Performance test of machine groundnuts husk peeling using a rotary multi-disc system - a case study

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ABSTRACT: One of the processes determining the quality of the ready-consumed groundnut is the process of peeling the groundnut husk. Today, the process of groundnut husk peeling is still done manually. This research aims to: 1) design the groundnut husk peeling machine with rotary multi-disc system; and 2) identify and test the machine's performance. This research was conducted by means of: 1) an exploration study of small-scale industries/groundnut material-based food production business units; 2) data analysis of the results of the exploratory study; 3) designing and construction of the machine; 4) testing the machine's performance; and 5) the prototype of improvement of groundnut husk peeling using the *rotary multi disc* that has been tested. It led to production of a prototype of groundnut husk peeling machine with an optimal performance that can increase the capacity and good quality of the result of peeling on the shaft rotation of the machine, n = 420 rpm, water volume of 10 litres and motor power, P = ¼ HP (185 W) on the capacity of 25 kg/hour with the quality of the entire peeled and unseparated products more than 97%.

INTRODUCTION

Groundnut is the sixth most important oilseed crop in the world. It contains 48-50% oil and 26-28% protein, and is a rich source of dietary fibbers, minerals and vitamins. Groundnut is grown on 26.4 million ha worldwide with a total production of 37.1 million metric tons and an average productivity of 1.4 metric ton/ha (FAO, 2003). Over 100 countries worldwide grow groundnut [1].

Indonesia has many types of agricultural products that are not dependent upon the season, such as the groundnut that abundantly available in nature. Groundnut is also a foodstuff widely consumed by people. This plant is processed to produce a variety of food such as candy, condiments, jams or snacks. This then has caused the increase of demand for groundnut.

Groundnut in Latin called *Arachis hypogaea* is one of crops that has been known as long as the production plant. Groundnut contains a vegetable protein source that is essential to the diet. Primarily, this foodstuff is used for consumption and as industrial raw material in addition to being used as an additional animal food. In industry, the groundnut is used as a raw material for manufacturing cheese, butter, oil, butter, candy or snacks [2][3].

Industry commonly purchases the groundnut in the form of peanut pods and seeds to be processed later to make various products. The industry in this case asks the farmers of groundnut to be a supplier that is capable of guaranteeing a regular and continuous supply of standardised quality. To meet these requirements, there must be an alternative in terms of the methods from traditional or manual post-harvest processing to mechanical and modern ones for productivity improvement and quality assurance [4].

One of the processes determining the ready-consumed groundnut quality is the process of groundnut husk peeling that aims to remove the husk stuck on the groundnut seed. The process of groundnut husk peeling is still mostly done manually and this method is less effective for its low capacity and requiring more labour, making it less efficient and hindering productivity. The process of manufacturing the groundnut in post-harvest, especially in husk peeling to obtain a clean groundnut, is time-consuming. Recently, manual husk peeling only results in the capacity of 4.2 kg/hour/person, causing work fatigue and causing the grains to be split at approximately 35% [5].

Based on this reality, to facilitate and meet the needs of the home industries (small-scaled industries) in producing peeled groundnuts with the aim to increasing production capacity and meeting the needs of society, an appropriate technology is required in the process of rapidly managing the post-harvest. That technology should include a groundnut husk peeling machine compatible with the characteristics and properties of foodstuffs of groundnuts, so as to not spoil the food in terms of either its physical or functional sides.

Appropriate technology is used to indicate a good match between the technology and the resources required for optimisation [6], while it can be stated that the appropriate technology is one of technology forms [7]. The form can be used to improve the performance of small and medium-scale industries. Thus, appropriate technology is technology that matches with the needs of society, is efficient and usefully based upon ability, is not damaging the environment, does not conflict with people's customs, and is used to improve the product/value-added of small-medium scale businesses.

