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Design and Analysis of Soybean Epidermis Peeling Machine for Farmers' Group Scale

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Abstract- This research aims to design and test a soybean epidermis peeling machine that is cost-effective, efficient, and suitable for small-scale farmers in remote areas. The research process involved designing, manufacturing, and technical testing of the TETA-II model soybean peeler. The data collected during the research was analyzed descriptively. The results showed that the TETA-II model soybean peeler has an average working capacity of 43 kg/hr at an engine speed of 2450-2550 (rpm) with a soybean soaking period of 6 hours. The highest yield from the peeler was achieved at a soybean soaking time of 8 hours (95.955%) and 6 hours (94.02%) at rpm 2450-2550. In future studies about the machine, to improve its efficiency, the scrubber roll system should be adjusted to regulate the stability of the fall of the soybeans being peeled, and the inner walls must be coated with plastic.

Keywords: Design, Technical Analysis, Peeling Machine, Soybean

INTRODUCTION

The soybean plant (*Glycine max* L. *Merrill*) is a well-known legume with excellent development potential. Its roots have root nodules, which form a symbiotic relationship with Rhizobium japonicum bacteria. These nodules work by binding free nitrogen elements. They can also fertilize the soil by saving on the use of NH_3 available and providing nitrogen elements to the soil. (Kumalasari *et al.*, 2015).

Strategies to increase soybean production should focus not only on cultivation but also on increasing plant productivity. Improving postharvest handling technology is equally critical to minimize yield losses. Postharvest soybean-handling activities include harvesting, transportation, drying, threshing, and storage. Therefore, it is essential to carry out these activities efficiently from harvesting until the soybeans are marketed (Cahyaningrum & Irawati, 2022).

A hot and humid tropical environment causes soybean plants to beat and results in seed deterioration during storage. (Krisnawati & Adie, 2008). The method for making tempeh with raw soybean materials removes the epidermis first. Peeling the epidermis of soybeans carried out by the tempeh artisans group in Kekalik Mataram still uses the conventional method. Namely, the seeds are boiled in boiling water first, then soaked and kneaded until the epidermis is peeled off (Ansar & Abdullah, 2022).

Research shows that the length of soaking soybeans only influences the level of taste preference and overall acceptability of soy milk. Apart from that, the best soaking time for soybeans is 12 hours because it can influence the level of taste preference with the highest acceptance (Margareta & Maryani, 2021).

Developing drought-stress tolerant soybean varieties through in vitro selection is a prospective alternative that can be used to overcome drought stress in the field. With in vitro selection,

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environmental conditions (temperature, pH, and humidity) can be controlled, uniformity of drought stress can be maintained, and in a relatively short time, we can identify varieties that are tolerant of drought stress (Widoretno *et al*., 2002).In Indonesia and other developing countries, protein deficiency is a problem because the relatively rapid increase in population causes the need to continue to increase. In contrast, the available protein sources are limited. One source of protein that is important to develop is soybeans. Soybeans are essential because their protein and fat content are expected to meet the community's nutritional needs, especially in rural areas. Compared to other food sources of protein (vegetables), soybeans have a higher protein content, namely around 35-45%. Apart from that, compared to animal protein sources, protein is more accessible to obtain, more straightforward to price, and easier to produce. Hence, soybeans are an essential source of protein for developing its uses.

In making tempeh, soybean seeds must go through a peeling stage to separate the epidermis from the cotyledons. Some peeling machines are already manufactured in Indonesia—some on a small scale and some on a middle scale. Romiyadi and Dwianda (2019) have designed and manufactured a 3 kg soybean peeling machine that uses two shafts to peel the soybean epidermis from the soybeans. It uses an electric motor with a power of 0.5 HP. The transmission system uses pulley transmission between electric motors. Other peeling machines were also designed by Susilawati et al. in 2023. This type of machine is manufactured for a 20 kg/hr capacity. Those machines have to assist farmers to make less effort to peel soybean epidermis.

There is a need for more soybean epidermis peeling machines in villages and remote areas, but many producers face challenges in acquiring them. The cost of importing machines from other islands, such as in Indonesia, is high, especially for villages far from cities with poor road connectivity and inadequate power supply. The high costs of purchasing and maintaining the machines can be a significant barrier, especially in economically disadvantaged areas. Furthermore, in some villages, small-scale farming practices may not justify the investment in such machines, as their use is more cost-effective at larger scales of production. Additionally, some people in these areas may prefer traditional processing methods due to cultural reasons or scepticism towards modern technology. In such cases, simple equipment is preferred over mechanized solutions.

