Design and Development of Young Areca Nut Slicing Machine

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Abstract. The selling price of thinly sliced young areca nut is higher than that round areca and splited areca nut, but the manual slicing process takes a long time, about 8 minutes/kg, and this process has a high risk. The young areca nut slicing machine was developed to solve the problem of manual slicing. The purpose of the research is to conduct machine design, machine testing (verification test, machine performance test, service test), and economic analysis. The young areca nut slicing machine was made and tested at the Metal Workshop and Agricultural Machine Tool Laboratory of the Payakumbuh State Agricultural Polytechnic from June to September 2021. The machine was made according to structural and functional designs. Verification tests were carried out with the aim of technically matching the data with the results of machine measurements. Parameter measurements were carried out to explain the performance of the young areca slicing machine. The parameters measured were: slicing capacity, slicing quality (average thickness and percentage of damage), specific power requirements, and power transmission efficiency. Economic analysis was carried out to explain fixed costs, variable costs, basic costs, and the break-even point. The results of the verification of the areca nut slicing machine are that with vertical type, specifications 65 x 45 x 75) cm, the driving motor is a 1 HP electric motor with a rotation speed of 1480 RPM that is transmitted through a v-belt connected to a pulley speed reducer and transmitted via a v-belt to slicer shaft. The results of the slicing capacity performance test are 50 kg/hour, slicing quality (4.2 mm thickness, and 8 percent broken percentage), the specific power requirement is 0.015 kw-hour/kg and the power transmission efficiency of 8.6%. The results of the economic analysis of the areca nut slicing machine are: fixed costs of IDR of 1,425,000/year, variable costs of IDR 11,397/hour, basic cost of IDR 239,8/kg, and the break-even point of IDR 1.845,7 kg/year. The developed areca nut slicing machine can increase the capacity, quality, and effectiveness of slicing young areca nut.

Keywords: *design and development; slicer machine; young areca nut*

1. Introduction

Areca nut (Areca catechu L.) is able to give a promising income, and become an export commodity [7] . According to [8], areca nut plants in several regions in Indonesia are planted as hedges. Areca nut is usually used as a textile dye [10] . Areca nut has long been traded by medicinal plant traders in the market as a traditional medicine, while areca nut that is used as an export commodity is areca nut in the form of seeds that do not have coir [11].

The main components of areca nut are carbohydrates, fats, fiber, polyphenols, alkaloids, and minerals. The main alkaloids in areca nut are arecoline, arecaidine, guvacoline and guvacine [12]. Areca nut contains 0.3 - 0.6% alkaloid, 15% red tannin, and 14% fat, starch, and resin [6].

The area of areca nut plantations in the Lima Puluh Kota Regency reaches 1,254 ha [2]. Areca nuts are traded after being dried either as whole, halved, or thinly sliced nuts. According to [4] , the selling price of thinly sliced areca nut is higher than that of whole and halved areca nut. This is because thinly sliced areca nut has a low water content of 0.9%, thereby increasing farmers' sales by 45% compared to sales of whole and halved areca nuts. However, the process of slicing areca nut takes a long time, 8 minutes/kg, and the work risk is high because it is still done manually. Based on this, it is necessary to develop a young areca nut slicer that can speed up the slicing process, reduce the risk of work accidents, and increase the slicing capacity of areca nut.

The areca nut slicing machine has been developed [1], of which the principle works horizontally with a capacity of 25.92 kg/hour. The areca nut crusher G4191 has been designed [5] with variations in engine speed and the distance between the blade and the blade on the quality of the areca nut crushing results. Slicing tools for young areca nut have also been developed using the Quality Function Deployment (QFD) Method [4].The areca nut crusher machine has been made in the shape of a trapezoidal funnel, the splitting system uses two splitters (vertical rotating blades) [3], then an areca nut crusher machine has also been designed using an electric motor as a source of power [9].