Appropriate technology of a groundnut husk peeling machine that is designed, manufactured and tested for its performance has a construction to generate a capacity up to 25 kg/hour using an electric drive motor with efficient electrical power at only ¼ HP (185 W) with a rotary system of multi discs able to reduce any damage to groundnut husk peeling to below 5% (more than 95% of the intact peeling). Hence, the appropriate technology of the groundnut husk peeling machine could be applied according to the needs of society, be dynamic, efficient, not damaging the environment and able to add value for the people using it [8].

This study aims to: 1) design a groundnut husk peeling machine using a multi-disc rotary system that can be the solution for any groundnut husk peeling machine with a capacity of 25 kg/hour; and 2) to identify and test the performance of this groundnut husk peeling machine using the multi-disc rotary system.

RESEARCH METHOD

Research Procedure

The aim is to make a groundnut husk peeling machine with rotary multi discs that is compatible with the needs of small-medium scale industries focused on the food products made from raw groundnut [9]. The steps of the research procedure are as follows:

1) Exploratory study of small-scale industries/groundnut material-based food product businesses related to groundnut husk peeling;
2) Data analysis of the results of the exploratory study, and the comparison of those the results with the results of a literature search, so as to design a groundnut husk peeling machine that is suitable for the conditions of small-medium scale industries/groundnut material-based food product businesses, measuring the capacity needed to peel groundnut husks;
3) Design and construct a groundnut husk peeling machine according to the design;
4) Test the performance of the groundnut husk peeling machine by combining the variables consisting of:

    a) capacity of peeling results (kg/hour);
    b) motor power required (W);
    c) optimal shaft rotation (rpm);
    d) water volume required for peeling (litres) to obtain good quality peeling results (not damaging the groundnuts);

5) Prototype improvement, so as to produce an engineered form of a groundnut husk peeling machine using the tested system of rotary multi discs (see in Figure 1).

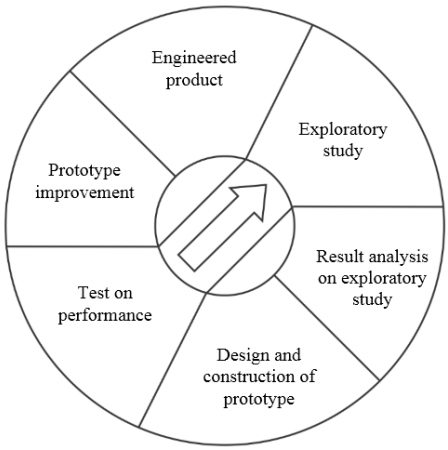


Figure 1: Research development procedure.

Data Analysis and Research Instrument

To obtain the optimal performance from the groundnut husk peeling machine, a test was conducted towards the condition of the independent variables including power, shaft rotation of the peeler, water volume during the process and the time required for the peeling process, and dependent variables including the capacity of the peeling results,

and control variables including six discs and the distance between the discs and the duration of the groundnut soaking in boiling water within 15 minutes prior to peeling. Meanwhile, the measuring instruments used included: a stop-watch, callipers, a tachometer (rotation measuring tools, rpm), water volume (litres) and scales (grams). To determine the differences in the capacity of the peeling results from the variety of treatments, ANOVA was used to observe the most optimum and best performance of the groundnut husk peeling machine in a variety of combinations of variables tested.

$$KMP = f(P, n, V, t, m) \quad (kg/hour) \tag{1}$$

where:

KMP: Performance of groundnut husk peeling machine (kg/hour) and the quality of the peeling product;
P: Power required HP or W;
n: Shaft rotation of peeling (rpm);
V: Total volume of water for processing (litres);
t: Time required in the peeling process (seconds);
m: Mass of peeled groundnuts per batch tested at weight of 4 kg.

