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Design, Development and Evaluation of Peeling Machine for Shallot Onion

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ABSTRACT

Shallot onions are one among the most important commercial vegetable and spice crops, widely used in the south Indian kitchen mainly for seasoning of curries. Shallot onion invariably forms afresh cluster of bulbs, often as many as 10 or 15 per cluster. The shallots are peeled by hand before using in food applications. It is very difficult to peel a lot number of shallots by hands and small tools. It is very essential to have machinery for peeling the shallot onion. Owing to the practical problem in peeling of shallot onion this study was taken up to design and fabricate a peeling machine for shallot onion. The fabricated peeling machine was evaluated for various design properties and the peeling efficiency was found to be 90.44% at 12 bar pressure with 5 sec peeling time for a sample weight of 600 g

Keywords: *Fabrication, Peeling, Shallots, Onion*

INTRODUCTION

Onion is a very essential vegetable in India, as throughout the globe, with high export potential and very frequently used in culinary. Next to China, India is the second-largest producer of onion in the world. According to the Indian Directorate General of Commercial Intelligence & Statistics (DGCIS) report during 2018-19 fresh onion export of India is 21,83,766.45 MT valuing Rs.3,46,887.36 Lacs. The major export is to Bangladesh, Malaysia, UAE, Sri Lanka, and Nepal. Among the variants of onion, shallots are very popular and distinct. The shallots are the major onion crop cultivated in Tamil Nadu especially in Trippur, Trichy, Perambalur, Dindigul, Thirunelveli, Virudhunagar, and Namakkal Districts. Approximately 85 per cent of shallots produced in Tamil Nadu comes from these districts (Parimalarangan et al., 2019).

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In India, presently about 35 to 40 per cent of the onion is estimated to be lost by post-harvest practices during various operations including handling and storage (Saraswathi et al., 2017). Primary processing operations such as stem, root cutting, peeling and grading of onion are very important post-harvest operations as it fetches high price to the grower and improved packaging along with the handling, bring an overall improvement in marketing the produce. The availability of labor is a major problem and steps taken to utilize modern machines for farming by the onion producers will benefit them a lot (Kanagaraju & Devaki, 2015). Mechanization enables the conservation of input through precision metering, ensuring better distribution, reducing the quantity needed for better response and prevention of losses of inputs applied. Mechanization reduces the unit cost of production through higher productivity (AshwiniTalokar et. al., 2014).

A literature survey indicates the non-availability of such type of processing machinery for the peeling of shallot onion, owing to the practical problem in the processing of shallot onion as they are in clusters and are of different size and shape. Kaveri and Thirupathi (2015) studied the geometrical properties like size, shape, and area of fresh and three months stored aggregatum onion, to design the equipment for processing and storage. Peeling machines are available only for bulb onion commonly. Also the peeling machines available uses almost the same concepts such as the use of water to peel off the onion skin. The peeling machine requires the shallots root to be removed before placing the shallots into the machine that will undergo horizontal rotation equipped with water supply along with mechanical abrasion. To overcome the practical difficulties in the existing machines, a machine is needed to peel the shallot onion with the simplest and effective ways. This research is focused on this area and this design and fabrication of the peeling machine for shallot onion has achieved the goal.

MATERIALS AND METHODS

Methodology Flow Chart

A field survey was done for available machinery in this aspect. It was found that peeling machinery is available only for bulb onion and not for shallot onion. Unlike bulb onion, shallots grow in clusters differing widely in their size and shape. Considering this variability, the machine designed and fabricated accordingly for shallot onion. The fabricated peeling machine for shallot onion was tested and validated for better efficiency. The sequential steps performed in the fabrication of the peeling machine for shallot onion are presented as follows.

