

Design and Development of Potato Processing Machine

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Abstract

Nowadays, the process of peeling and cutting potatoes usually made separately, either using manual method or machine where peeler machine is used to peel potatoes skin while cutter machine is used for cutting only. This is not only requires a lot of manpower and also time consuming which is affecting the quality of the end product due to browning effect. Equipment that is capable to do all the processes starting from the cleansing, peeling skin and cut potatoes to the desired shape is required. A new innovative potato processing machine that has been designed and developed consists of a framework, a peeler machine mounted on the frame, a cutter machine mounted on the frame and a controller mounted on the frame to control both peeler and cutter machine. The operation of this machine started with 15 kilograms of potatoes placed into peeler drum and water is poured into the drum for cleaning process. Result found that this machine is capable in peeling 15 kilograms of potatoes in 1-2 minutes. A sliding divider is installed vertically on peeler drum to prevent potatoes from entering the cutter machine during the peeling process so that potatoes skin can be peeled properly. A connector installed in perpendicular from the peeler machine to cutter machine to allow potatoes into space of cutter machine with appropriate feed rate for cutting process based on required shape. Cutter machine is equipped with perforated collectors to allow the cut potatoes to be soaked in the liquid for the purpose of cleaning and anti-browning treatment. As a conclusion, this machine can minimize the time and manpower required to process the potatoes.

Keywords: potato peeler, potato cutter, browning reaction

1.0 Introduction

Peeling of vegetables and fruits is one of the most frequent process in food industry, hotels, canteens and restaurants even at house hold purposes. Potato is probably the most popular food and widely consumed item in the Malaysian diet. Potato is a very rich source of starch and it also contains phosphorus, calcium, iron and some vitamins. Apart from use of fresh potatoes for the purpose of making vegetables and gravy, they are dehydrated in the forms of slices, sticks, cubes or powder to impart better shelf life. Yet another popular use is to make wafers or chips that are why potato became popular food item not in home but also in hotels, canteens

and restaurant. Hence peeling method of potato is point of interest. The process of peel and cut potatoes usually made separately, where peeler machine used to peel potatoes while cutter machine is used for cutting only. This caused time consuming which not only requires a lot of manpower in fact expose the potato to the browning reaction which affect the quality of the end product. Therefore, it is necessary such equipment that can do the overall process starting from the cleansing, peeling skin and cut potatoes to the required shape. Based on the information obtained from SME companies that worked together for this PPRN project, manual method only capable produced 15 kilograms per hour and is not enough to cop the demand in the market. Companies are facing problems when demand is up to 75 kilograms especially during festive seasons.

The concept of this Potato Processing Machine is based on current phenomenal of potato processing methods used in today's food processing industry. Food manufacturer requires two different machine to do peeling process and cutting process. In addition, Small and Medium Entrepreneurs (SME) in Malaysia is quite difficult to find industrial scale potato cutter machine with affordable prices. Most of the potato cutter in the market is suitable for table top and cannot load the potatoes in bulk. SMES need a multipurpose processing machine to simplify the process but still within a reasonable price. This potato processing machine which is granted by Public-Private Demand Drive Research Grant 2016 is focussed on peeling potato skin and cut in cube shape. They require a machine that can increase production rate and keep the quality of potato cube. Thus, the study is to design and develop a machine that combine the process of potato peeling and cutting.

Method of peeling used by potato chip manufacturers using abrasion results in more starch and less dietary fibre than the steam peeling method used in the production of dehydrated potatoes. Potato peels with either abrasive brush or steam peeling methods were extruded (Al-Weshahy and Rao, 2012). Abrasive peeling was carried out with an abrasive peeler in a drum with a rough inner surface and a motor. After the potatoes are put inside the drum, the inlet is covered, and the drum is allowed to rotate for a short time. This method is more suitable for root vegetables than fruits, because the latter are usually rather soft. Sweet potato is usually peeled by this method (Lin, 1995). According to Barry Ryan (2000), he realized that abrasive peeler are suitable for root vegetable. But it bruises and damages the underlying tissue of outer surface which leads the leakage of cellular fluid which are responsible for biological growth. Suter (2002) developed roller type potato peeler. It uses set of abrasive roller. The motion of roller is controlled by means of sensor. The focus was only on electronic and drive control system. The drawback of such type of peeler neither achieved high efficiency nor reduces peel losses. Chand, K. (2013) has designed and tested a pedal operated integrated potato peeler and slicer. The integrated unit saved 88 % and 54 % energy consumption as compared to manual and hand operated peeler and slicer, respectively. The pedal operated integrated peeling and slicing machine was more economical because it had very high

capacity, reduced the manpower in comparison with the hand operated machine as well as the manual.