KMP (the performance of the groundnut husk peeling machine) is the dependent variable, while its independent variables include:

1. The motor power P of variables tested at value of (P = ¼ HP) based on the calculation of required power minimum ¼ HP (185 W); thus, the 185 W power is not varied and only one type of electric motor is installed in accordance with the purpose of the adequacy of groundnut husk peeling machine that is ¼ HP (185 W) as shown in Figure 2.
2. The n variable (cylinder rotation of peeler), an electric motor rotation used was 1,400 rpm. For the purposes of research on the groundnut husk peeling machine, it was conducted by changing the size of the pulley wheel diameter of rotation transmission to obtain suitable rotation comparisons. The test was performed at a distance of 32 cm between the axis of the pulley wheel on the electric motor and the axis of the pulley wheel on the disc of the peeler with the ratio of rotation as follows (Figure 3):

    a. Rotation n1 = 350 rpm (reduction ratio of wheel d1a = 5 cm and d2 = 20 cm);
    b. Rotation n2 = 420 rpm (reduction ratio of wheel d1b = 6 cm and d2 = 20 cm);
    c. Rotation n3 = 525 rpm (reduction ratio of wheel d1c = 7.5 cm and d2 = 20 cm).

3) The total water volume for the processing was tested on a volume of V1 = 10 litres and V2 = 12 litres and the height of water used must exceed the height of the surface of the nuts to be peeled, so as not to damage the surface of the groundnuts.

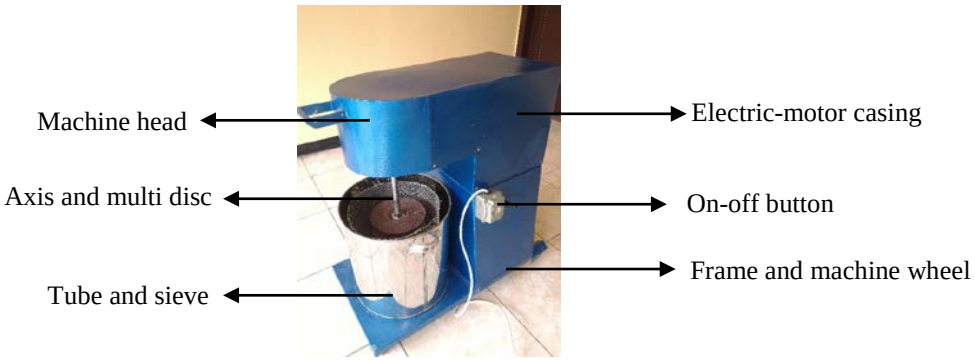
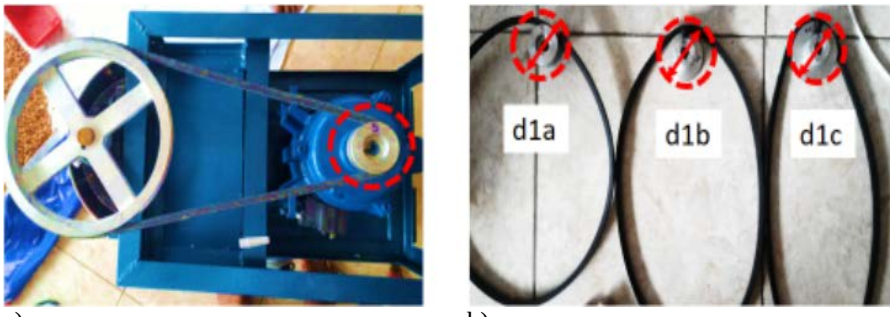


Figure 2: Performance of groundnut husk peeling machine by specification: dimension (80 cm x 45 cm x 90 cm), power capacity ¼ HP (185 W)), material (iron, stainless plate), capacity (4 kg/batch in10 minutes or ±25 kg/hour).



… a) b)

Figure 3: a) transmission system to reducing a rotation of the groundnut husk peeling machine; b) a type of pulley wheel sizes (in diameter: n1, d1a = 5 cm; n2, d1b = 6 cm; n1, d1c = 7.5 cm).

Table 1. Performance of the combination of treatment variables towards the average of peeling time and the quality of the peeling product.