Design of peeling machine for shallot onion

The machine was fabricated with the following parts as shown in Figure 1,

- Feeding arrangements
- Shearing cylinder
- Inlet and outlet mechanism
- Waste collection system
- Main control panel

The feeding arrangement was designed to feed the different sizes of shallots in different quantities. After considering the factors, a vibrating feeder was found to be suitable for these applications. The vibrator feeder with a tray of (L x B) was used for feeding of shallots. The tray is made up of stainless steel and fixed on the electromagnetic coil. The frequency of vibration is adjusted by using single-phase rheostat. It has predetermined ten steps starting from 1 to 10 steps by 1. The time of vibration also controlled by the timer fixed in the control panel. Using the combination of time and frequency of vibration the quantity of shallot is fixed. It is fixed on the top of the machine.

The inlet mechanism was designed at the top and the outlet mechanism was designed at the bottom of the main shearing cylinder. A stainless steel plate of 3 mm thick was given for input and output gate for the cylinder (Figure 2). The opening of both plates was done by pneumatic control. A pneumatic piston and cylinder arrangement was used for operating the plates. The time for opening and closing is controlled by the main control panel.

The waste collection system is mainly for the collection of peeled skin from the shallots. The term peeling represents the removal of at least 3 layers of the outer skin of the shallots. The peeled skin should be collected separately from the cylinder and it should not mix with the peeled shallots. The shearing action is done by compressed air so the outlet is air with peeled skin. Considering these factors, the collection system is incorporated with a cyclone separation system.

The main shearing cylinder is working in the principle of collision of shallots with the wall of the cylinder along with collision of each other due to centrifugal force. The centrifugal force is generated in the shallots due to the pressurized air passed through it in the tangential pattern. Holes were provided at the bottom of the cylinder in the form of tangentially at the periphery of the cylinder. The reducer nozzles were provided at the hole to give air-jet action to the shallots. The air jet gives collision and also some peeling initiation to the shallots. The size of the hole was decided to 3 mm after some preliminary studies. It was also available readily in the market and easy to replace the materials. An air compressor is used for the supply of pressurized air to the shearing cylinder using pneumatic tubes.

The main control panel consists of a metal box, circuit breakers, MCB with proper rating, timers, touch panel, and on/off switches. This is designed for automatic and manual control of all the parts mentioned in the design. This main control panel design has features for the future addition control of the total shallot processing system.

1. Hopper
2. Top closure for feeding the shallot
3. Stainless steel deskinning chamber
4. Nozzle
5. Pneumatic cylinder
6. Stainless steel pipe to remove the excess air and skin
7. Hopper to remove deskinned Shallot
8. MS frame

