Development of Batch Type Multiplier Onion (Onion Aggregatum) Peeler with Centrifugal Discharge

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Abstract

Multiplier onion (Onion aggregatum) is consumed in large quantity in southern provinces of India. These are used in large quantities in the catering and pickling industries, creating a need for peeling equipment. Multiplier onion peeling is an essential step in producing many of the onion products such as dehydrated onions, onion powder, onion flavoring, onion salt, onion rings, and pickled and canned onions, which is a very tedious process. A batch type peeling machine suitable for farm-level operation was designed and tested for multiplier onion. The equipment consisted of a cast aluminum drum seated over a rotating disc. Inner surface of the drum and top surface of the lower disc are covered with corrugated rubber sheet which aids in the peeling process. The multiplier onion needs to have the ends cut with a sharp knife and soaked in clean water for a period of 10 min to assist the loosening of peel followed by air drying for 1-2 min to remove the surface water. Major operational parameters: speed of operation and abrasive surface on the drum were optimized for peeling efficiency, damage to the bulb and other performance parameters. The capacity of the peeler was about 50-60 kg/h. The peeling efficiency was about 92 percent with unpeeled and damaged percentage being 6 and 2 percent, respectively. The cost economics study revealed that the equipment had a saving in labour and cost to a tune of about 68 and 69 percent, respectively, with a payback period of 1.40 years. The equipment can be adopted by small and medium multiplier onion processing industries.

Introduction

Multiplier onion (Onion aggregatum) is consumed in large quantity in the southern provinces of India. Peeling is a time consuming process, as a result of which working women avoid this particular type of onion even though it is much preferred and reported to have many medicinal advantages. These onions are used in large quantity in the catering and pickling industries, creating a need for mechanized peeling equipment. The mean weight of multiplier onion bulb per plant is 75 g and the number of bulbs per plant ranges from 8-10. The moisture content of the bulb was about 84.5 percent (w.b). The pungency of the multiplier onion is around 17 micro mole per gram and was grouped as strong onion as per the standard given by Schwimmer and Weston (1961). They reported that strong onions produce 16-20 micromoles of pyruvic acid per gram of onion.

Multiplier onion peeling is an essential step in producing many of the products such as dehydrated, powder, pickled and canned products. Several methods can be used for peeling multiplier onions. The common methods used in modern processing industry are lye treatment and flame peeling. Lye peeling and flame peeling methods are harsh and are not suitable for many multiplier onion products. In lye peeling or flame peeling, onions are abraded and then treated in a hot solution of caustic soda or burnt by passing through a furnace. Burnt skins are removed by scrubbing them with brushes. These methods suffer from a number of disadvantages. First, they produce incompletely peeled multiplier onions, that is, the core of the root remains with the onion bulb and require further processing. Chemical and flame treatment tend to damage the onions and their flavor compounds which affect the quality of some products. These technologies are relatively

expensive, inefficient, and generally create unpleasant working conditions. Compared to the above two methods, mechanical peeling has many advantages. The tip and the root of the onion are physically cut. There is no undesirable chemical or thermal to the onions thus resulting in a higher quality product. This is important for onions that are pickled or used as fresh ingredient for canned products. Hence a batch type mechanical peeler for multiplier onion bulbs with centrifugal discharge was developed for the benefit of small onion processing industries.

Materials and Methods

Preparation of Multiplier Onion for the Experiments

Pungent Multiplier onion (Co-3) was procured from the local vegetable market. Damaged/spoiled multiplier onions were discarded and the good multiplier onions were used for the studies.

Determination of Frictional Properties of Multiplier Onion

Scientists have directed great efforts in evaluating the basic physical properties of agricultural materials and have pointed out their practical utility in the machine and structural design and in the process and control engineering. (Maw *et al.*, 1996; Viswanathan *et al.*, 1997). Agricultural materials especially bulbs pose special problem in determining their physical properties because of their diversity in the shape, size, moisture content and maturity indices.

The design oriented frictional properties of multiplier onion such as rolling angle, coefficient of friction were determined by the following standard methods. Based on the size of the bulblets, the onions were divided into various size groups: 12 mm, 14 mm, 18 mm and 20 mm. These were the commercial sizes commonly used in the trading of the multiplier onion in the local and international markets.

Moisture content: Moisture content was determined by AOAC oven method (AOAC, 1975) at 60 ºC expressed in percent, wet basis.

