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Mechanism and Test on The Performance of Sesame Peeling Machine Using Wet System

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Abstract

Sesame is one of commodities highly potential to support a variety of industries and promising for export. To respond this, it is deemed essential to analyse and construct any forms of sesame processing technology. An appropriate technology that is highly needed by farmers or community of small-scale industry for the management of post-sesame harvest is sesame peeling machine. The objectives of this research are to (1) develop a model of mechanism for sesame peeling machine using wet system that can accomplish the post-harvest of sesame peeling at capacity above 120 kg/hour, and (2) to observe the performance of sesame peeling machine using wet system. The research method was conducted through the ways of (1) exploratory study on the small-scale industry/sesame-based farming in relation to the sesame peeling system, (2) data analysis on the result of exploratory study, (3) design and construction of the sesame peeling machine, (4) test on the performance of sesame peeling machine to observe the product capacity of sesame peeling (kg/hour) in terms of more intact quality by combining some variables consisting of (a) electrical power required (watt), (b) optimal axis rotation (rpm), (c) water flow rate required in peeling (litre/minute) to make the production from the peeling undamaged and (d) clearance (mm). From the test result on the performance, it was observed that the most optimal combination of variable treatment that is able to enhance the capacity and the quality of the peeling results was obtained in the water flow rate (Q) at 2.5 litres/minute, the clearance regulation (C) at 2.5 mm, the axis rotation of sesame machine (n) at 560 rpm, and electrical power (P) at 1 PK (740 watts). From such treatment combination, the capacity 140 kg/hour with 95% of intact peeled production (the level of damage under 10%) was obtained.

Keywords: sesame peeling machine, test of machine performance, sesame

Introduction

International market for sesame commodity starts to have been a concern from a variety of countries including Indonesia. As revealed by projection of FAO (Food and Agriculture Organization), the number of world consumption on sesame has been annually increasing approximately at 500 tons. Meanwhile, the import of sesame increased around 6% to 8% every year until 2012. In consideration to the condition of consumption and import, it can be assumed that the prospect of sesame market in the world is relatively good (Anindita,2007).

Annually, the development of the sesame in Indonesia increases. In 2006, the area of this plant reached at 4.788 hectares, spread in any regions. It is expected that the potency of the sesame commodity can be more developed in consideration to its benefit and access opportunity for both local and international market (http://heropurba.blogspot.com/2012/11/ pengolahan-wijen-dalam pengembangan. html, accessed in 10 October 2014). Sesame is one the most potential commodities to support the development of any industries and promising export. In response to this, it is deemed necessary to analyse and construct any forms of technology in sesame processing. One of the appropriate technologies highly needed by farmers or small-scale industry for the management of post-harvest of sesame is the technology of sesame peeling machine.

Those issues above shows a need for the development of appropriate technology to solve any issues in the management of post-harvest of sesame seeds in accordance with the urgent issue and highly needed by a community in an area to develop the business/production particularly in an industry of processing the post-harvest of sesame, thus the mechanism of the sesame peeling is deemed very essential to be soon designed, constructed and learned.

The development of the sesame peeling machine that has ever been done by Mizar (2003) has resulted in a prototype in small-scale capacity (maximum at 60 kg/hour). However it was found that the result of the peeling process has made more sesame seeds damaged in view of the small size of the wheel of peeler and the complexity of the *clearance* of the peeler wheel. The prototype still made any damage on the result of peeling reaching at more than 25%. Hence, there is a need to develop the construction of the sesame peeling machine to enhance the capacity at twice reaching 120kg/hour or more with a bigger wheel of peeler, simple in clearance and able to minimize the damage on the result of the peeling of sesame seeds reaching under 10% or above 90% of the peeling result remains intact.

As stated by Indriyono (1998), the appropriate technology is the technology that is mostly related to the small-scale industry, farming, and rural development in which its classification or sophisticated level in the middle position – meaning that the position of its technological specification is positioned at the modest and advanced level. Meanwhile, according to Sewoyo (as in Alkadri, *et al*., 2000) appropriate technology is a technique and devices developed and applied in accordance with the needs of society, dynamic, adaptable with capacity, environmentally-friendly and usable by society in enhancing the added values for those using it.