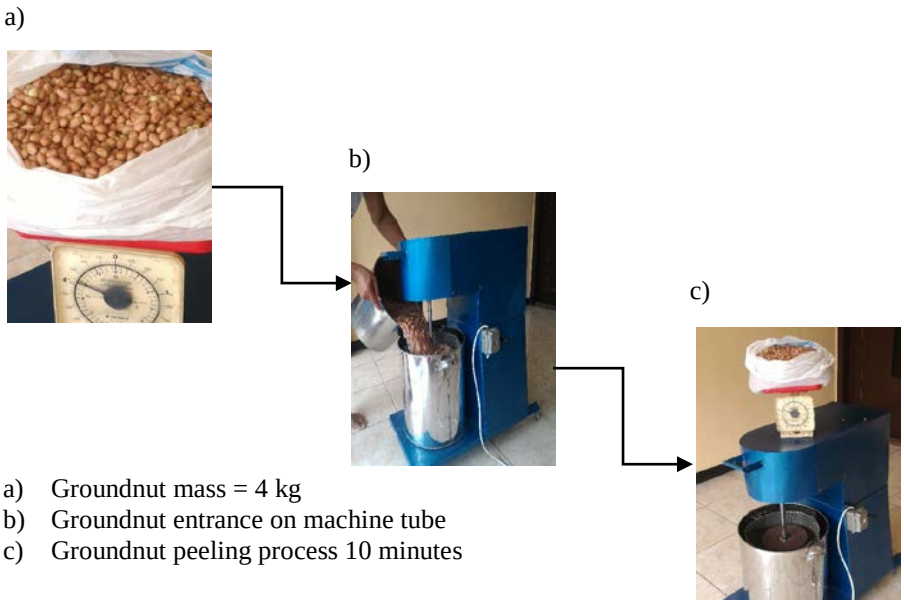
Shaft rotation	n1 = 350 rpm		n2 = 420 rpm		n3 = 525 rpm	
Water volume (lt)	V1 = 10	V2 = 12	V1 = 10	V2 = 12	V1 = 10	V2 = 12
Number of data	Time (t, seconds) required for the peeling process and the quality of the peeling product at the mass of 4 kg groundnut					
1	702	738	576	642	390	444
2	684	744	570	648	402	438
3	672	732	564	642	396	456
4	690	750	582	636	408	432
5	672	726	588	672	384	450
Average time (s)	684	738	576	648	396	444
Quality (%)	Cloven < 3% Intact > 97	Cloven < 3% Intact > 97%	Cloven < 3% Intact > 97%	Cloven < 3% Intact > 97%	Cloven > 5% Intact < 95%	Cloven < 5% Intact > 95%

Further, the test on the machine's performance was conducted with a combination treatment of the following variables: P, V1 and V2, n1 to n3 (see in Table 1).

RESULTS AND DISCUSSION

The design and manufacture of the prototype construction of the groundnut husk peeling machine using a *rotary multi-disc system* was done using a wet process produced as illustrated in Figure 4. The work principle is as follows: The peeling process with this machine was done by soaking groundnut seeds that have been dried into hot water for 10 to 15 minutes until the husks become soft (easy to peel) and, then, inserted into the cylinder (stainless steel sieve) in which the filter cylinder had been installed. The peeler cylinder/tube was filled with water as the peeling medium (with the volume of water as high as 7 to 10 cm above the groundnut surface).

Furthermore, the motor of the peeling machine was turned on, so as to make the axis and a series of peeling discs rotate in the peeling chamber. As the groundnut seeds were entered through six paring discs with a quite rough surface and arranged in certain way, then the groundnut seeds would be bruised and the husk would be peeled. Furthermore, the groundnut husk later mixed in the cylinder tube would go in the process of separating the seeds from the husk.



a) Groundnut mass = 4 kg
b) Groundnut entrance on machine tube
c) Groundnut peeling process 10 minutes

Figure 4: Illustration of the peeling process.