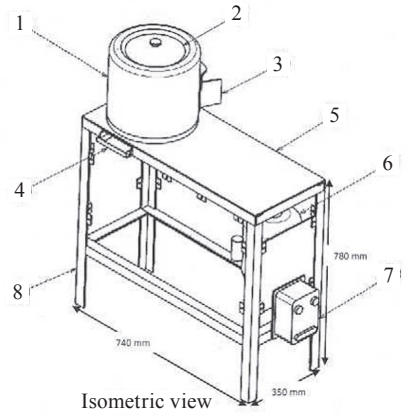
Size: Size is the measure of physical dimension of the object. Fruits and vegetables are irregular in shape and a complete specification of their form theoretically requires an infinite number of measurements. From practical point of view, measurements of several mutually perpendicular axes are to be taken. However the measurements along major and minor axes were taken for describing the size of the multiplier onion (Mohsenin, 1986).

Rolling resistance: To determine the rolling angle, the bulb to be tested was kept at the center of the working surface, (horizontal platform) in the most stable position (on their base) to prevent toppling over (top upwards). Rolling resistance was determined for various sizes of multiplier onion (Buyanov & Voronyuk, 1985).

Sliding Coefficient of static friction: Coefficient of static friction is the ratio of the force required to slide the bulb over a surface divided by the normal force pressing the bulb against the surface. Coefficient of friction was determined for multiplier onion bulbs on three surfaces: rubber, galvanized steel and plywood. (Oje and Ugbor, 1991). When the tangential force overcomes the frictional force between two surfaces, then the surfaces begin to slide relative to each other. In the case of a body resting on a flat surface, the body starts to move. The coefficient of sliding friction is generally lower than the static coefficient of friction.

Pretreatment for multiplier onion peeling: Optimization studies were carried out to study the effect of soaking time on the ease of peeling

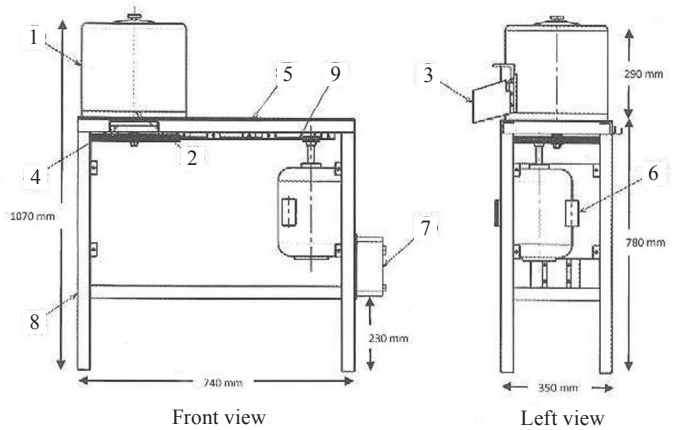
Fig. 1 Isometric view of multiplier onion peeler



Isometric view

1 = Peeling chamber; 2 = Removable inlet cover; 3 = Discharge chute for peeled multiplier onion; 4 =Outlet for peeled skin; 5 = Working platform; 6 = Motor; 7 = Starter; 8 = Outer frame

Fig. 2 Front view and side view of multiplier onion peeler



Front view Left view

1 = Peeling chamber; 2 = Removable inlet cover; 3 = Discharge chute for peeled multiplier onion; 4 =Outlet for peeled skin; 5 = Working platform; 6 = Motor; 7 = Starter; 8 = Outer frame

of multiplier onion The multiplier onion after cutting the top and the base was subjected to hand peeling to know the effect of the soaking on the loosening of the skin, so that the time of the soaking for mechanical peeling could be optimized. The standardization of the peeling parameters were carried out for the following grades of multiplier onion, which are commercially available in the market: 12 mm; 14 mm; 18 mm and 20 mm

Description of Batch Type Multiplier Onion Peeler

Based on the optimized parameters, a batch type multiplier onion peeler with centrifugal discharge was developed at the Research workshop of Regional Centre of Central institute of Agricultural Engineering, Coimbatore, India (**Figs. 1** and **2**).