Previous work shows clearly that mechanical peeling can fascinate the customer needs because of its benefits. The mechanical peeling becomes so popular because they produced fresh peeled product. Therefore the objectives of this project are to design and develop potato processing machine for identified Small and Medium Entrepreneurs (SME) industry such as food industries, restaurants, hotels and canteens; to compare processing time manually and by machine and to determine the performance of the machine.

2.0 Methodology

Figure 1 shows the Potato Processing Machine while Table 1 shows the components of this invention. This machine is made up of a frame mounted with a peeler machine and a cutter machine. The peeler machine equipped with inlet water channel and outlet water channel to help the peeling process. In this invention, the inlet water channel located at the top of the peeler machine and outlet water channel located at the lower frame. A divider doors that can slide installed vertically peeler drum. This door is in square shape made of stainless steel with thickness of 2 millimetres.

A connector installed in perpendicular from the peeler machine to the cutter machine. From the study, the optimum angle is 45 degrees aimed at allowing potatoes into space of cutter machine with appropriate feed rate. The connector can also be removed from the cutter machine if the process is not needed and also for washing and sterilization purposes. Cutter machine complete with a perforated collector to allow the potatoes have been cut to be soak in the liquid for the purpose of rinsing or anti-browning treatment.

In this invention, a controller is mounted on the frame which functions to control both the peeler machine and the cutter machine. This controller has two switches to switch on and off peeler and cutter machine separately. Additionally, there are two pocket attached on one side of the frame to put the blades used for the cutter machine. There are various blades that can be used for the process of potatoes and can be can be changed based on required shape and size of end product. At the back view of this invention, there is a door panel designed to ease the purpose of maintenance. Other than that, the wheels are mounted on frame to let the machine portable.