The main disadvantage of some of these machines is that they are only used to split old areca nut into 2 to 4 slices, while the most expensive areca nut is the young betel nut that is thinly sliced with a thickness of 3 to 5 mm. Young areca slicing machine made by CV. Appropriate Technology can already be used for slicing young areca nut. The weakness is that the slices of areca nut are in the same direction as the areca nut fiber, while the slices of young areca nut traded in the Lima Puluh Kota Regency are slices that cut the betel nut fiber. Based on the above explanation, it is necessary to develop slicing machine for young areca nut. The developed slicing machine for areca nut is used to slice young areca nut by cutting the fiber to an even size without causing damage to the raw material because the priorities are safety, simplicity, and compact form so that the manufacturing and operating process does not require too much cost and the price of the machine can be reduced so that it is affordable for small farmers.

The purpose of the research is to conduct machine design, machine testing (verification test, machine performance test, service test), and economic analysis. The benefit of this research is that this machine is expected to help farmers in slicing young areca nut as a means to save time and energy and reduce the risk of work accidents.

2. Methodology

The slicing machine for young areca nut was made and tested at the Metal Workshop and Agricultural Machine Tool Laboratory of the Payakumbuh State Agricultural Polytechnic from June to September 2021.

The research was conducted by conducting tool design and tool performance testing. The tool was made according to the structural and functional design with the research flow scheme as presented in Figure 1.

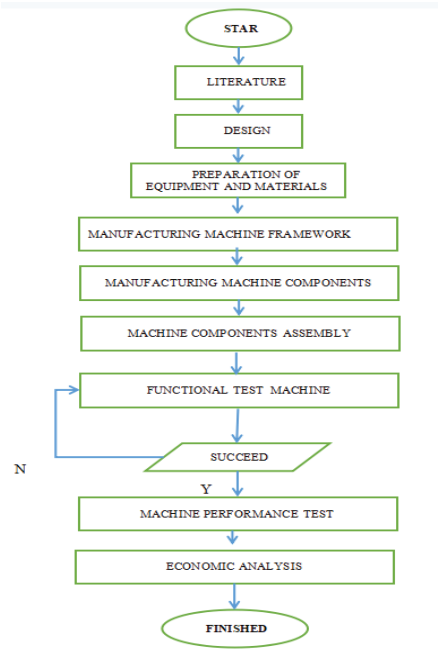

Figure 1. Research Flow Chart

Young Areca Nut Slicing Machine Design

Using a 1 HP electric motor as a power source, the specifications of slicing machine for young areca nut was developed with dimensions: 60 cm in length, 41 cm in width, and 74 cm in height. The rotation speed of the electric motor is 1480 RPM that is transmitted through a v-belt, which is connected to a pulley speed reducer that will reduce the speed of the electric motor, then from the pulley speed reducer, transmitted through the v-belt to the slicing shaft. The frame of the young areca slicing machine is made of angled iron measuring 4 cm × 4 cm × 3 mm, the pulleys on the electric motor and speed reducer are 3 inches and 2 inches, respectively, while the speed reducer and slicing shaft are 4 inch and 5 inch. The machine design can be seen in Figure 2.

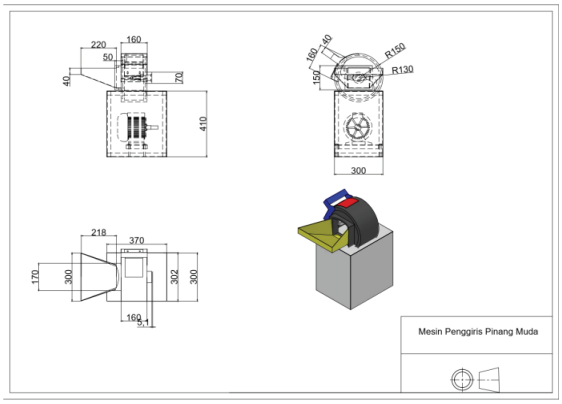

Figure 2. Young Areca Nut Slicer Machine Design

Functional Design

Functional design is an explanation of each function on the machine. Support, namely the frame, must be able to support all components and materials to be sliced. Slicer plays an important role to obtain material that has a small size and quality. Rotation distributor to channel rotation from the rotation source to the slicer shaft uses a speed reducer and a v-belt. The drive (electric motor) is a source of rotation that keeps all components running properly. Friction remover (bearing UCP 205) serves to eliminate friction in engine components. The outlet is the outlet for the sliced material.