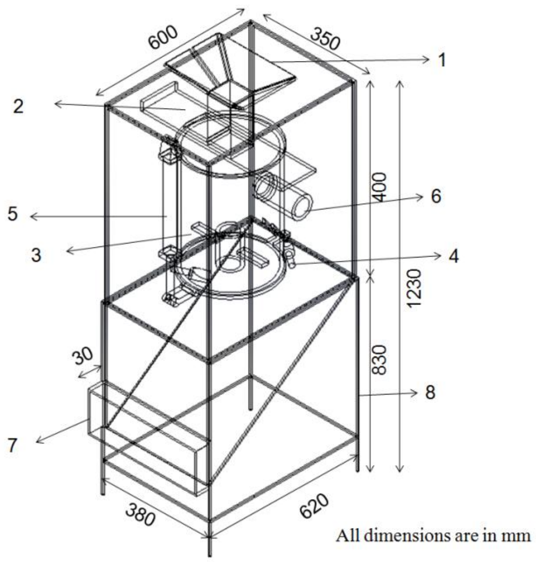

Figure 1: Isometric view of peeling machine

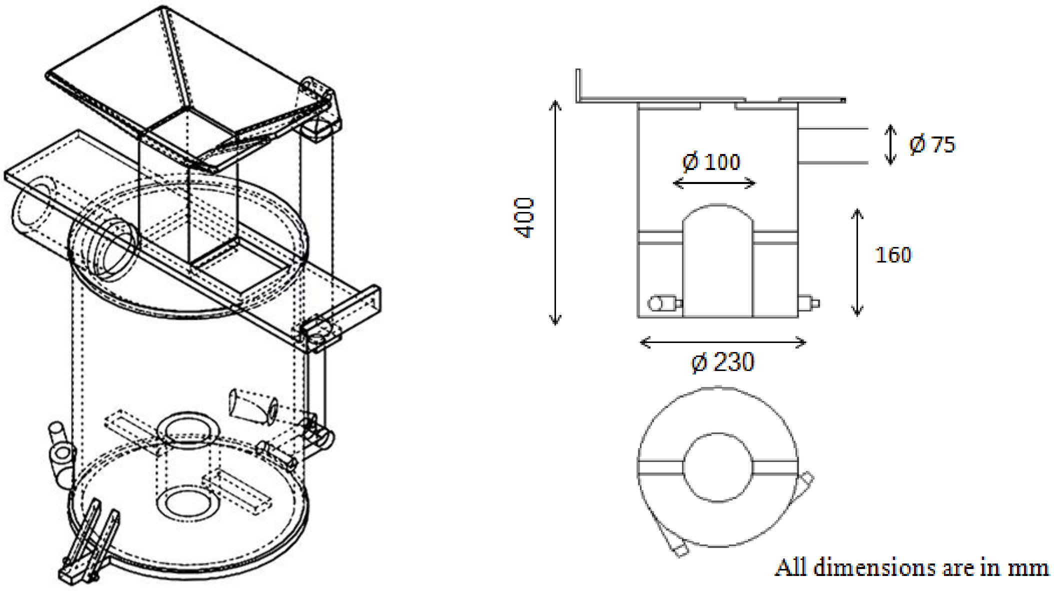

Figure 2: Isometric view of Shearing Chamber

Methods

Peel mass percentage

The peel mass represents the sum of the weight of the 1st, 2nd, and 3rd peel of the onion. The percentage is calculated according to the peel mass removed to the initial weight of the shallots (Srivastava, et al., 1997).

$$M_{c.p} = \frac{M1+M2+M3}{Mtotal} \times 100$$

Where $M_{c.p}$= Estimated peel mass in percentage,

M1 = Mass of first layer skin in g

M2 = Mass of second layer skin in g

M3 = Mass of third layer skin in g

Mtotal = Total weight of shallots taken in g

Percentage of peeling

The removed peel percentage was calculated (Srivastava, *et al*., 1997) from the following equation,

$$P_r = \frac{Mass\ of\ the\ peeled\ shallots}{Initial\ mass\ of\ shallots} \times 100$$

Where P_r = Percentage of peeling

Efficiency of peeling

The peeling efficiency was calculated using the equation mentioned below; it is the ratio of the percentage of peel removed to percentage peel mass estimated (Srivastava, et al., 1997).

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

Where, η_p = Efficiency of peeling in percentage,

P_r = Percentage of peel removed,

$M_{c.p}$= Estimated peel mass in percentage

Capacity of machine

The peeling capacity of the machine was calculated using the following equation (Srivastava, et al., 1997). It is also generally called the capacity of the machine. For this calculation, the loading time, peeling time, and unloading time should be considered.

$$C_P = \frac{Wb}{T1+T2+T3} \times \frac{3600}{1000}$$

Where, C_P = Peeling Capacity (t/h),

Wb = Weight of batch shallot inside the machine (kg),

T_1 = Loading time (s),

T_2 = peeling time (s),

T_3= Unloading time (s).

RESULTS AND DISCUSSIONS

Peeling of shallots

The experiments were conducted on the fabricated peeling machine considering the following parameters like the size of the holes, inlet pressure, sample weight, and peeling time. The hole sizes were decided according to the available nozzles like 2, 2.8 and 3.1 mm in diameter. These are readily available and easy to replace. The inlet pressures 10, 11, and 12 bar were decided according to the preliminary studies. The sample weights were also decided 500, 600, and 700 g according to the capacity of the machine and the working inlet pressures. The peeling time of 5, 10, and 15 sec was decided with preliminary studies. When the peeling time was more than 15 sec, more damage to the peeled shallots was observed. Using these combinations of parameters, the results were observed and the weight of peeled, unpeeled, damaged, and skin removed was calculated. The peeling percentage was calculated as the ratio of the undamaged peeled shallots to the total input weight. It was excluding the damaged peeled shallots. The damage was ascertained based on the peeling i.e. when more than three layers were being peeled off.