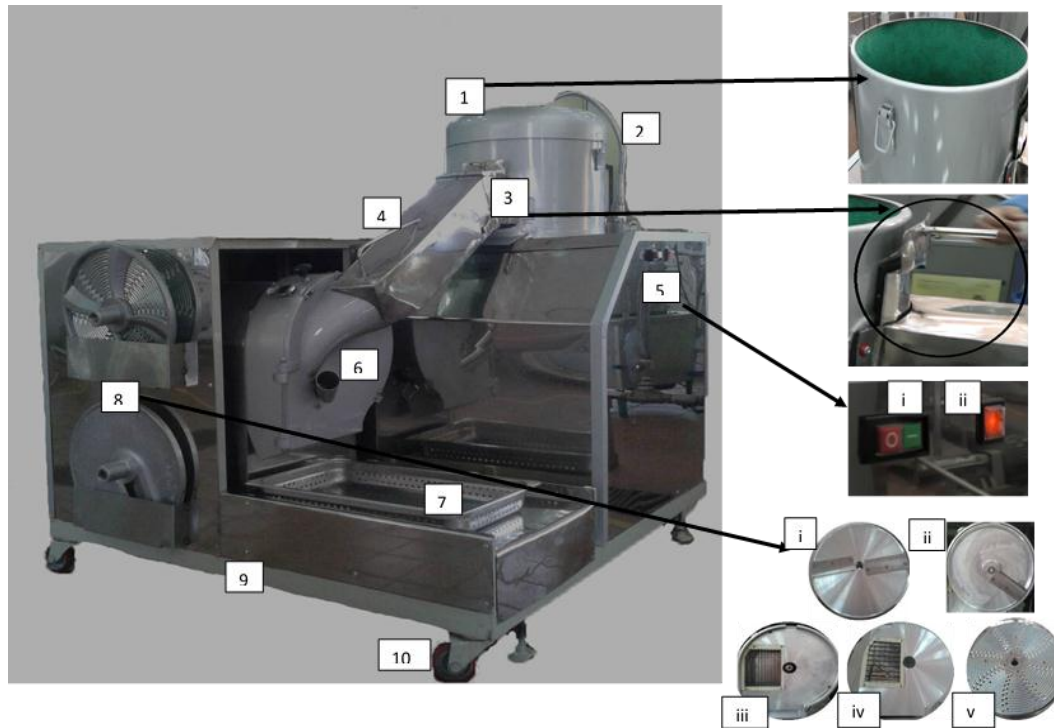


Figure 1: Potato processing machine

Table 1: Components of the machine

1	Tank for cleansing and peeling
2	Water inlet pipe to rinse peeled potato skin
3	Divider door to prevent potatoes enter space of cutter machine during peeling process
4	Connector to allow peeled potatoes move to cutter machine for cutting process
5	Control panel (i) start button for peeler machine (ii) start button for cutter machine
6	Space for cutting process
7	Perforated tray to collect cut potatoes
8	Cutter blades: (i) thin slices; (ii) thick slices; (iii) the shape of a small cube; (iv) the shape of a large cube ; (v) grate
9	Machine frame
10	Castors

The flow operating process of potato processing machine project is shown in Figure 2.

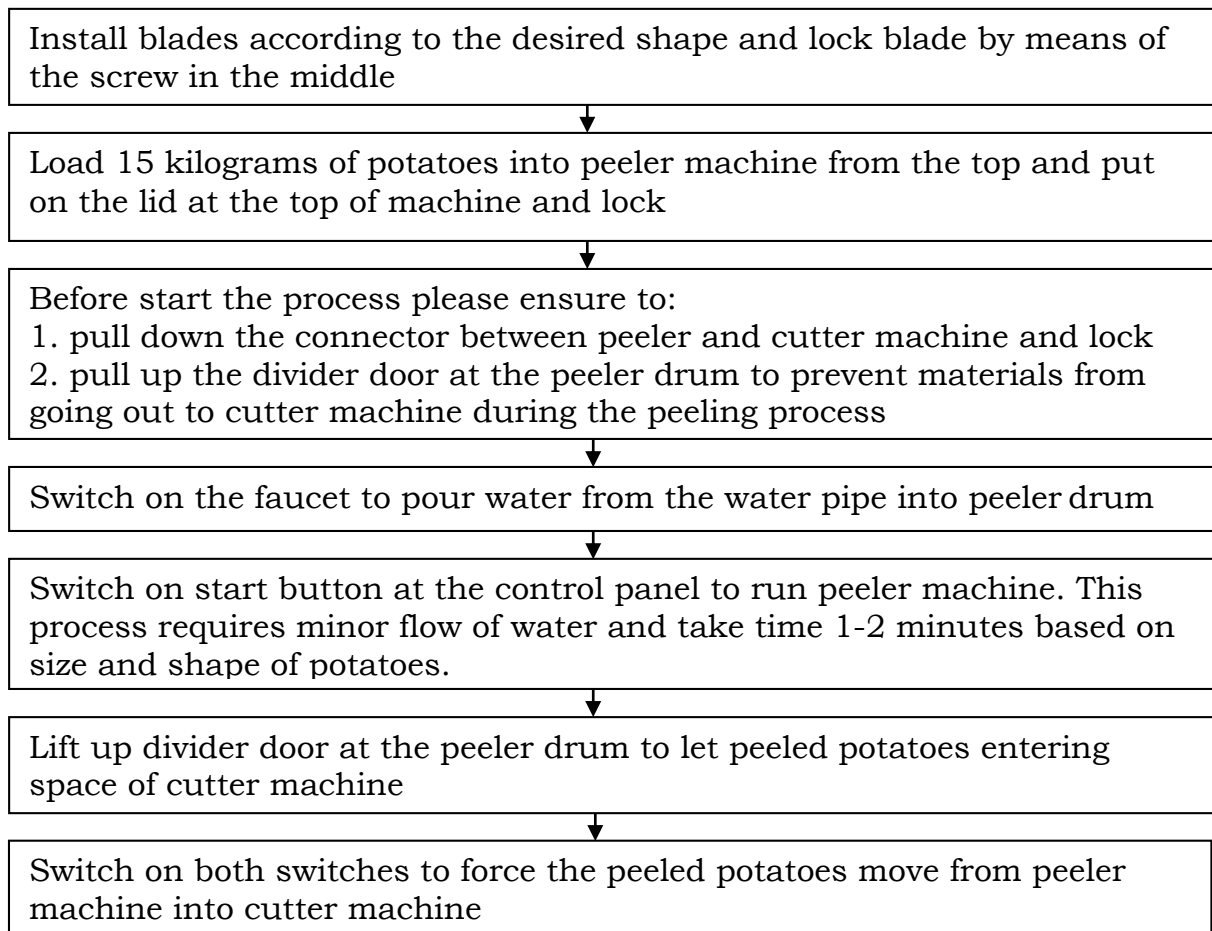


Figure 2: Basic steps of potato processing machine

3.0 Results and discussions

3.1 Processing Time by Manual Method

Manual processing method consumes more time and energy. This is because there are three separate steps need to be performed by the workers. The first step will be cleansing the potatoes to remove all the contaminants such as soil. After the cleaning process is done in the sink, the worker should lift up the potatoes to a more suitable place to do peeling process. After peeling process complete, workers need to rinse the potatoes to make sure hygiene then continue with cutting process based on size and shape required. These steps should be repeated for every single potato.

