Design and Development the Onion Peeling Machine Using Diamond Mesh Shape Tromp Peeler

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Abstract
Onion peeling machine was developed for a Small-Scale Food Industry. The machine was equipped with horizontal rotating tromp peeler and aided with compressed air to remove the outer layers of the shallot skin. The goals and objectives for this project will focus on design, invention and fabrication that improves and reduce the operation time, enhances the ability and effectiveness of onion peeling machine. The machine was tested to determine the machine peeling capacity, the percentage of removed shallots skin and peeling efficiency towards three different types of shallots (Siam, India, Rose India). Results shows that the peeling capacity for India and Siam shallots skins were no significant difference compare with India Rose. The percentage of removed shallots skins are higher for Siam (84%) and India (80%) shallots due to the very thin membrane of the skins compare with India Rose (76%) that had strong roots and thick membrane layers. As a conclusion, this onion peeling machine was designed, fabricated and tested successively for different types of shallots and capable to peels the shallots skin to produce higher throughput.
Keywords: onion, shallot, peeling machine

1.0 Introduction

In Malaysia, the imports of onions are between 150 000 to 250 000 tonnes each year. According to International Food and Agriculture Organization (FAO), the onion intake is average 12 kilograms of each year. The number are growing in 2009, when the FAO reported the consumption of onions by Malaysians increased by two kilograms to 14 kilograms a year due to their usage in almost all types of people's cuisine. In preparing raw materials, peeling is one of the important stages that will affect the quality and price of the end product. In Food Industry, a conventional method for peeling the onion manually is still applied. Though, due to the lack of productivity and efficiency, a combination method is invented (FAO 2015).

According to SME Corp Malaysia, 98.5% of business establishment in Malaysia are Small and Medium-sized Enterprise (SME). The government is encouraging

all sectors to supports the SME industries trough several grants such as Public Private Research Network Grant (PPRN). Therefore, this study was done to develop an onion peeling machine that will aid the development of SME industries especially in a services sector 89.2% (809125 SMEs) that contribute highest percentage to Gross Domestic Product (GDP), exports and employment the than others sector (SME 2016).

At the first stage, a conceptual design was drawn and experimented. Shallots were chosen that other onions due to the SMEs issues regarding longer peeling time, higher labour cost and not fulfilled the desired quality product. To remove shallots skin in a large scale, a mechanical abrasion method was selected using a tromp peeler. The combination of abrasion from the tromp peeler with vertical rotation was tested and aided with compressed air that will removed the shallot skin. Preliminary tests were conducted for a tromp peeler speed and peeling efficiency. Throughout the continuous Research and Development (R&D) with continuous improvement, this combined mechanical method was able to prolong the shelf life of onion and produce high quality of shallot product. This onion peeling machine can be conducted by one operator in a short time.

2.0 Literature Review

Today, onion is a one of the universal vegetables used for most countries. Onion peeling is an important step in producing many of the onion products such as onion powder, onion flavoring and fried onion. According to William, *et al.,* (2016), from the record user interviews, time to peel an onion by hand average around 15 second per person (4 onions/minutes) and it's depend on the person and able to peel onion up to 50lbs (22.6796kg) continuously at a time. According to Bagher Emadi (2005), peeling methods can be divided into three categories: mechanical, thermal and chemical peeling. The different technique method of peeling depends of the variety and specification of the product. The most common type of peeling is mechanical peeling. There are several types of mechanical peeling tools such as milling cutter, abrasive devices attached or coated to drums, rollers, knifes and blades. Those devices briefly described using related works of interest as follow:

i. Milling Cutter

Peeling by using milling cutter was facing with clogging issue. Therefore this method had been prevented from being applied commercially in Food Industry.

ii. Abrasive Devices

Abrasive devices are commonly coated at the surface of drums. This is the common methods for small amount of potatoes peeling that result in high output, but low waste produced (Somsen, et al. 2004). This method is still

relevant for root vegetables even though lower quality product compared to hand peeling.

iii. Drums

According to Singh (1995), the potato skins were peeled during drum rotation with supported by abrasion method. The best result was obtained when loading 20kg of potatoes using 30 rev/min of speed in 8 minutes.

iv. Knives and Blades

Srivastava, *et al.*, (1997), in their study report that the development of onion peeling machine consist of four blades and the machine was assisted with compressed air jets. The result shows 17% of the outer layer of the onion skin being removed. Bagher Emadi (2005) mention that there are several thermal peeling methods such as flame (dry heat) peeling, steam (wet heat) peeling, thermal blast peeling, freeze-thaw, and vapour explosion (vacuum peeling). In the chemical peeling method, skin will be softened from by soaking the vegetables in hot alkali solution. The quantity of solution and the period of different kind varied with the amount of vegetables. The example of chemical peeling methods is caustic (lye) peeling and enzymic peeling. However, this type of peeling especially lye peeling, and flame peeling methods are harsh and are not suitable for many onion products. (Wang, 1993, Srivastava et al., 1997 and Naik, et al., 2007).