Effect of combination of nozzle size, working pressure, time of peeling and sample weights

At the nozzle size of 2 mm, the sample weight of 500, 600, and 700 g of shallots was peeled in time of 5, 10, and 15 sec at the working pressure of 10, 11, and 12 bar respectively. The experiments were conducted in the combination above-mentioned parameters and the results were observed.

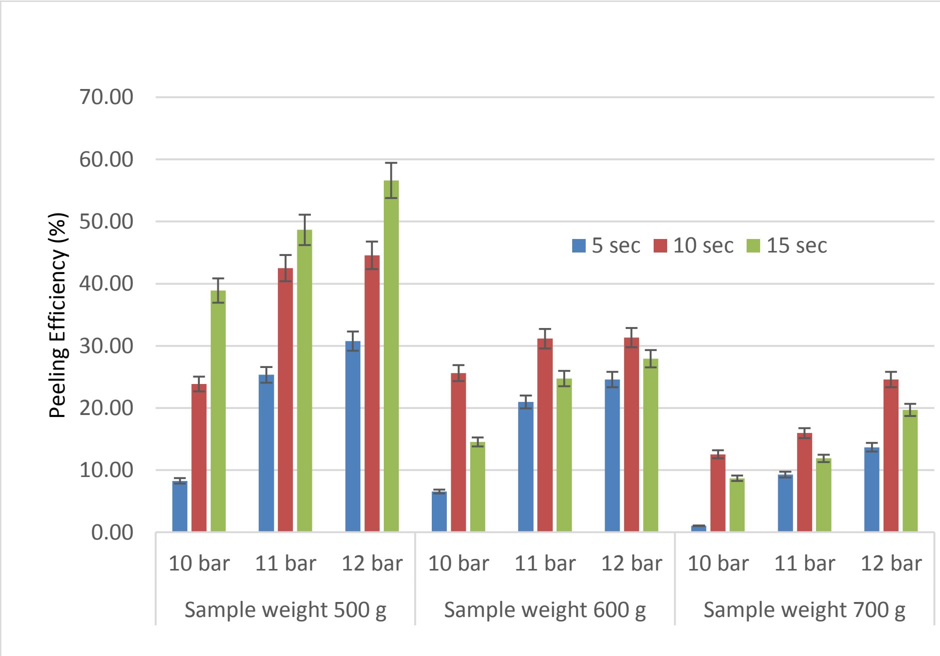

Figure 3: Effect of working pressure, peeling time for 2 mm nozzle size for different sample weights on the peeling efficiency of shallot onion

Figure 3 shows the result of the peeling percentage on the combination of various parameters like working pressure, time of peeling, and sample weights at the nozzle size of 2 mm. The maximum peeling percentage of 56.60 was achieved at 12 bar pressure on 15 sec peeling time for 500 g of the sample weight. The lesser sample weight with maximum working pressure on the maximum of peeling time gave this result. For 500 g sample, the peeling percentage was increased with increasing time of peeling and increasing in working pressure. This trend happened because of less sample weight exposed to the increasing pressure create more shearing force due to rotational and collision forces. Also, the increase in the peeling time creates the exposure of all the shallots to the air. For 600 and 700 g of sample, all the working pressure created very less peeling percentage due to insufficient working pressure from this nozzle size for this bulk quantity of shallots. The air coming out from the nozzle was a more focused and narrow diverging angle of stream.