The calculation of time for manual processing method;

1 potato \approx 100 grams (small size potato)
75 kilograms potatoes \approx 750 potatoes

The average time required by a single worker:

5 seconds to wash each potato using manual method.

For 75 kilograms, which is about 750 potatoes
 $750 \text{ potatoes} \times 5 \text{ seconds} = 3750 \text{ seconds} = 62.5 \text{ minutes} = 1.04 \text{ hour}$

An employee can carry average 10 kilograms of potatoes from the sink to the processing area for one trip

75 kilograms of potatoes = 7 trips
1 return trip \approx 1.5 minutes
7 trips \approx 10.5 minutes = 0.18 hour

30 seconds to peel a potato skin using manual peeler.

For 75 kilograms or 750 potatoes
 $750 \times 30 \text{ seconds} = 22500 \text{ seconds} = 375 \text{ minutes} = 6.25 \text{ hours}$

30 seconds to cut a potato into cube shape.

$750 \text{ potatoes} \times 30 \text{ seconds} = 22500 \text{ seconds} = 375 \text{ minutes} = 6.25 \text{ hours}$

Thus, a worker requires average 1.04 hour to wash 75 kilograms of potatoes, 0.18 hour to carry the potatoes from sink to processing area, 6.25 hours to peel potatoes skin and 6.25 hours to cut potatoes into desired shape. Total handling and processing hours are 13.72 hours.

A worker will be working 8 hours a day, hence a worker needs around 13.72 hours = 1 day and 5.72 hours to handle and process 75 kilograms (750 potatoes) start from cleansing, peeling and cutting process. However this time consuming process is not practical because can lead browning reaction to the end product. To reduce processing time and control browning reaction, this process needs to be done by more than one worker.

If a worker is able to process 25 kilograms (250 potatoes) of potatoes in an average of 4.57 hours, this means that 3 workers are required to complete processing for 75 kilograms of potatoes in same day. However, human error can cause the size of the cube produced is not uniform in size and shape.

3.2 Processing Time by Potato Processing Machine

As mentioned earlier, capacity of the peeler machine will be 15 kilograms and average peeling time 1-2 minutes based on size and shape of potatoes. Operator can observe the peeling process through the lid at top of the peeler drum to decide either to stop or keep continue the peeling process. If the peeling time is too long and exceeds the optimum time will cause a high weight loss on potatoes.

Let say:

1 potato \approx 100 grams (small size potato)

Peeling process for 15 kilograms (150 potatoes) using processing machine \approx 1.5 minutes.

During peeling process, tap water is poured using water faucet located at the top of peeler drum to rinse the potato skin and the waste water will come out through the drain outlet at the bottom of the frame. That's mean

cleansing and peeling process happen at the same time. After stop the peeling process, the operator can proceed to the cutting process by lifting the separator door on the peeler drum to allow the potatoes enter the space in the cutter machine. Cutting process for the 15 kilograms (150 potatoes) just take time around 1 minutes.

Total handling and processing time for 15 kilograms (150 potatoes) is 2.5 minutes per run. To process 75 kilograms (750 potatoes) need the machine to run for 5 times, that's mean only 12.5 minutes. This data showed a reduction in processing time by 98.48% compared to the manual method to process 75 kilograms of potatoes. This reduction in processing time will definitely prevent the browning reaction of the final product. Additionally, the operation of this machine is very simple and requires only one operator and can produce uniform size and shape. Comparison between manual method and using potato processing machine as shown in Table 2.