Furthermore, as stated by Schumacher in B2PTTG-LIPI (2005), any developing countries are able to realize a development by using technology that particularly is

made and managed by them using its local potencies. Such technology is termed as *"Appropriate Technology"*. This term is no longer limited to the simple technology but has experienced a development based on the context of efficiency and effectiveness of technology. Appropriate technology admittedly triggers the growth and is viewed as a technology suitable with condition, time, space and affordable and simple for the users. As explained by Khalil (2000), *Appropriate Technology is used to indicate a good match between the technology utilized and the resources required for its optimal use.* Angkasa (2003) stated that appropriate technology is one of the forms of technology that can be utilized to enhance the work performance of the small and medium-scale industry.

Thus, the appropriate technology refers to a technology that matches with the needs of society, efficient and effective, adaptable with capacity, environmentally friendly, appropriate with the public custom and suitable to be utilized to enhance the products/added value for small-medium scale business.

Sudarmo (2005) detailed the performance or the achievement of technology measured based on four factors: first, *technical feasibility* - technology must result in more values; have a variety of features or capabilities to fulfil any needs, is cost-effective in utilizing the resources including energy, have durability and any other technical factors. The second factor is that the technology must create an economic productivity or financial benefit. The third factor, meanwhile, refers to the technology acceptance for the society (user) and the last factor is that the technology must be compatible with environment in which this factor will determine the sustainability of the existence of technology among society as the used. The four factors become the parameters used to evaluate technology in common.

The appropriate technology of developed sesame peeling machine has a construction that can result in more capacities (reaching more than 120 kg/hour) with the larger wheel of peeler, simple in clearance and able to minimize the damage of sesame seeds until below 10% (more than 95% of the peeled products remains intact). Thus, the appropriate technology of sesame peeling machine can be applied in line with the needs of society, dynamic, environmentally friendly and applicable for the society in enhancing the added values for the society as the users.

Sesame (*Sesamumindicum L.*) is an oil plant that has so long been cultured in Indonesia, particularly in Java Island (Central Java and East Java), South Celebes, and NTB (Western Lesser Sundas). Sesame seeds contain 35%-60% of oil, 20% of protein, and 11% of carbohydrate. These seeds are commonly used for any industrial needs, ingredient of snack, cooking oil, particularly in pharmaceutical, plastic, margarine, soap and cosmetic industry.

The sesame seeds are in the range of 2 mm to 2.5 mm in diameter and 3 mm to 4 mm in length (Rukmana, 1998). One kilogram of the seeds contains around 300 to 500 thousands of sesame seeds or 1000 seeds are estimated to have 2.5 gr – 3.5 gr in weight. Due to the variety of its skin thickness, the size of the seeds is various. Here, the thinner the seeds, the better the quality. There is a tendency that a thinner skin of sesame has higher oil content from the kernel. The sucrose content of kernel of seeds is in the range of 55% to 85% (http://202.159.94.166/rittc/teknis/teknis 5&19.htm).

The further process for the sesame seeds is the one-day drying process under the sun to achieve the water level under 7% (Mardjono, R. and Suprijono, 2005).

In common, the peeling process of sesame seeds skin is given to use the sesame as the foodstuff and the needs for the further process. This peeling process is mostly done by the large-scale industries or even the peeled sesame is the imported commodity. Meanwhile, at the farming level, the technology of the sesame peeling is still done through a manual procedure that is by pounding. The mechanism of the sesame peeling is highly needed to cope with the issue in the processing in the post-sesame harvest particularly in the process of peeling the sesame skin. The peeling process is done by damping and peeling the dried sesame seeds using the machine and washed to remove the skin before being dried.

This research was aimed to: (1) develop the model of sesame peeling mechanism using wet system that can give solution in the post-harvest of sesame with the capacity more than 120 Kg/hour and (2) observe the performance of the mechanism of sesame peeling using wet system.

