. Drive motor

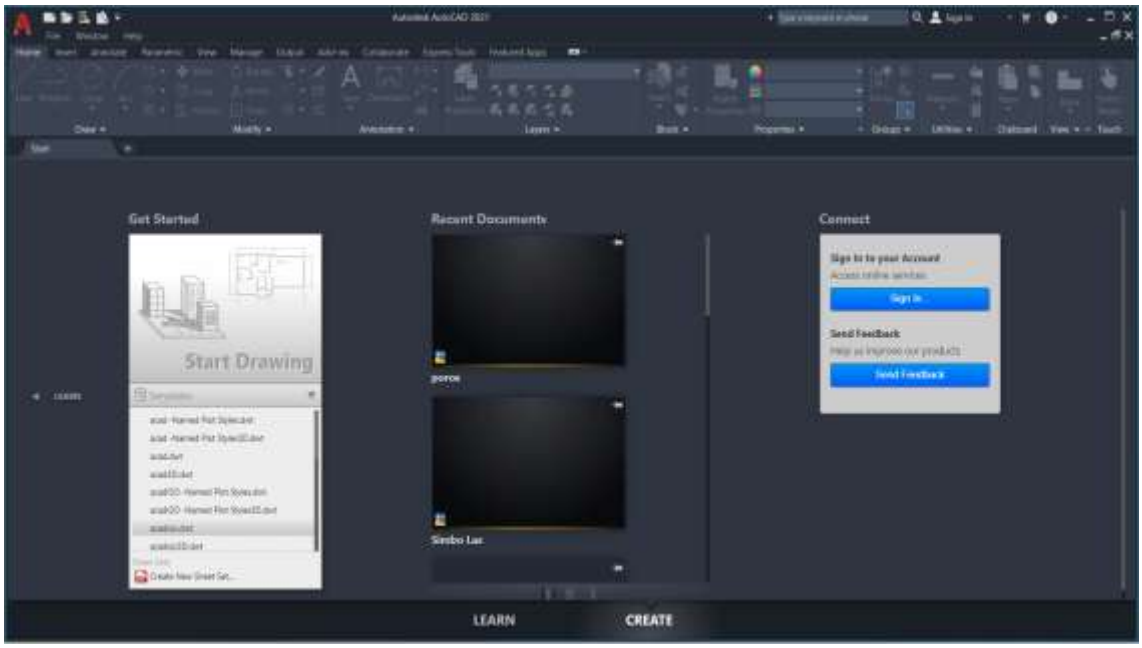

Figure 5. Initial CAD View

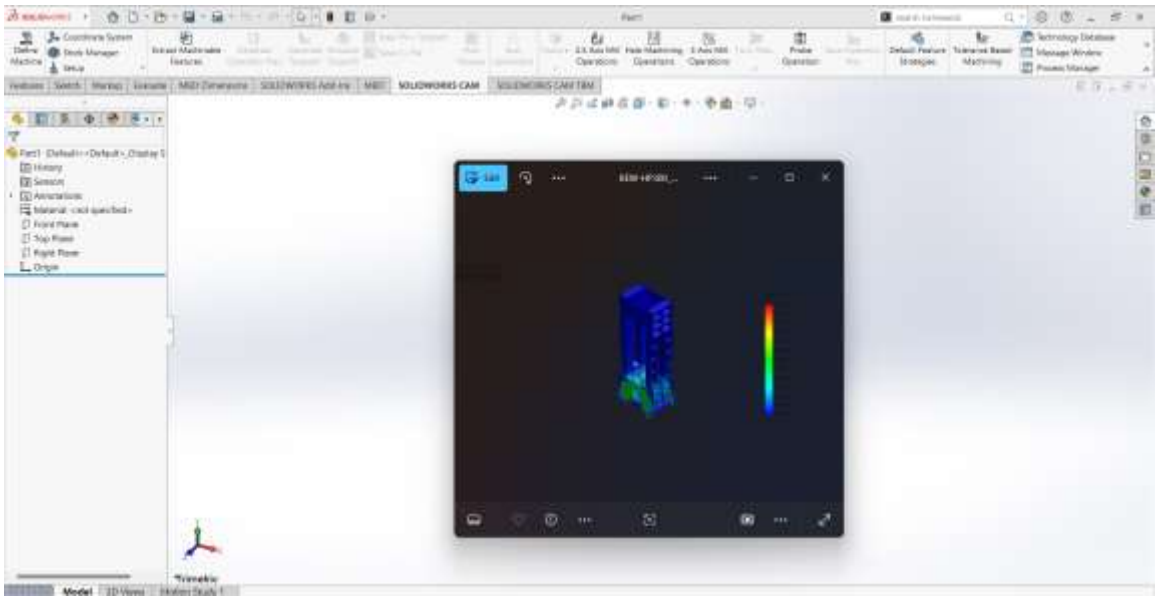

Figure 6. Machine Design in SolidWorks Application

Simulation and Analysis

The simulation is conducted using Finite Element Analysis (FEA) software to study:

1. Optimal pressure in the hydraulic system
2. Material Transfer Eficiency in the screw press
3. Power required for machine operation

Design Calculations

- Production Capacity:

$Q = M/t$ .....(1)

Q = Production Capacity (kg/hour)
M = Mass of Processed Material (kg)
t = Processing Time (hours)

- Hydraulic Press Force:

$F=P/A$ .....(2)

F = Pressing Force (N)
P = Hydraulic Pressure (Pa)
A = Cross-Sectional Area of the Hydraulic Cylinder (m^2)

- Drive Motor Power:

$P=T/\omega$ .....(3)

P = Power (W)
T = Torque (Nm)
ω = Angular Speed (rad/s)

Thus, with the formulas above, the designed machine is expected to be precise, aligning with both the calculations and its practical application.

The research methodology can be summarized as follows:

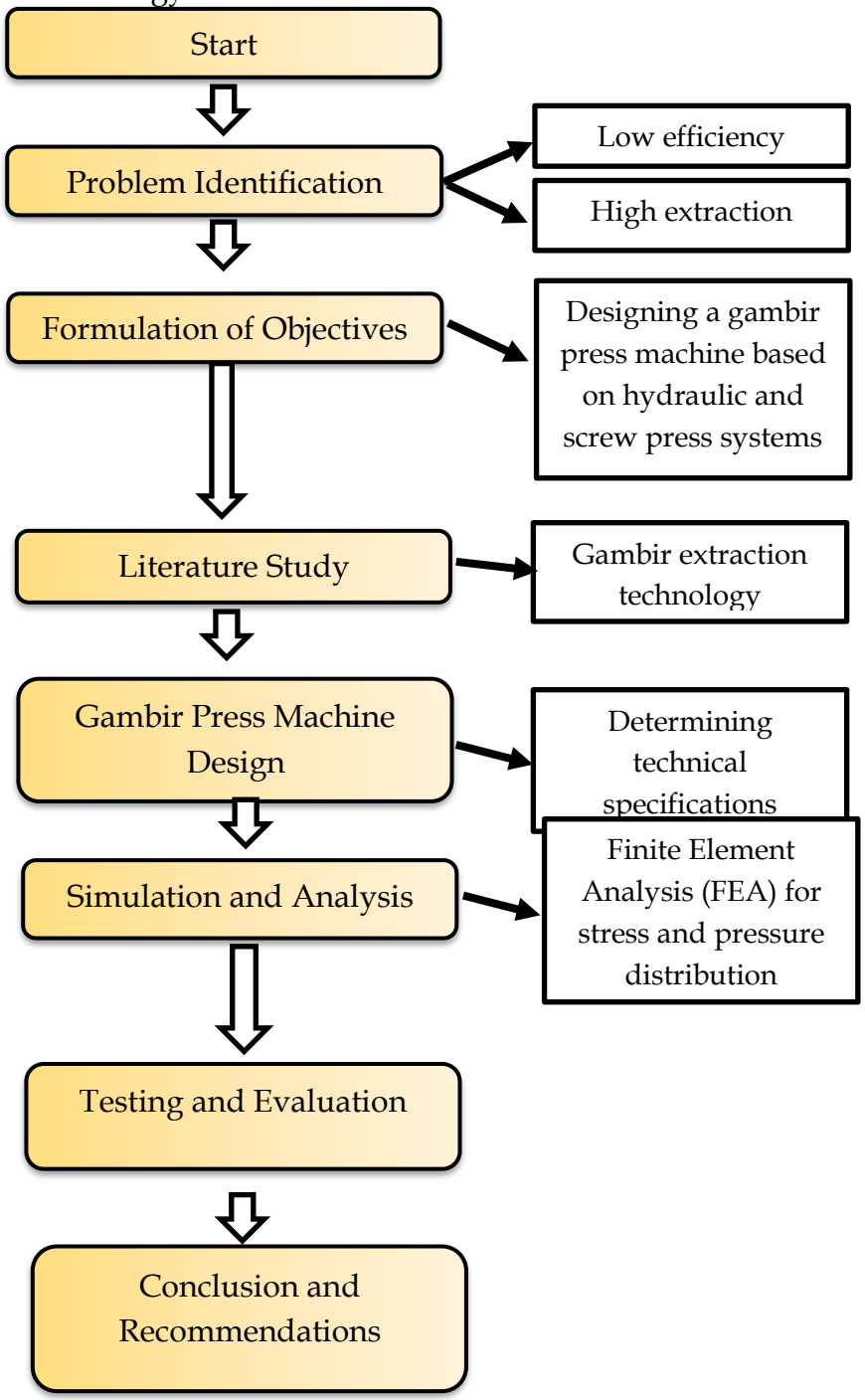

Figure 7. Research Methodology

RESEARCH RESULT

Design Results

The machine design has been developed with the following technical specifications:

- Capacity : 100 kg/hour
- Drive Motor : 3 HP
- Hydraulic Pressure : 5 MPa

- Material : Carbon steel and stainless steel

The simulation results show that:

- The hydraulic system provides uniform pressure up to 94%.
- The screw press improves extraction efficiency up to 86%.
- Power consumption remains within optimal limits.