3.0 Methodology

The raw materials used for this study were India Rose, Siam and India shallots. The fresh and well matured shallot were bought from Pasar Borong Selayang, Selangor. The selection of raw material was made by segregate it from foreign materials and small stones.

Figure 1: India Rose shallots

Figure 2: Siam shallots

Figure 3: India shallots

3.1 Sample Market Research

Current markets research in the shallot peeling industry shown there were several peeling machines that using almost the same concept. For example, in Figure 4 shows the Onion Peeling Machine 1 using water to peel off the shallots skin. The peeling machine requires the shallots root to be remove before placing the shallots into the machine that will undergo horizontal rotation equipped with water supply. Using the mechanical abrasion method, the capacity of this machine is 70-100 kg/hr where the size is 500cm x 500cm x 1500 cm and the power used is 0.1- 3kW.

Figure 4: Onion Peeling Machine 1

Figure 5 shows the Onion peeling Machine 2 for large onion. This machine is suitable for large onion between 45mm to 115mm diameter. Using floating knife, it will cut the top and the bottom of the onion. The machine finally removes the skin using compressed air. The large onion system consists of dry peeling process. Onions were loaded automatically with continuous operation, speed of 110 carriers/minute and the capacityof this machine is approximately 750kg per hour.

Figure 5: Onion Peeling Machine 2

3.2 Design Details

Average manual peeling was 4 shallots per minutes per person. Therefore, approximately 240 shallots (4kg) were able to be peeled in 1 hour per person which is very time consuming. By designing a new semi-automatic shallot peeling machine will help improving the quality of shallot as well as improving the production yield.

Figure 6: Shallot Manual Peeling

The goals and objectives for this project will focus on design, invention and fabrication that improve and reduce the operation time, enhances the ability and effectiveness of onion peeling machine. Once the design was completed, the conceptual design was tested and fabricated. Preliminary test was performed to evaluate their performance. The machine will then be upgraded via R&D stage.

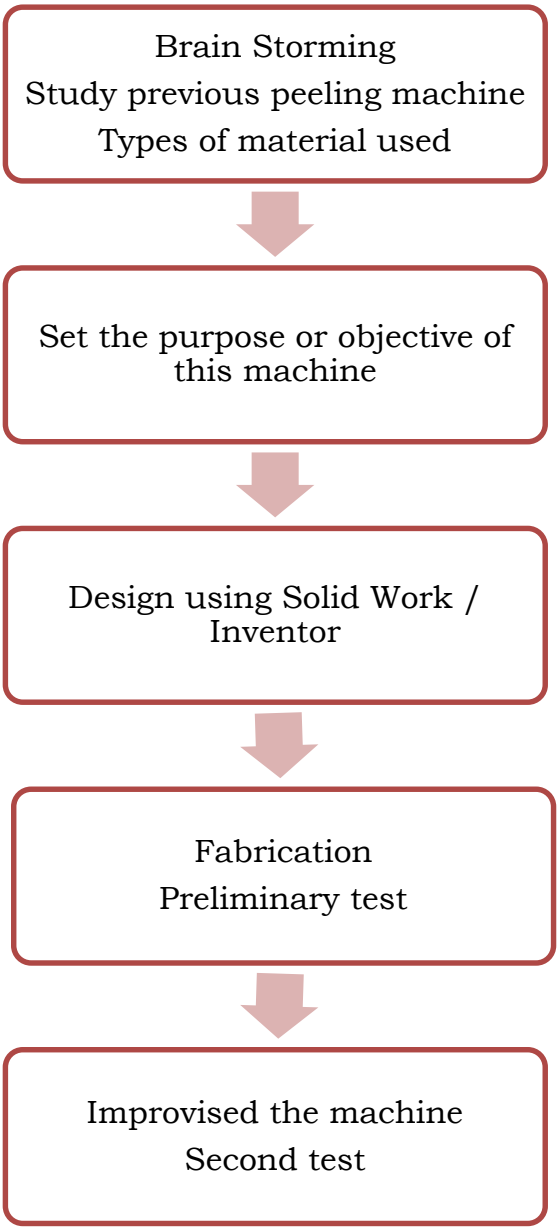

Figure 7: Process Flow of Shallot Peeling Machine Development and Assessment

3.3 Machine Peeling Capacity

For peeling capacity, the sample was weighed to determine the initial mass (Mi) before entering the machine. After peeling process, the shallots sample was weighed again to determine mass after leaving the machine (Mm) Machine peeling capacity (Cp) was determined by dividing shallot load (kg) with

summation of loading time (minutes), peeling time (minutes) and unloading time (minutes) using following Equation 1:

$$Cp = \frac{Lc}{Tl + Tp + Tu} \quad (1)$$

where:
Cp = machine peeling capacity (ton/h)
Lc =loading capacity (kg)
Tl = loading time (minutes)
Tp = peeling time (minutes)
Tu = unloading time (minutes)