Method

Research Procedure

To result in the mechanism of sesame peeling machine using wet system with the capacity of 120 kg/hour or more in accordance with the needs of the small-medium scale industry or farming business in the post-harvest of sesame, the following procedure, as seen in Figure 1) is required. The first one is the exploratory study to the small-medium scale industry or farming business based on sesame in relation to the sesame peeling system. The second one is related to the data analysis on the result of exploratory study and compare it to the result of library research that in turn enables to create a design of the sesame peeling machine in accordance with the small-medium scale industry/farming business in the post-harvest of sesame, to measure the capacity required in the sesame seed peeling. The third procedure is to design and construct the sesame peeling machine based on the result of design and the fourth one is to conduct a test on the performance of sesame peeling machine by combining the variables that consist of (a) capacity of the result of sesame peeling (kg/hour), (b) motoric capacity required (watt), (c) optimal axis rotation (rpm), (d) product capacity of sesame peeling (kg/hour), (b) motoric capacity required (Watt), (c) optimum axis rotation (rpm), (d) water flow rate required in peeling (litre/minute) to prevent the damage in the result of peeling and (e) the clearance of peeling wheel (mm).

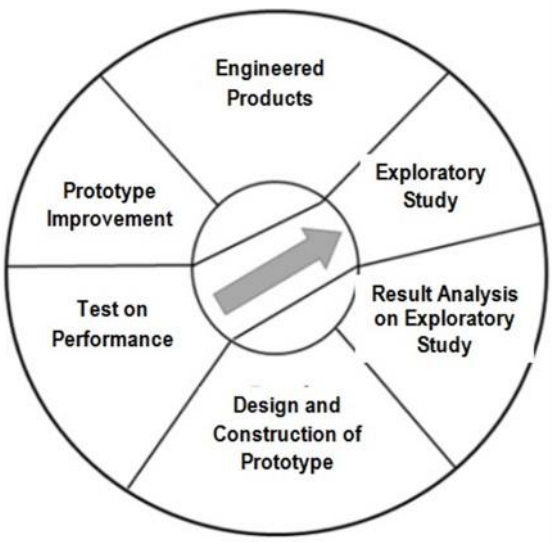


Figure 1: Procedure of Development Research

Data Analysis and Research Instrument

To obtain an optimum performance of the sesame peeling machine, the condition of the free variables: capacity, rotation, flow meter, and clearance of peeling wheel was tested to obtain the optimum result of peeling (the best) as its bound variables. The instruments used to measure included stop-watch, Vernier calliper, tachometer (rpm), *flow meter* (flow rate of water in litre/minute), and scales (gram). Further, ANOVA (analysis of variance) was used to observe the differences on the capacity of the peeled product based on the variety of treatments to figure out the most optimum performance of the sesame peeling machine in any combinations of the free variables tested.

KM = f (P, Q, n, c) (Kg/hour),
KM : Performance of sesame peeling machine (kg/hour)
P : Capacity required (PK)
Q : Flow rate of water for processing (liter/minute)
n : The rotation of the peeling wheel (rpm)
C : *Clearance* of the peeling wheel (mm)

Remarks:

KM (the performance of the sesame peeling machine) refers to the bound variable. Its free variables, meanwhile, include:

1. Variable (capacity) tested in value of (P = 1 PK) based on the calculation required capacity at minimum of 1 PK (740 watt); therefore, the 740-watt capacity was not varied and only one type of electrical motor was installed in accordance with the needs of capacity of the sesame peeling machine (1 PK = 740 watts)
2. Variable Q (Flow meter for processing) was tested at the value of 2 litres/minute, 2.5 litres/minute and 3 litres/minute.