The test results on the performance of groundnut husk peeling machine:

1. The driving motor power, P = 1/4 HP (185 W), not varied.
2. Variable n (peeling cylinder rotation), the electric motor rotation used was 1,400 rpm for the research purpose on the groundnut husk peeling machine conducted by changing the pulley wheel size (in diameter) of transmission to obtain the compatible comparison on rotation. The test was conducted at a distance of 32 cm between the axis of the pulley wheels on the electrical motor and the axis of the pulley wheel on the peeling disc with a ratio of rotation as follows:

a. Rotation of n1 = 350 rpm (the ratio of wheel reduction of d1a = 5 cm and d2 = 20 cm);
b. Rotation of n2 = 420 rpm (the ratio of wheel reduction of d1b = 6 cm and d2 = 20 cm);
c. Rotation of n3 = 525 rpm (the ratio of wheel reduction of d1c = 7.5 cm and d2 = 20 cm).

3. The total volume of water for the processing to be tested was V1 = 10 litres and V2 = 12 litres. The depth of water used must exceed the height of the surface of the groundnuts that would be peeled, so as not to damage the surface of the groundnuts.
4. The time (t) required in the peeling process (at second) and (minute + second)
5. The mass of groundnuts m peeled was entered per batch and weighed 4 kg.
6. The performance of the groundnut husk peeling machine (kg/hour) was expressed in the time required for the peeling process on the dry weight of 4 kg of groundnut per batch that later can be expressed in kg/hour, while the quality of the peeling products was stated as the percentage of seed intactness that had been peeled as shown in the last column of Table 1.

From the result of the performance test, it was found that the optimal result of the peeling in the form of the intactness of the peeling products of groundnut husks at more than 97% (> 97%), came from the combination of the following variables:

1. P, n1, V1: average of time required for the peeling of 4 kg of groundnut included 11.4 minutes or the capacity of the peeling results (KMP) = 4 x (60/11.4) = 21.05 kg/hour (good product quality, intact > 97%).
2. P, n1, V2, average of time required was 12.3 minutes or the capacity of the peeling product (KMP) = 4 x (60/12.3) = 19.51 kg/hour (good quality result, intact > 97%).
3. P, n2, V1, average of time required was 9.6 minutes or capacity of the peeling products (KMP) = 4x (60/9.6) = 25.00 kg/hour (good product quality, intact > 97%).
4. P, n2, V2, average of time required was 10.8 minutes or the capacity of the peeling product (KMP) = 4x (60/10.8) = 22.23 kg/hour (good product quality, intact > 97%).
5. P, n3, V1, average of time required was shorter (6.6 minutes) or the capacity of the peeling product (KMP) = 4 x (60/6.6) = 36.36 kg/hour but, the quality of the product still showed scratches on the surface and some groundnuts were cloven (> 5% or those intact < 95%).
6. P, n3, V2, average of time required was shorter (7.4 minutes) or the capacity of the peeling products (KMP) was more = 4 x (60/7.4) = 32.43 kg/hour (the good product quality though some were cloven around 5% or those intact were >95%).

In the combination treatment of the variables, tests were performed with five repetitions on each variable (Table 1). Hereafter, the average of processing time (minutes) for each variable combination was calculated to present a classification quality of peeling process and showed that the most optimal result (the best performance) was found in the condition of the following variable combinations: motor power, P = ¼ HP (185 W), rotation (n2) = 420 rpm, and water volume used (V1) = 10 litres with the good product quality and the level of intactness of > 97% on the capacity of 25 kg/hour.

The accuracy of the shaft rotation, adequacy of the total water volume and the treatment of the material before being placed into the peeling machine was the key factor for the level of quality and intactness of the groundnut seed from the peeling products. The test on the performance in this research was conducted at the shaft rotation of 350 rpm, 420 rpm, and 525 rpm with water volumes during the peeling process of 10 litres and 12 litres. The more the volume of water, the longer the time required for the peeling, but if there was too little water, it could have an impact on the groundnut surface, even damaging it. In terms of the used rotation ratio, the faster the shaft rotation, the faster the time for the peeling.