3.4 Percentage of Removed Shallot Skin

To determine the percentage of removed shallot skin, sample mass after peeling (g) was divided with initial sample mass (g) minus sample mass after peeling (g). The calculation was made by using Equation 2:

$$Rp = \frac{Mi - Mp}{Mp}\ x\ 100 \quad (2)$$

where:
Rp = the percentage of removed shallot skin (%)
Mi = initial sample mass (g)
Mp = mass of peels removes (g)

4.0 Results and Discussions

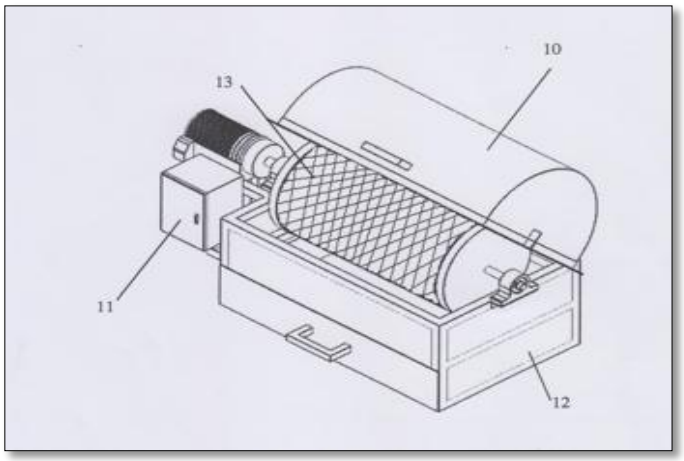

Figure 8: Shallot Peeling Machine Design

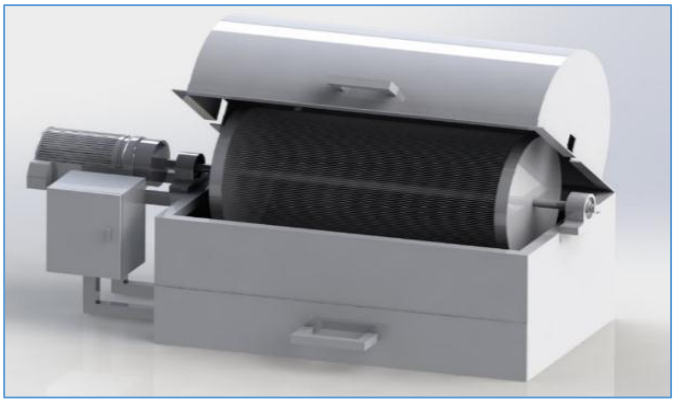

Figure 9: Shallot Peeling Machine 3D Design

Figure 10: Conceptual Design Test 2

Figure 11: Completed Fabrication Onion Peeling Machine

Figure 12: Peeling Machine Test

Shallots peeling machine in Figure 8 and 9 was comprising of a rolling device in conjunction with blower for breaking the skin of the shallots and detaching them. Based on Figure 8, it consists of four main parts which were top lid (10), motor and gear box (11), tromp peeler (13) and skin container (12). Figure 11 shows the crucial part in the machine was tromp peeler that made from diamond mesh shape Food Grade Stainless Steel. The motor operates at 1/15 HP was connected to gear box to reduce the speed of 1450 rpm with ratio 10:1. Stainless Steel rods with 1.5cm diameter length to support the tromp peeler was used. Stainless Steel Nuts were chosen to cap the end of the rod to secure the Peeler Assembly. Peeling capacity and the percentage of removed peels were the main items of the peeling machine performance evaluation. These parameters were evaluated using 60 rpm, 15min peeling time and 5 kg loading capacities which were the best speed and peeling time for this machine. Table 1 show the machine peeling capacity for three different shallots. Siam shallots were able to be peeled of 0.44 kg/min compare with India and India Rose shallots that reduce to 0.375 kg/min and 0.306 kg/min. Different types of shallots will result difference in peeling capacity due to different thickness of membrane cell. Siam and India Shallots consist of three layers of membrane cell. However, their thickness was different where the India Rose have the thicker membrane layer.