3. Variable n (The rotation of the peeling wheel), the rotation of electrical motor was at 1400 rpm. The diameter of rotation transmission wheel was substituted to obtain the comparison of proper rotation in which the test was conducted at:
    - Rotation at 560 rpm (comparison to the wheel reduction at R1=10 cm and R2= 25 cm),
    - Rotation at 448 rpm (comparison to the wheel reduction at R1=8 cm and R2= 25 cm),
    - Rotation at 336 rpm (comparison to the wheel reduction at R1=6 cm and R2= 25 cm),
4. Variable c (*clearance*, the estrangement distance of the peeling wheel, mm) was tested at c= 2 mm, 2.5 mm, and 3 mm.

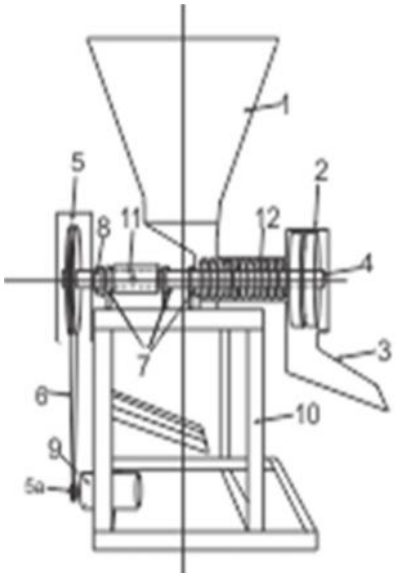
Furthermore, the test on the performance of the machine was conducted through the treatment of the following variable combinations: P, Q1 s/d Q3, n1 s/d n3, C1 s/d C3 (See Table 1).

Figure 2: The component of regulation and measurement of the estrangement distance of the peeling wheel, *flow meter* and stopwatch on the test of machine performance

Result And Discussion

The design and the construction of the prototype of the sesame peeling machine using wet system, as seen Figure 3 and Figure 4, were conducted through the following principles: it began by turning on the electrical motor. Subsequently, the sesame seeds that have been apart from the stem and firstly drenched to remove the pebbles were placed into a *hopper (in-take*) accompanied with small flow of water. Here, the

sesame would be pulled two by screw into the peeling room. Since the sesame entered in between two grooved wheels managed in certain estrangement through which the sesame entered and were fiddled, the skin of the sesame was then peeled. The sesame later blended with skin and water would exit through an outlet to go to the process of separating the seeds from the skin by means of water for several times prior to be dried.



Remark:

1. intake/Inlet (Hopper)	7. Main Shaft
2. Cylinder /peeling wheel	8. Bearing
3. Outlet	9. Electrical motor
4. Cylinder House	10.Machine Frame
5. Pulley (Wheel)	11. Estrangement control
6. V-Belt Regulator	12. Thread of Clearance

Specification:

Dimension	**: P x L x T = 800 x 500 x 130 mm**
Electrical Power	**: 1 PK (740 watt)**
Capacity	**: 140 Kg/hour**
Axis	**: Length X Diameter = 550 mm x 1 inch**
Peeling Wheel	**: Diameter 10 inches**
Belt	**: V-belt type A57 (450-mm shaft distance)**