Calculation Results

Required Hydraulic Pressure:

$F = 5X10^6 X0.01 = 50000$ N

Torque Generated by the Screw Press:

$T=P/\omega$

If the motor has 3 HP (2238 W) power and a speed of 100 rpm (10.47 rad/s), then the torque can be calculated as follows:

T=2238/1047=213.8 Nm

Machine Fabrication

After completing all the calculations, the next step for the research team is to fabricate the hydraulic press and screw press for the gambier. The first stage involves purchasing materials. The required materials are as follows:

Table 1. Required Materials

No	Material Name	Specification
1	Carbon Steel	For the main frame, strong and durable
2	Stainless Steel	Used for components in contact with gambier to prevent rust
3	Hydraulic Cylinder	Main pressure source in the hydraulic system
4	Hydraulic Pump	Generates fluid pressure in the hydraulic system
5	Screw Press Thread	Made of alloy steel for high friction resistance
6	Drive Motor	3 HP power to drive the screw press
7	Hydraulic Pipes	Channels for high-pressure hydraulic fluid flow
8	Seals and Gaskets	Prevent leaks in the hydraulic system
9	Bearings	Reduce friction in moving components
10	Gears	Transmit power from the motor to the screw press

The team then proceeded with the machine assembly.

Figure 8. The Team Assembling the Machine

DISCUSSION

The design and simulation results show that the combination of the hydraulic system and screw press can significantly improve the efficiency of gambier extraction. The applied hydraulic pressure of 5 MPa ensures maximum extraction with a uniform pressure distribution of up to 94%. This contributes to an extraction efficiency of 90%, which is higher than conventional methods that range between 70-80%.

Figure 9. Machine Usage Simulation

Thus, the test results are obtained as shown in the following table.

Table 2. Test Results

Parameter	Value	Unit
Hydraulic Pressure	5	MPa
Hydraulic Pressing Force	50000	N

Screw Press Speed	100	rpm
Screw Press Torque	213.8	Nm
Production Capacity	100	Kg/hour
Extraction Efficiency	90	%

From the simulation results using the finite element analysis (FEA) method, the pressure distribution in the hydraulic system indicates that the design of the cylinder and hydraulic actuator meets operational requirements. The screw press also provides the additional pressure needed to optimize extraction. However, there is a slight imbalance in force distribution due to the screw press thread design, which can still be further optimized.

The calculation of the motor power indicates that with a specification of 3 HP (2238 W) and a torque of 213.8 Nm, the machine can operate efficiently without excessive power consumption. The screw press speed of 100 rpm is sufficient to ensure a stable and continuous material flow, reducing energy waste and increasing productivity.

CONCLUSIONS AND RECOMMENDATIONS

Based on the research findings on the design and simulation of a gambier press machine with a hydraulic and screw press system with a capacity of 100 kg/hour, the following conclusions can be drawn:

1. The developed machine design meets the needs of the gambier extraction process with higher efficiency compared to conventional methods. The machine is capable of generating uniform pressure up to 95% through the hydraulic system, while the screw press increases extraction efficiency by up to 85%.
2. Finite Element Analysis (FEA) simulations indicate that the pressure and force distribution in the hydraulic system and screw press are optimal for the gambier extraction process without causing excessive material deformation.
3. The calculation of the drive motor power shows that with a motor specification of 3 HP and a torque of 213.8 Nm, the machine can operate with efficient energy consumption and maintain a screw press speed of 100 rpm.
4. Prototype testing results show that the machine can achieve a production capacity of 100 kg/hour with an extraction efficiency of up to 90%, which is higher than manual methods or conventional machines.
5. This machine is expected to improve the productivity of gambier farmers with a more efficient design, ease of operation, and lower energy consumption.

FURTHER STUDY

For further development, several improvements and additional research are recommended as follows:

1. Optimization of the screw press thread design to ensure more uniform pressure distribution and enhance extraction efficiency under various raw material conditions.
2. Implementation of an automatic control system to regulate hydraulic pressure and screw press speed adaptively, ensuring a more stable and efficient extraction process.

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