When designing a cost-effective soybean peeling machine, several factors must be considered. The machine should be efficient, gentle, and consistent to ensure that the soybeans are not damaged during the peeling process. It should be able to remove the epidermis without crushing or breaking the beans because damaged beans can decrease the final product's value and quality. Moreover, the machine should be capable of peeling as many beans as possible in a single pass while minimizing the number of unpeeled beans. This research aims to design and test a soybean peeling machine that is both cost-effective and efficient for small-scale village farmers while simplifying the soaking process.

LITERATURE REVIEW

The post-harvest process for soybeans that uses machines is usually threshing and separating the epidermis. Threshing involves separating the soybean seeds from the pods. After the soybean seeds are separated from the pod, the epidermis or outer layer of the seeds needs to be removed. This process can be done manually or using a peeling machine for greater efficiency and speed. This process is important to produce many soy products such as tofu and tempeh (Tagah et al, 2022).

Soybean epidermis peeling machine is an essential machine for efficient soybean processing. Romiyadi and Dwianda in 2019 designed a small soybean epidermis peeling machine. This machine is handy in settings where traditional, labour-intensive methods are still used. The machine is designed to peel the epidermis off soybeans in batches of up to 3 kg per process. It has two shafts that work together to peel the soybeans and is powered by a 0.5 HP electric motor. The machine also has a transmission system that includes a pulley transmission between the electric motor and the first shaft and a sprocket

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and gear transmission between the first and second shafts.

The soybean epidermis peeler machine comprises several components (Susilawati et al., 2023). These components include a housing, which is the primary structure that encloses the machine's components. The housing is typically designed with specific dimensions to ensure efficient operation. The peeling mechanism involves shafts, abrasive surfaces, or blades that physically remove the epidermis from the soybeans. An electric motor powers the machine and provides the necessary force for peeling. The transmission system, which may include pulleys, gears, or sprockets, transmits power from the motor to the peeling mechanism. A crank system might be used for manual operation, while electronic controls regulate the operation in more advanced models. Input and output hoppers are also provided for feeding soybeans into the machine and collecting the peeled soybeans.

The following components work together to peel soybean epidermis efficiently, reducing manual labor and improving processing time: a peeling mechanism with two discs, one functioning as a stator and the other as rotors, and stomping feet for stripping perfection. Manual stripping of soybean epidermis takes 1 hour for 10 kg of soybean seeds, with a peeling and splitting efficiency of 90%. However, industries can now use a skin peeler machine that can process up to 50 kg/hour, with a stripping percentage of 85%. The machine can peel soybeans in three forms: peeled in splits, crushed, and whole. The size of the peeler disc gap is a determining factor in the efficiency of the peeling process. If the soybeans are peeled larger than the peeler disc gap, they will crumble. If the soybeans are peeled in size smaller than the gap, many soybeans will remain unpeeled. If the size of the soybeans is close to the size of the peeler disc, they will be peeled or split. The peeling disc's speed also affects the stripping process's efficiency. A higher speed of the peeling disc will increase the peeling force, while a lower speed will reduce it. The quality of the peeler is considered good if all the skin is peeled off, the breakdown quality is good if the soybean is broken into two pieces (not crushed), and the separation soybean husks are of good quality if all the skin is removed from the soybean.

RESEARCH METHODOLOGY

Place and time of research

This research was conducted at the Agricultural and Biosystems Engineering Laboratory of the Faculty of Agriculture at Sam Ratulangi University and the Workshop on Jl Kembang Larat no. 2 in Manado. The research period was five months.

Materials and Equipments

TETA-II model soybean peeler, container, stopwatch, tachometer, scales, screw micrometer, driving machine, sieve, plastic bag, needle, stove, candle, caliper, stationery.

Research method

This research carried out several steps: designing the machine, manufacturing, technical tests, and descriptively explaining data resulting from technical tests. Figure 1 describes the design of the Soybean epidermis peeler.

Size and Description Figure 1.

- Dimensions: Length 55cm

- Width: 40cm Height: 109cm

- Weight: 83kg

- Propulsion Engine: Robin Engine Ey 18-3D

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- HP/Rpm max = 5/4000

- Displacement = 182 cc

- Fuel = Gasoline

- Transmission: With a V-belt from the engine to the shaft of each pulley.

The pulley used in this machine is made of tin; the diameters of pulleys I and II are 5cm and 10cm, respectively, with a V-Pulley shape. The pulley's shape is made so that the belt can be in the middle of the pulley. V-pulley is efficient in power distribution and low slip. Meanwhile, the V-belt used is a V-belt made of rubber.