Structural Design

Structural design is the structure needed to carry out the functions in the functional design: 1). The frame that is made of angled iron measuring 6 m × 4 cm × 4 cm × 3 mm, with a height of 74 cm, a width of 41 cm, and a length of 60 cm; 2). Slicing knife using stainless steel with a diameter of 30 cm and a thickness of 6 mm; 3). Electric motor power 1Hp 1480 RPM; 4). Speed Reducer of 1 : 20.

Test Method

a. Verification test, which was carried out with the aim of technically matching the data with the results of machine measurements (type, model, serial number, manufacturer, and dimensions; drive motor unit (type, model, serial number, power/revolution, and dimensions)).
b. Machine Performance Test. The parameters measured are: measurement of slicing capacity, calculation of slicing quality (average thickness, variety of cut thickness, percentage of damage), specific power requirements, and power transmission efficiency
c. Service Test. Test parameters: ease of operating the machine, machine noise, and safety for the operator

Economic Analysis of Young Areca Slicing Machine

Economic analysis is one of the analyses used in fundamental techniques. The cost analysis consists of fixed costs, variable costs, Break Event Point (BEP), and basic costs

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3.Results and Discussion

3.1. Design and Development of Young Areca Nut Slicer Machine

The process of making the components of the young areca nut slicing machine started from cutting the material, making the frame, making the blade cover, making the blade, and making the blade disc. After all the components have been made, the next step was the assembly process. The results of the assembly can be seen in Figure 3.

Figure 3. Young Areca Slicing Machine

3.2. Machine Testing

a. Young Areca Slicing Machine Verification Test

The test results of the verification of the young areca nut slicing machine can be seen in Table 1.

Table 1. Verification Test Results of Young Areca Slicing Machine

Parameter	Description
Type	Horizontal
Dimension (P x L x T)	65 cm x 45 cm x 75 cm
Power	Electric Motor 1 Hp
Electric Motor Rotation Speed	1480 RPM
Transmission system	V-Belt and Pulley

The rotation speed of the electric motor, which is 1480 RPM, is transmitted through a v-belt that is connected to a pulley speed reducer that reduces the speed of the electric motor, then from the pulley speed reducer, it is transmitted through the v-belt to the slicing shaft. The pulleys on the electric motor and speed reducer are 3 inches and 2 inches, while the speed reducers and slicing shafts are 4 inches and 5 inches.

b. Performance Test of Young Areca Slicing Machine

1. Slicing capacity is calculated by the following formula:

$$Cp = \frac{Wp\ (Kg)}{t\ (hour)} = 50\ kg/hour$$

2.Quality of Slicing Results

- Average Slice Thickness

The average thickness of the Slice Results is calculated by the following formula:

$$\text{average thickness } \frac{\sum_{i=1}^{n} T}{n} = 4.2\ mm$$

- Broken Percentage

Percentage of broken nut is calculated by the formula:

$$\%br = \frac{Wbr}{Ws} \times 100\% = 8\%$$

3.Specific Power Requirement

Specific power requirements can be calculated by the formula:

$$Psp = \frac{Pm}{W1h} = 0.015\ kw\text{-}hour/kg$$

4.Efficiency of Machine Working Mechanism

Power forwarding efficiency can be calculated by the following formula:

$$ns = \frac{n2 \times d2}{n1 \times d1} \times 100\% = 8.6\%$$

C.Economic Analysis

Analysis of the operational costs of the young areca nut slicing machine can be assumed as follows:

Selling price of equipment (P) = IDR 7,500,000
Number of hours worked per year (X) = 2400 hours/year
Number of working hours per day = 8 hours
Approximate engine life (N) = 8 years
Interest rate per year (I) = 12%
Areca slicing wages per kg = IDR 1,000
Capacity of young areca slicing machine © = 50 kg/hour
Number of operators = 1 person
Number of working days per year = 300 days

1. Fixed Cost (BT)

The fixed cost components for the young areca nut slicing machine consist of depreciation costs, capital interest, and warehouse costs.

fixed cost (BT) = Depreciation cost + capital interest + warehouse cost
= IDR 843,750/Year + IDR 506,250/Year + IDR 75,000/year
= IDR 1,425,000/Year