Figure 3: The Design of Construction of Sesame Peeling Machine Using Wet System

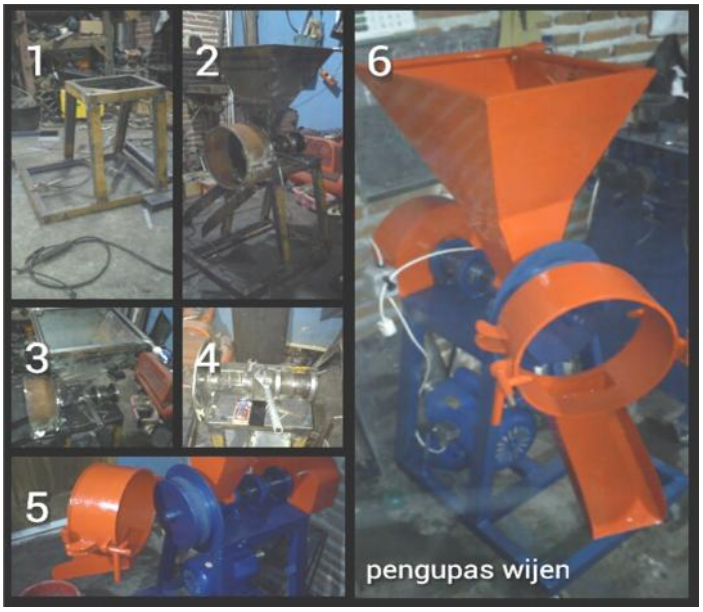


Figure 4: Procedure of Making Construction Sesame Peeling Machine Using Wet System

Remarks:

1. Machine frame Construction
2. Inlet Installation (Hopper)
3. Water channel and Control Valve on hopper
4. Grooved axis and estrangement installation
5. The position of installing the peeling wheel and Peeling House
6. The intact construction of the sesame peeling machine using wet system

The Result of the Test on the Performance of Sesame Peeling Machine Using Wet System:

1. Electrical Power of Motor (P) = 1 PK (740 Watt), (not varied)
2. Variable Q (Flow meter for processing) was tested at the value of Q1 = 2 litres/minute, Q2 = 2.5 litres/minute, Q3 = 3 litres/minute.
3. Variable n (The rotation of peeling cylinder) refers to the rotation of electric motor at 1400 rpm. For the research need, it was conducted by replacing the size (diameter) of rotary transmission wheel to obtain a proper rotary comparison including:
   Rotation (n1) = 560 rpm (comparison to the wheel reduction at R1=10 cm and R2= 25 cm),
   Rotation (n2) = 448 rpm (The comparison to the wheel reduction at R1= 8 cm and R2= 25 cm),
   Rotation (n3) = 336 rpm (comparison to the wheel reduction at R1= 6 cm and R2= 25 cm),
4. Variable C (*clearance*, estrangement distance among peeling wheels, mm) was tested at C1= 2 mm, C2 = 2.5 mm, and C3= 3 mm. The test of the performance was conducted at the best clearance to obtain the quality of the intact peeling products as maximal as possible. It was then found that the best clearance was C2 = 2.5 mm; thus, for the clearance of C1 = 2 mm and C3 = 3 mm it was only measured for the whole of its peeling products.
5. The performance of the sesame peeling machine is stated in the fresh weight of sesame from the peeling product with the very minimum/time (kg/hour), while the quality was stated in the percentage of the intactness of peeled sesame seeds.

Table 1: The Test Result on the Performance of the Treatment Variable Combination (Mizar, M.A. 2014)

Capacity and Quality of the Result of the Test on Machine Performance	Capacity and Quality of the Result of the Test on Machine Performance	Capacity and Quality of the Result of the Test on Machine Performance
P, Q1, n1, C1 Peeled Products damaged (10% - 15% intact)	P, Q1, n1, C2 130 Kg/hour (rounded) (60% -70% intact)	P, Q1, n1, C3 Peeled products (10% -15%)
P, Q2, n1, C1 Peeled products damaged (10% - 15 % Intact)	**P, Q2, n1, C2** **140 Kg/hour(>95% Intact)** *(rounded)*	P, Q2, n1, C3 Peeled products (10% -15%)
P, Q3, n1, C1 Peeled Products damaged (10% - 15% Intact)	P, Q3, n1, C2 145 Kg/hour*(rounded)* (60% - 70%Intact)	P, Q3, n1, C3 Peeled products (10% -15%)
P, Q1, n2, C1 Peeled Product damaged (10% - 15% Intact)	P, Q1, n2, C2 95 Kg/hour*(rounded)* (60% - 70% intact)	P, Q1, n2, C3 Peeled Products (10% -15%)
P, Q2, n2, C1 Peeled Product damaged (10% - 15 % Intact)	**P, Q2, n2, C2** **100Kg/hour (Intact >95%)** *(rounded)*	P, Q2, n2, C3 Peeled Products (10% -15%)
P, Q3, n2, C1 Peeled Product damaged (10% - 15% Intact)	P, Q3, n2, C2 105 Kg/hour *(rounded)* (60% - 70% intact)	P, Q3, n2, C3 Peeled Products (10% -15%)
P, Q1, n3, C1 Peeled Product damaged (10% - 15 %Intact)	P, Q1, n3, C2 70 Kg/hour *(rounded)* (60% - 70% intact)	P, Q1, n3, C3 Peeled Products (10% -15%)
P, Q2, n3, C1 Peeled Product damaged (10% - 15% intact)	**P, Q2, n3, C2** **75 Kg/hour (>95 %Intact)** *(rounded)*	P, Q2, n3, C3 Peeled Products (10% -15%)
P, Q3, n3, C1 Peeled Product damaged (10% - 15 %Intact)	P, Q3, n3, C2 80 Kg/hour *(rounded)* (60% - 70 % Intact)	P, Q3, n3, C3 Peeled Products (10% -15%)