Things that are observed and measured:

- Initial Weight of soybeans (before soaking)

- Weight of soybeans after soaking

- Weight of shelled soybeans at a particular time

- Weight of unpeeled soybeans

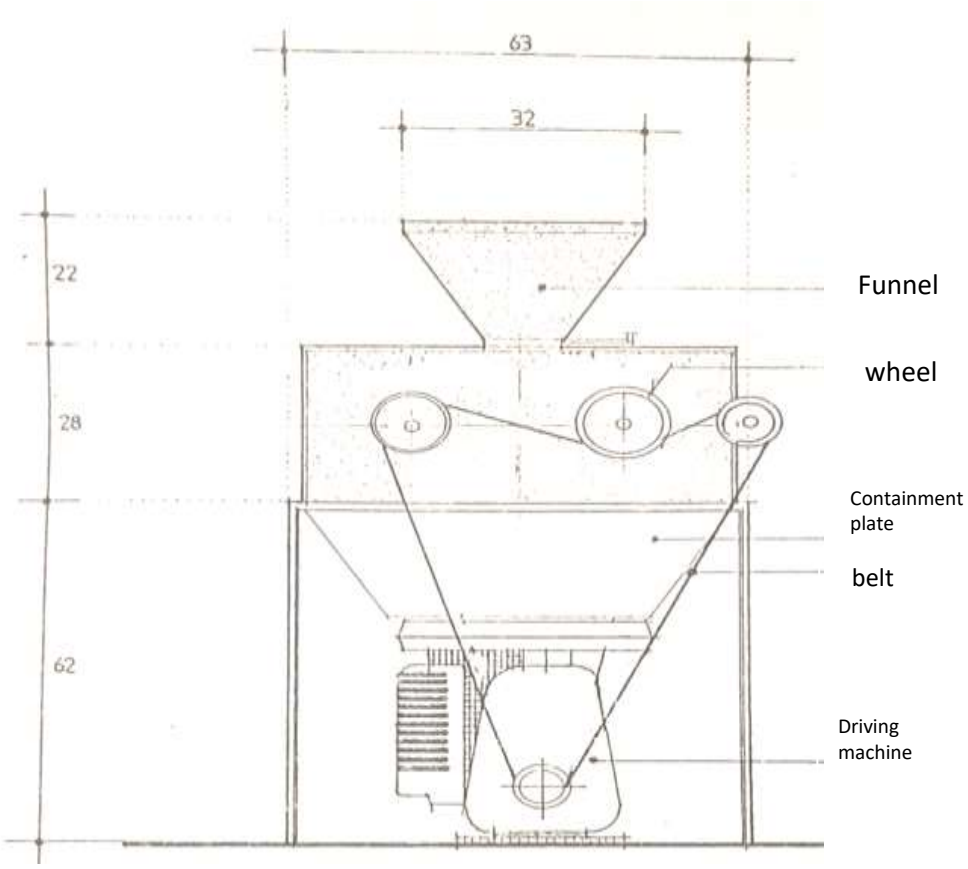

Figure 1. Design of Soybean Epidermis Peeler model TETA-II (in cm)

- Working capacity of the machine

W_h

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$$Ca = \frac{W_h}{T} \text{ (kg/hr)}$$

Where: Ca = Working capacity of the machine
W_h = Weight of peeled soybean
T = time

RESULTS AND DISCUSSION

The results of the design and manufacture are shown in Figure 2.

Peeling mechanism

Peeling is carried out using two rubber rolls with a thickness of 1.7 cm, diameter of 21cm, rubber roll distance of 0.35 cm, and rpm of the roll I and roll II is 1:2. The distance between the two rubber rolls can be adjusted by moving the position of the rubber roll pulley shaft I via the screws. In this study, the rubber roll distance was kept constant at 0.35 cm based on the average size of dry soybean seeds. After peeling, the soybeans fall onto an open cross-sectional area with a slope of 30º and then enter the container. The peeled soybeans fall together with the epidermis; later, in the container, a separation is made between the epidermis and cotyledons.