Table 2: Comparison between manual and machine method

Methods Differences	Manual processing Method	Machine processing method
Time	13.72 hours (823.2 minutes) per man	12.5 minutes per machine
Operation	Triple (cleansing, peeling and cutting process separately)	Single (3 in 1)
Manpower	Needs more manpower (66 workers are needed to get the same time as did by machine)	One worker
Capacity	Depending on worker's capability	360 kilograms / hour
Quality of product	<ul style="list-style-type: none"> • Human error can cause the size of end product is not uniform in size and shape. • Time consuming can lead browning reaction to the end product 	<ul style="list-style-type: none"> • Uniform size and shape • Fast process can prevent browning reaction

3.3 Evaluation of the Potato Processing Machine

Machine capacity, percentage of the removed peels, calculated peels mass to be removed and peeling efficiency were the main items of the machine performance evaluation. These parameters were evaluated using medium size Russet Potato and three replicates were used for each experiment. The sample was weighed before feeding to the machine to determine the M_i (initial mass). The potato sample was weighed again after peeling process to determine M_m (mass after leaving the machine). All calculations are based on the data for the peeler machine because the performance of the cutter machine is dependent on the peeler machine.

Table 3: Sample data to evaluate machine performance

Parameter	Sample 1	Sample 2	Sample 3	Average
Initial mass, Mi (gram)	150.25	198.45	226.80	191.83
Peels mass to be removed, Mr (gram)	4.22	5.76	6.80	5.59
Sample mass after leaving the machine, Mm (gram)	146.34	193.29	220.90	186.84

3.3.1 Machine Capacity

Machine peeling capacity (kilogram/hour) was defined as the batch load of the potatoes divided by the total peeling time (loading time + peeling residence time + unloading time) in an hour, and could be calculated using the following equation 1:

$$Cp = \frac{Lb}{(Tl+Tr+Tu)} \times 60 \tag{1}$$

Where:

Cp = machine peeling capacity (kg/h)

Lb = batch load (kg) = 15 kg

Tl = loading time (min) = 30 seconds = 0.5 minutes

Tr = peeling residence time (min) = 1.5 minutes

Tu = unloading time (min) = 30 seconds = 0.5 minutes

Hence,

$$Cp = \frac{15}{(0.5 + 1.5 + 0.5)} \times 60$$

$$Cp = 360 \text{ kg/h}$$

3.3.2 Percentage of The Removed Peels

Peels removed percentage was defined as the ratio of the mass of peels removed by the machine to the initial mass of the sample expressed as percentage as follows:

$$Rp = \frac{Mi-Mm}{Mi} \times 100 \tag{2}$$

Where:

Rp = the removed peels by the machine (%)

M_i = initial sample mass (gram)

M_m = sample mass after leaving the machine (gram)

Hence,

$$Rp = \frac{191.83 - 186.84}{191.83} \times 100$$

$$Rp = 2.60\%$$

3.3.3 Calculated Peels Mass Percentage

The calculated peels mass percentage was defined as the ratio of the peels mass to be removed to the total potato mass which could be determined as follows in equation 3:

$$Mc.p = \frac{Mr}{Mt} \times 100 \quad (3)$$

Where:

$Mc.p$ = the calculated peels mass (%), to be removed

Mr = peels mass to be removed (gram)

Mt = total potato mass = initial mass (gram)

Hence,

$$Mc.p = \frac{5.59}{191.83} \times 100$$

$$Mc.p = 2.91\%$$

3.3.4 Peeling Efficiency

Peeling efficiency was defined as the ratio of the peels removed by the machine (%) to the calculated peels mass (%) to be removed. It could be computed as follows in equation 4:

$$\eta_p = \frac{Rp}{Mc.p} \times 100 \quad (4)$$

Where:

η_p = peeling efficiency (%)

Rp = the removed peels by the machine (%)

$Mc.p$ = the calculated peels mass (%), to be removed

Hence,

$$\eta_p = \frac{Rp}{Mc.p} \times 100$$

$$\eta_p = \frac{2.60}{2.91} \times 100$$

$$\eta_p = 89.35\%$$

The close the value of η_p (%) to 100, the higher peeling efficiency, η_p (%) less than 100 refers to an incomplete peeling potatoes, while η_p (%) greater than 100 denotes some weight loss of potatoes for the sized samples.

4.0 Conclusion

This invention has proved in increasing the production rate with uniform size and shape of potatoes and at the same time prevent browning reaction due to fast processing time compared to manual method. Machine's capacity and efficiency was 360 kg/hr and 89.35%, respectively. This machine saved 98.48% time consumption as compared to manual peeling-cutting method where 66 workers are required to do the same work as what the machine can perform. At the same time, this invention also can help SME to produce more new products to expand their business.

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