In terms of the used rotation ratio, and in an attempt to result in maximal peeling without any damage, the shaft rotation should be 420 rpm, which could result in the capacity up to 25 kg/hour with the level of intactness of the peeling product at > 97% intact and not split. For the rotation of 350 rpm, the result was quite good that is > 97% intact and not split, but requiring longer time with the result of only 19.5 kg/hour to 21 kg/hour. On the other hand, at the rotation of 525 rpm using the 12 litres of water, the result of the peeling experienced a scratch on the surface and slitting at > 5%, but at the rotation of 525 rpm with 12 litres of water volume, the maximum result of 32.43 kg/hour with the good product quality was obtained though some were split at around 5% or the intactness at > 95%.

Thus, the combination of variable treatments to achieve the most optimal result on the performance test that is to increase the capacity and the quality of the peeling result, established that the shaft rotation of machine at (n) = 420 rpm, water volume of 10 litres and the motor power, P = ¼ HP (185 W) comprised the optimal solution. On this treatment combination, it resulted in the capacity of 25 kg/hour with the quality of the intactness of peeled and not split at more than 97%.

In general, the mechanism of the groundnut husk peeling machine can be used for small-scale food industry, particularly for the groundnut-based food material or by groups of farmers in managing groundnut husk peeling in post-harvest periods. The construction of the machine from this research used a multi-disc system with a wet process

(using water in the peeling process). This aims to obtain efficiency in groundnut husk peeling that is fast and guarantee quality for intactness and hygiene.

The results of this research can address any problems in the process of groundnut husk peeling in accordance with the aim of this machine, including the appropriate technology machine in removing the husks of the groundnut at more than 97% efficiency and being simple in its operationalisation. When compared with the research results obtained by Sutejo and Adithya on the performance test of the groundnut husk peeling that resulted in the value of the peeling around 35 kg/hour with the percentage of split husks at 35%, and when compared with the manual method that only produces 4.2 kg/hour/person, the groundnut husk peeling machine using a multi-disc system could save energy and time (increasing the work efficiency) and enhance productivity as it can result in peeling with the capacity up to 25 kg/hour with the level of intactness at more than 97%, and could even reach 32 kg/hour at the level of intactness of the result of the groundnut peeling of more than 95% [8].

CONCLUSIONS

The most optimal construction of a groundnut husk peeling machine with a rotary disc system using a wet process with a capacity of 25 kg/hour has been produced. It can enhance the capacity and the quality of the peeling results reached at the shaft rotation of machine n = 420 rpm, water volume at 10 litres and motor power, P = ¼ HP (185 W) on the capacity of 25 kg/hour with the quality of the result of the intactness for those peeled and not split groundnuts of more than 97% [10].

REFERENCES

1. Shubham, D., Design and fabrication of groundnut pod separating machine. *J. of Recent Research in Civil and Mechanical Engng*. 2, **2**, 147-150 (2015).
2. Kemala, M., Peanut Oil, 13 December 2016, http://www.lipi.go.id
3. Woodroof, J.G., *Peanut*. New York: The AVI Publishing Company (1983).
4. Rahayuningtyas, A. and Afifah, N., Performance test machine thresher peas on playback speed variation. *Seminar Science and Technology*, Lampung University, Indonesia (2008).
5. Agus, Design of crank type epidermis peeler for peanuts (Arachis hypogea). *J. TEP Bogor Institute of Agriculture*, 26, **2,** 107-115 (2012).
6. Khalil, T.M., *Management of Technology (The Key to Competitiveness and Wealth Creation)*. Singapore: McGraw-Hill Companies Inc, (2002).
7. Angkasa, Assessment mechanism of agricultural technology diffusion right order. BPPT, *Seminar Proc. on Technol. for Country*, Indonesia, 140-155 (2003).
8. Sutejo, A. and Adithya R.P., Design of crank type epidermis peeler for peanuts (Arachis hypogaea). *J. of Agricultural Engng.*, 26, **2**, 107-114 (2012).
9. Shigley, J.E. and Mischke, C.R., *Mechanical Engineering Design*. (6th Edn), New York: McGraw-Hill Companies Inc,, 18 (2001).
10. Mizar, M.A., *Mesin Pengupas Kulit Ari Kacang*, Patent Registration Number: S10201607914, State University of Malang (2016).