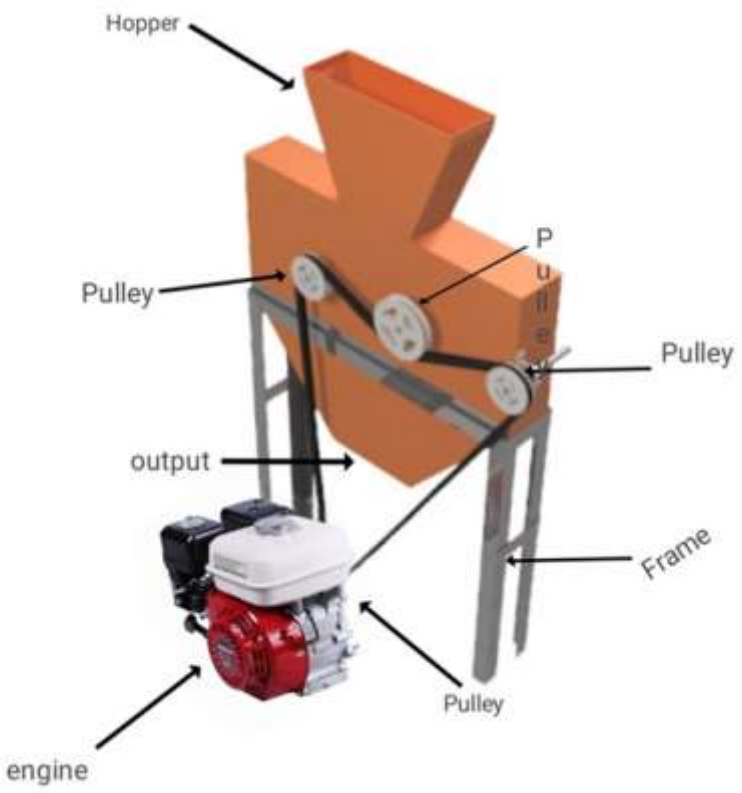

Figure 2. Soybean Epidermis Peeling Machine

Working Capacity

The average working capacity obtained when using this machine is 43kg/hr, with the results still being a mixture of whole and crushed shelled seeds. In Table 1, the working capacity of the machine produced in each repetition can be seen.

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Table 1. Working capacity of TETA-II model soybean peeler (rpm 2450-2550, damping time 6 hours)

	Weight of Soybean (gram)	Peeling Time (Second)	Unpeeled seeds (gram)	Yield		Working Capacity (kg/hr)
				Peeled seeds (gram)	Broken seeds (gram)	
I	1000	76,8	59,70	590,25	350,05	44,08
II	1000	84,4	62,16	527,85	409,99	40,00
III	1000	81,0	58,04	552,10	389,86	42,87
IV	1000	74,5	64,12	587,73	346,14	45,13
V	1000	77,6	55,82	525,75	421,44	43,94
Average	1000	78,86	59,77	556,736	383,50	43,00

The material intake hole is funnel-shaped, with a length at the top of 32 cm, a width of 32cm, and a height of 22 cm. The tamping capacity of the material intake chamber is 5kg. The working capacity mentioned above can be further increased if the rubber roll is added with an additional roll to regulate the stability of the fall of the soybean seeds to be peeled. As a comparison, the results of a survey conducted by researchers at two *tempeh* production sites in Manado show that peeling was carried out using traditional trampling, producing an average of 30kg/hr. So, based on the results above, it can roughly be said that the Teta II model is still better and more capacity-efficient the work is different than traditional.

Yield

The average results of the work of the soybean epidermis peeler Machine at various soaking times can be seen in Table 2.

Table 2. Average yield of peeler at various soaking times (rpm 2450-2550)

Soaking time (hr)	Initial Soybean weight (gram)	Unpeeled soybean (gram)	Peeled Soybean (gram)	Broken soybean weight (gram)	Yield (%)
2	1000	267,59	361,72	362,51	72,42
4	1000	95,48	383,96	511,85	89,58
6	1000	50,97	556,74	383,50	94,02
8	1000	30,80	487,80	471,66	95,95

From Table 2, the highest yield was achieved at a soaking time of 8 hours (95.95%), then 6 hours (94.02%), 4 hours (89.58%), and 2 hours (72.42%). However, when looking at the Weight of whole peeled soybeans, the soaking time of 6 hours showed the highest yield (556.74 grams). It is crucial to achieve high yields during the soybean peeling process. The distance between the conveyor and the soybean should be maintained at 6 mm to ensure that all soybeans are entirely removed from the peeling system. If the distance is incorrect, the soybeans might break and not be adequately peeled (Nguyen et al., 2018). Proper distancing is necessary to prevent physical damage to the soybeans. Excessive pressure or friction can damage the beans, reducing their quality and value. Maintaining the correct distance is essential in optimizing the soybean peeling process, leading to high-quality output, efficient processing, and lower operational costs.

Conclusion

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1. The working capacity of the TETA-II model soybean peeler at rpm 2450-2550 with a soybean soaking time of 6 hours produces an average working capacity of 43kg/hour

2. The highest immersion of the peeler at rpm 2450-2550 was achieved at a soybean soaking time of 8 hours (95,955) and 6 hours (94.02%)

3. Overall, this machine is suitable for peeling soybean epidermis.

Suggestion

In order to optimize and increase the effectiveness of the Machine, It still needs to be equipped with a rubber roll system to regulate the stability of the fall of the soybeans that will be peeled. A container for the peeled material and the inner walls need to be coated with plastic.

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