2. Variable Costs

Variable costs are affected by the hours of use of the tool. Variable costs for young areca nut slicing machines consist of operator wages, maintenance costs, and electricity costs.

variable costs (BTT) = Operator wages + maintenance costs + electricity costs
= IDR 10,000/hour + IDR 810/hour + IDR 586,912/hour
= IDR 11,396.9/hour

3.Basic cost (BP)

$$\text{Basic cost} = \frac{BT/X \times BTT}{C}$$

$$= \text{IDR } \frac{1{,}425{,}000/\text{year}}{\frac{2400 \text{ hours}}{50 \text{ kg/hour}}} + \text{IDR}11{,}396.9/\text{hour}$$

= IDR 239.8/kg

4. Break Event Points (BEP)

$$\text{Break Event Point (BEP)} = \frac{BT}{R - \left(\frac{BTT}{C}\right)}$$

= 1,845.7 kg/year

The relationship between fixed costs, variable costs, and break event points can be seen in Figure 3.

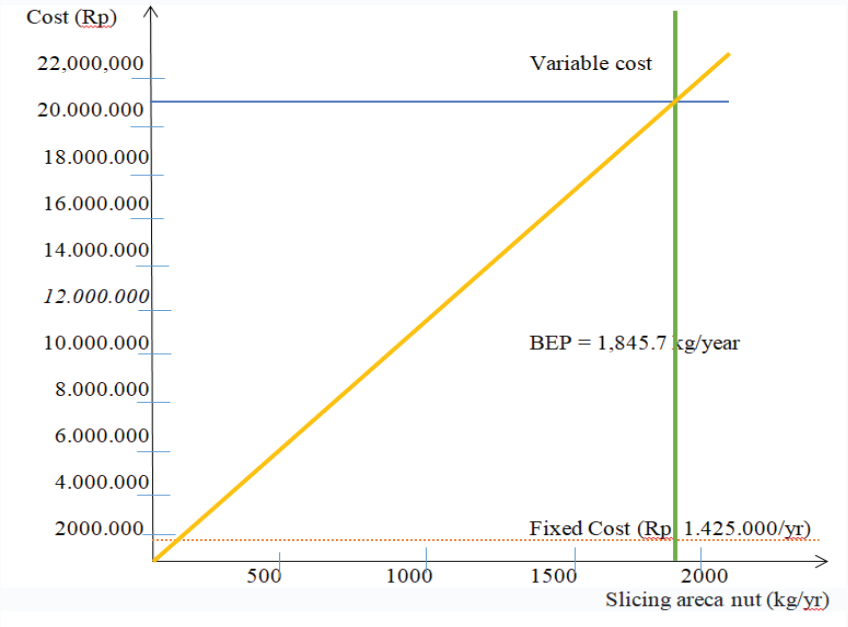

Figure 4. The Relationship between Fixed Costs, Variable Costs, and Break Event Points

The total cost of making a young areca nut slicing machine is IDR 6,320,000, the selling price is IDR 7,500,000, fixed cost is IDR 1.425.000/year, variable cost is IDR 11,396.9/Kg, basic cost is IDR 239.8/Kg, and break event point is 1,845.7 kg/Year.

4.Conclusion

The machine is manufactured according to the structural and functional design. The results of the verification of the areca nut slicing machine are: vertical type, with specifications of 65 x 45 x 75 cm and driving motor of a 1 HP electric motor with a rotation speed of 1480 RPM, which is transmitted through a v-belt connected to a pulley speed reducer and transmitted via a v-belt to slicer shaft. The results of the slicing capacity performance test are 50 kg/hour and slicing quality with 4.2 mm in thickness and 8 percent broken percentage, the specific power requirement is 0.015 kw-hour/kg, and the power transmission efficiency is 8.6%. The results of the economic analysis of the areca nut slicing machine are: fixed costs of IDR 1,965,000/year, variable costs of IDR 11,397/hour, basic cost of IDR 244.3/kg, and the break-even point of 7,222kg/year. The developed areca nut slicing machine can increase the capacity, quality, and effectiveness of slicing young areca nut.

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