The maximum peeling percentage was observed at 10 sec peeling time in all working pressure. In 10 sec the exposure of the shallots to the air and got peeled easily. In 15 sec the peeled shallots create the friction on the cylinder because of its wet nature. This friction force is maybe more than the rotational force created by air and form the clumps at the cylinder. The maximum peeling percentage of 31.33 and 24.60 at 12 bar of working pressure for 600 and 700 g of the sample respectively was observed. The sample weight 600 g gave better peeling efficiency than the 700 g sample as compared. More sample weight creates more internal friction and the friction force unable to overcome by working pressure. At the nozzle size of 2.8 mm, the sample weight of 500, 600, and 700 g of shallots was peeled in time of 5, 10, and 15 sec at the working pressure of 10, 11, and 12 bar respectively. The experiments were conducted in the combination above-mentioned parameters and the results were observed.

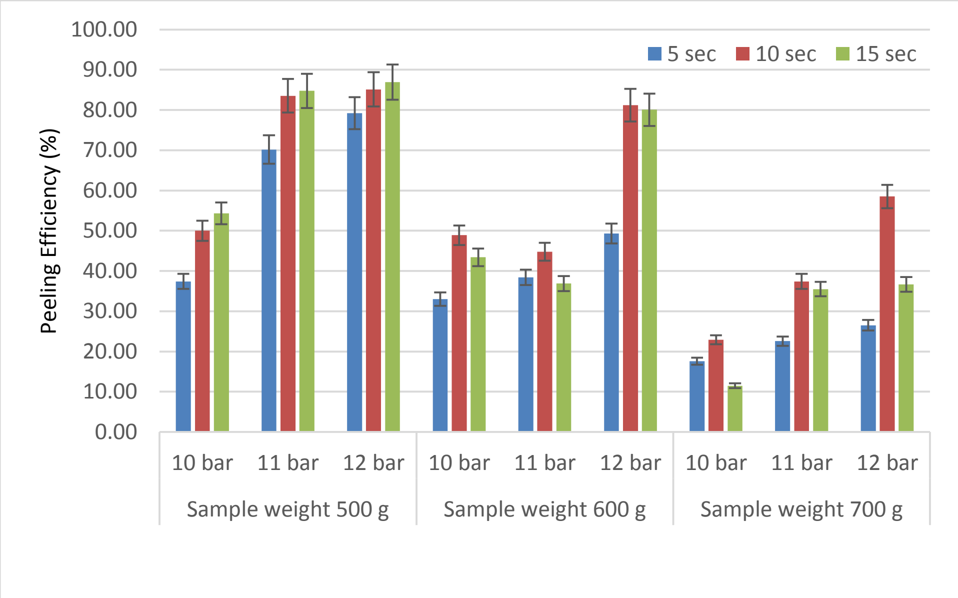

Figure 4: Effect of working pressure, peeling time for 2.8 mm nozzle size for different sample weights on the peeling efficiency of shallot onion

Figure 4 shows the result of the peeling percentage on the combination of various parameters like working pressure, time of peeling, and sample weights at the nozzle size of 2.8 mm. The maximum peeling percentage of 86.92 was achieved at 12 bar pressure on 15 sec peeling time for 500 g of the sample weight. It follows the same trend as the nozzle size of 2 mm but gave more efficiency than the nozzle size of 2 mm. This is happened because of more quantity of air came out of the nozzle and more sufficient for the peeling. For 600 and 700 g of sample, all the working pressure created very less peeling percentage due to insufficient working pressure from this nozzle size for this bulk quantity of shallots. The air coming out from the nozzle was a more focused and narrow diverging angle of stream. The maximum peeling percentage was observed at 10 sec peeling time in all working pressure. In 10 sec, the exposure of the shallots to the air and got peeled easily. In 15 sec the peeled shallots create the friction on the cylinder because of its wet nature. This friction force is maybe more than the rotational force created by air and form the clumps at the cylinder. The maximum peeling percentage of 81.22 and 58.51 at 12 bar of working pressure for 600 and 700 g of the sample respectively was observed. The sample weight 600 g gave better peeling efficiency than the 700 g sample as compared. More sample weight creates more internal friction and the friction force unable to overcome by working pressure. At the nozzle size of 3.1 mm, the sample weight of 500, 600, and 700 g of shallots was peeled in time of 5, 10, and 15 sec at the working pressure of 10, 11, and 12 bar respectively. The experiments were conducted in the combination above-mentioned parameters and the results were observed.