From the result of the test on the performance, an optimal peeling was obtained with the wholeness of sesame peeling at more than 95% (>95 %) in the combination of variables as follows:

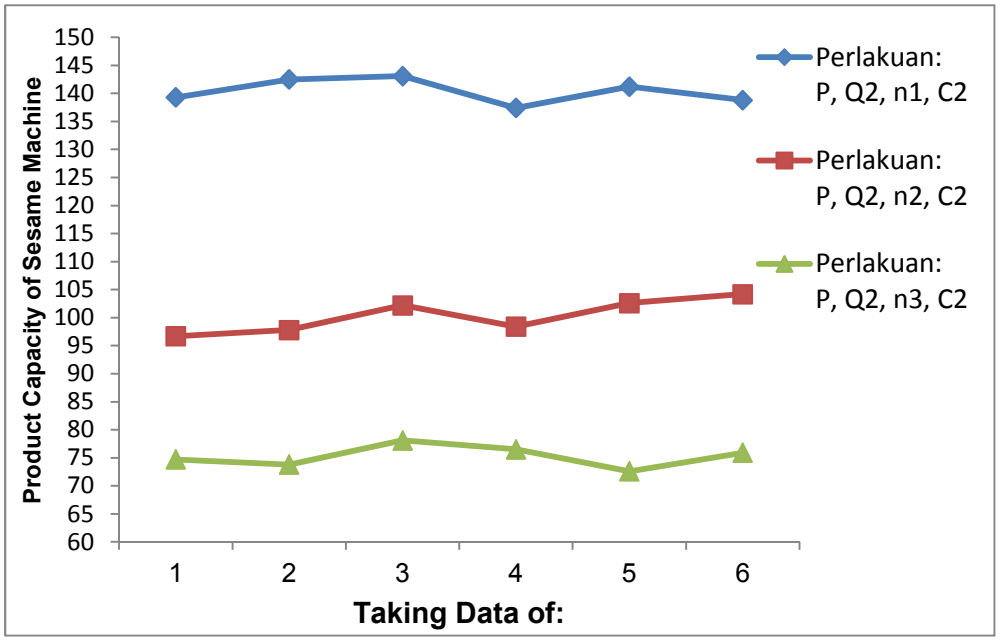
(1) P, Q2, n1, C2, capacity of mean result: 140 Kg/hour (>95% intact)
(2) P, Q2, n2, C2, capacity of mean result: 100 Kg/hour (>95% intact)
(3) P, Q2, n3, C2, capacity of mean result: 75 Kg/hour (>95% intact)

Furthermore, a test on the performance of those three variable combinations was conducted with 6 repetitions on each. Its result can be seen in Table 2 and Figure 5. As shown in Figure 5 and Figure 6, the most optimal result was found in the condition of the following variable combinations: Motoric Capacity (P) = 740 watt, Flow Rate

(Q2) = 2,5 litres/minute, Rotary Speed (n1) = 560 rpm, and the clearance of peeling wheel (C2) = 2,5 mm.