Table 1: Machine Peeling Capacity for Three Different Shallots

Drum Speed (rpm)	Peeling time (min)	Loading Capacity (kg)	Machine Peeling Capacity (kg/min)		
			Types of shallots		
			Siam	India	India Rose
60	15	5	0.440	0.375	0.306

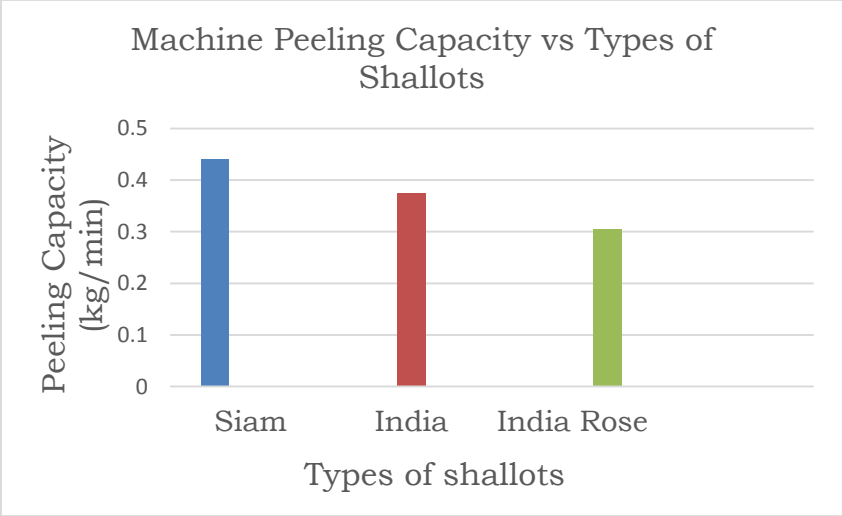

Figure 13: Machine Peeling Capacity for Three Different Shallots

Table 2 and Figure 14 show the percentage removed of shallots skin for three different shallots. 84% of Siam shallots were able to be peeled of compare with India and India Rose shallots that able to be removed to 80% and 76%. Different types of shallots will result difference in percentage removed of shallots skin due to different thickness of membrane cell. In this result, the highest percentage of shallots skin able to be removed was Siam shallots followed by India shallots and India Rose shallots.

Table 2: Percentage Removed of Shallots Skin for Three Different Shallots

Drum Speed (rpm)	Peeling time (min)	Loading Capacity (kg)	Percentage removed of shallot skin (%)		
			Types of shallots		
			Siam	India	India Rose
60	15	5	84	80	76

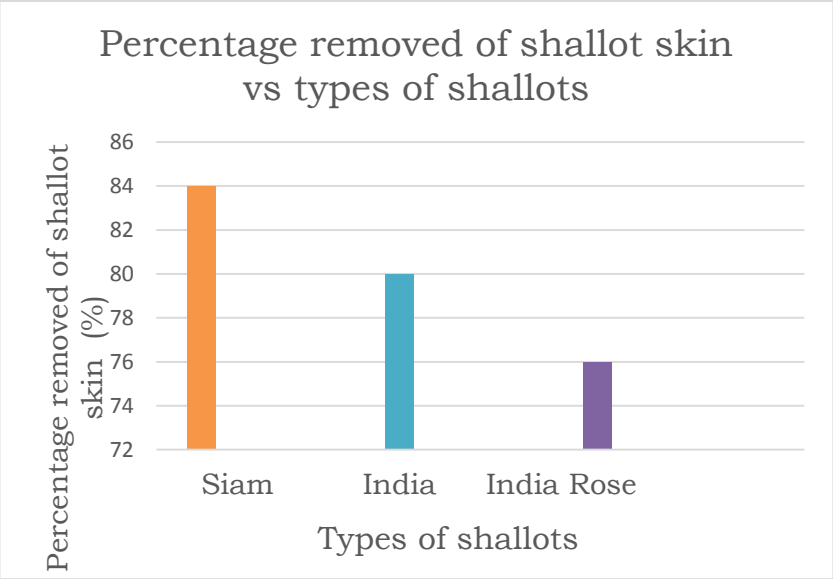

Figure 14: Peeling Removed of Shallots Skin for Three Different Shallots

5.0 Conclusion and Recommendation

This onion peeler machine provides a simple automation that meets the customer requirements that allowed for a significant reduction of operating labour and increased throughput capacity throughout the entire shallot peeling process. This onion peeling machine was designed, fabricated and tested successively for different types of shallots. Results had shown that this machine capable to peels the shallots skin at 76%, 80% and 84% using different varieties of shallots. Further researches need to be carried out for different operational parameters; rotational speed, feeding rate and peeling residence time.

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