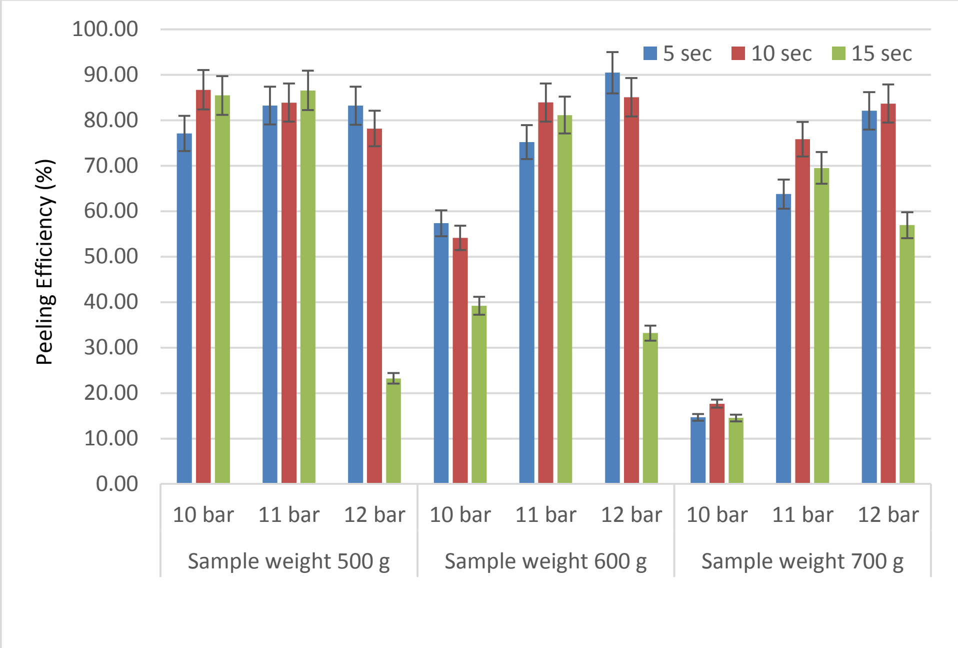

Figure 5: Effect of working pressure, peeling time for 3.1 mm nozzle size for different sample weights on the peeling efficiency of shallot onion

Figure 5 shows the result of the peeling percentage on a combination of various parameters like working pressure, time of peeling, and sample weights at the nozzle size of 2.8 mm. The maximum peeling percentage of 90.44 was achieved at 12 bar pressure on 5 sec peeling time for 600 g of the sample weight. The graph shows that the quantity of air coming out from the 3.1 mm nozzle is more sufficient for the peeling of shallots. All the weights 500 g, 600 g, and 700 g show the peeling efficiency of more than 80 per cent in a certain pressure. For 500 g of shallot, the maximum peeling efficiency of 86.70 percentage was obtained in 10 bar pressure in 10 sec. For 700 g sample weight, the maximum peeling efficiency of 83.65 percentages was obtained in 12 bar pressure in 10 sec. In 500 g of sample weight, all the shallots were peeled but the damaged shallots were obtained more so overall peeling efficiency was reduced. In 600 g of sample weight, the undamaged shallot was obtained less than 500 g so overall peeling efficiency found high. The 600 g of sample weight is more optimal for the peeling for 5 sec in 12 bar pressure.

CONCLUSION

The peeling machine for shallot onion was designed, fabricated on studying the various parameters of physical and mechanical properties. The machine was tested for effective utilization. The peeling percentage varied with sample weight, working pressure, and peeling time. Of all the tested parameters it was found that maximum peeling of 90.44 percentage was achieved with 600 g of sample weight when peeled at 12 bar pressure on 5 sec peeling time. The fabricated peeling machine is first of its kind for shallots which is advantageous for farmers and processors reducing drudgery and product loss, thus fetching more yield and price for the produce.

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Conflicts of Interest Statement

The authors have no financial conflicts of interest to declare.

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