Table 2: The Test Result on the Performance of Treatment Variables Combination on the Optimum Capacity and Product Quality (>95%) of Sesame Peeling Machine (Mizar, M.A. 2014)

Capacity and Quality of the Result of the Test on Machine Performance **P, Q2, n1, C2**	Capacity and Quality of the Result of the Test on Machine Performance **P, Q2, n2, C2**	Capacity and Quality of the Result of the Test on Machine Performance **P, Q2, n3, C2**
139,30 Kg/hour (>95% intact)	96,70 Kg/hour (>95% intact)	74,70 Kg/hour (>95% intact)
142,50 Kg/hour (>95% intact)	97,80 Kg/hour (>95% intact)	73,80 Kg/hour (>95% intact)
143,10 Kg/hour (>95% intact)	102,20 Kg/hour (>95% intact)	78,10 Kg/hour (>95% intact)
137,40 Kg/hour (>95% intact)	98,40 Kg/hour (>95% intact)	76,50 Kg/hour (>95% intact)
141,20 Kg/hour (>95% intact)	102,60 Kg/hour (>95% intact)	72,60 Kg/hour (>95% intact)
138,80 Kg/hour (>95% intact)	104,20 Kg/hour (>95% intact)	75,90 Kg/hour (>95% intact)
Mean = 140.38 Kg/hour (>95% intact)	Mean =100.32 Kg/hour (>95% intact)	Mean =75,27 Kg/hour (>95% intact)



Remark:

P (Electrical Power at 740 Watt), Q2 (Flow Rate of Water at 2,5 litres/minute), n1(560 rpm), C2 (clearance 2,5mm)

P (Electrical Power at 740 Watt), Q2 (Flow Rate of Water at 2,5 litres/minute), n2(448 rpm), C2 (clearance 2,5mm)

P (Electrical Power at 740 Watt), Q2 (Flow Rate of Water at 2,5 litres/minute), n3(448 rpm), C2 (clearance 2,5mm)

Figure 5: The Graph of the Test Result on the Performance of the Combination of Treatment Variables on the Capacity and the Quality of Optimum Result (>95%) Sesame Peeling Machine

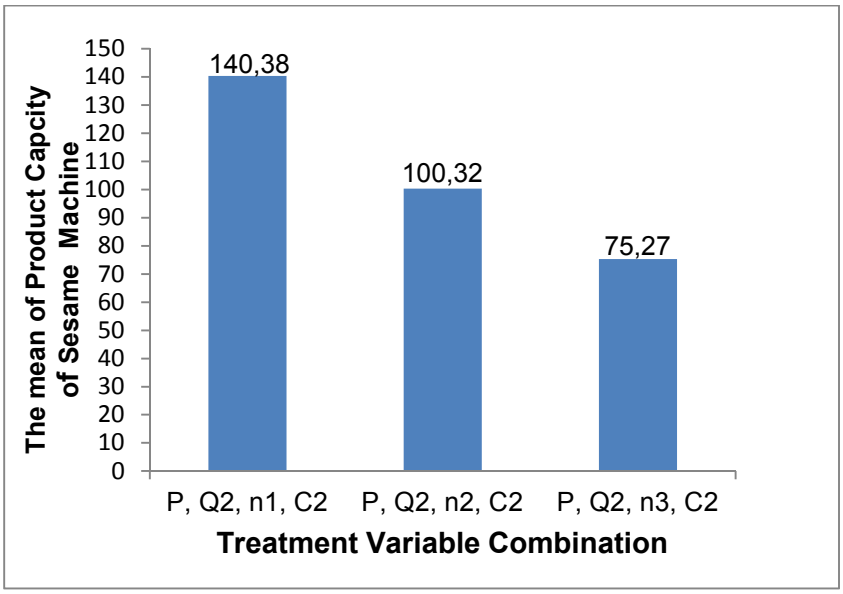


Figure 6: The Graph of Comparison in Optimum Product Capacity and Quality (>95%) Of Three Variable Combinations in Sesame Peeling Machine

In general, mechanism of sesame peeling machine can be used to fulfil the needs of both the small-scale food industry particularly for the sesame-based food and farming business in managing the post-harvest of sesame peeling process. The machine construction from this research used wet system (using water media in peeling process). This aims to obtain efficiency in peeling the skin of sesame seeds with acceleration and guarantee in quality of the intact peeled products with the hygienic peeling stone surface which was curved and grooved to avoid any corrosion as a preventive action for any contamination on its processed product.

The result of the research is able to cope with any problems or difficulties in the sesame peeling process in line with the objective of this machine including appropriate technology-based machine in peeling the sesame. It is due to both its ability to produce the wholeness level in sesame peeling at more than 95% and its

simplicity in operation. In addition, this machine is able to save power and time (enhancing the work efficiency) as it can result in the peeling with capacity until 140 Kg/hour in contrast to the previous manual process using pounding method that only resulted in 15 Kg/hour. Mizar (2003) also has ever conducted a research on the sesame peeling machine with the maximum capacity of peeled products at only 60 Kg/hour with the smaller diameter of peeling wheel.

The clearance regulator and the fastener of cylindrical grinder clearance were used to regulate the space clearance of two cylinders of peeling stone. The accuracy of the distance of two stone cylinders came to be the key of achievement in terms of the intactness level of sesame seeds as the peeled products. When the space was oversized, the sesame seeds would not be peeled; while when it was too tight, the sesame seeds would be damaged or broken. Through the water flow, the peeled sesames would be sent out through an outlet and were ready for the process of separating the sesame seeds from the skin.

In this research, the test on the performance was conducted in the clearance of 2 mm, 2,5 mm and 3 mm. Regulating the clearance of 2 mm resulted in a damaged peeled products by only remaining the intact sesame seeds at 10% to 15%. Meanwhile, the one at 3 mm contributed to the very minimum peeling (only 10% to 15% of the sesame seeds were peeled and intact and other were not). The best thing in the clearance regulation was achieved at 2.5 mm in which it could produce the intact peeled products until 95%.

In terms of water flow rate (Q), the test was conducted at Q = 2 litres/minute, Q = 2.5 litres/minute, and Q = 3 litres/minute. At Q = 2 litres/minute and at Q = 3 litres/minute, the result obtained was not maximum, while at Q = 2.5 litres/minute, it was found maximum as the very slow water flow would hinder the flow of sesame seeds into the peeling cylinder. Similarly, when being hindered so long in between the peeling cylinders, the sesame seeds would be damaged. On the other hand, the too fast water flow could make the seeds so rapidly pushed to come in and out of peeling cylinder that, in turn, could make the result of peeling not maximal and many of them not peeled.

In terms of the use of rotary ratio to achieve the more maximum result of peeling (not damaged), the accurate axis rotation of sesame peeling machine was at 560 rpm that could produce the capacity until 140 kg/hour with the wholeness level of peeled products at 95%, while at the rotation of 448 rpm and 336 rpm the capacity was not really maximum approximately 100 Kg/hour and 75 Kg/hour apart from the intact products reaching at 95%. Thus, the most optimal combination of the variable treatment from the result of the test on the performance that can enhance the capacity and the quality of the peeled products was obtained at the flow rate of water at (Q) = 2.5 litres/minute, estrangement installation (C) = 2.5 mm, axis rotation of sesame machine (n) = 560 rpm, and electrical power (P) = 1 PK (740 watt). In such treatment combination, the capacity of 140 kg/hour with the intact peeled product more than at 95% was obtained.

Conclusion

A construction of sesame peeling machine using wet system with the capacity of 140 kg/hour has been found maximal at most. It can increase the capacity and quality of the products with the flow rate of water at (Q) = 2.5 litres/minute, the regulation of the clearance at (C) = 2,5 mm, axis rotation of sesame machine at (n) = 560 rpm, and electric power at (P) = 1 PK (740 watt) in the capacity of 140 Kg/hour with the quality of the peeled product at more than 95% intact.

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