The equipment consists of the following parts:

1. Peeling drum: The equipment consists of a cast aluminum alloy drum of size of 300 mm diameter and height 290 mm, and the drum is seated over a 300 mm diameter disc. The drum is mounted on a bearing shaft to enable smooth rotation (**Figs. 3** and **4**). Two bumps are provided on the circular base to break rotary movement of the multiplier onion on the lower portion and provide swirling action so that efficient peeling takes place.
2. Removable inlet cover: The outer inlet cover is used to cover the aluminum alloy drum when the equipment is in operation, so that the multiplier onion during the process of peeling does not spill out of the unit.
3. Discharge chute for peeled multiplier onion: An opening of 140 mm × 100 mm is used for discharge of peeled multiplier onion. The discharge gate is raised at the end of each peeling operation enabling centrifugal ejection of the product by the rotary motion of the disk. Manual unloading and separation of the peelings and product are avoided by this method, providing for faster and higher throughput operations. The outlet opening is located in proximity to the periphery of the abrasive disk and centrifugal force expels peelings from the processing chamber during the peeling operations.
4. Working platform. The working platform is used for keeping the samples to be peeled
5. Motor with a starter: A one hp single phase electrical motor with starter is used for the operating the equipment.
6. Outer frame: The whole assembly of drum and disc is mounted on a M. S. outer frame 740 mm × 350 mm × 780 mm

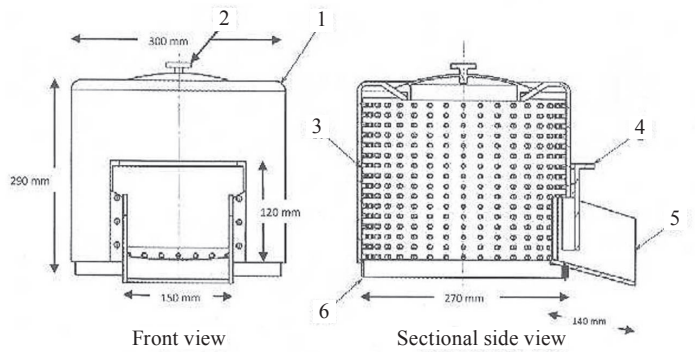
Optimization of Time of Soaking for Easy Peeling of Multiplier Onion

Soaking of multiplier onion eased the peeling operation. To standardize the time of soaking, 100 grams of different grade multiplier onion 12 mm, 14 mm dry, 18 mm dry and 20 mm wet were subjected to various soaking times of 5, 10, 15, 20 and 25 min for all the grades. After the fixed soaking time, the samples were removed and peeled manually and the time noted. The same person was used throughout the experiment with sufficient time in between two samples.

Optimization of the operational parameters viz., speed of operation of peeling drum and abrasive surface used as peeling material:

The peeling efficiency basically depends on the right choice of the abrasive material and the speed of operation. Different abrasive materials viz., plastic brushes of 2 mm, CI abrasive chips glued on the revolving disc and along inner wall and bottom surface of the peeling drum and rubberized mat were experimented. The rpm of the disc was reduced from 1,440 (1 hp single phase motor) to required speed by using a belt and pulley type of re-

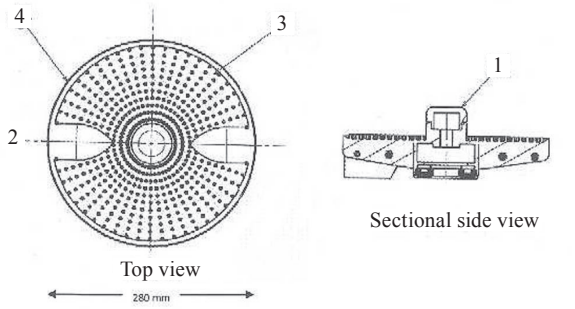
Fig. 3 Front view and sectional cross view of the peeling drum



Front view Sectional side view

1 = Peeling drum; 2 = Removable inlet cover; 3 = Peeling side surface; 4 = Sliding discharge cover; 5 = Discharge chute for peeled multiplier onion; 6 = Circular base plate

Fig. 4 Top view and sectional end vie of the peeling drum



Top view Sectional side view

1 = Drive spindle; 2 = Bumps; 3 = Lower peeling surface; 4 = Hub

duction system. Different speeds of rotation of the peeling drum viz., 720 rpm, 600 rpm, 300 rpm and 150 rpm were evaluated. The best abrasive surface was optimized based on percentage of multiplier onion peeled, unpeeled and damaged with respect to various speed of rotation of the peeling drum. The multiplier onion peeler was developed at the optimized abrasive surface and speed of operation.

Cost Economics

The data and information collected both on conventional method of peeling of multiplier onion and by using multiplier onion peeler were analyzed for cost of peeling. The cost of the multiplier onion peeler was assumed to be Rs 20,000 ($ 400) with the annual usage of 540 h. The life of multiplier onion peeler was 5 years with the salvage value of 10 percent. Straight line method was used for cost economic calculation with rate of depreciation of 10 percent. The fixed and variable costs for operating of the multiplier onion peeler were calculated as per the procedure enumerated by RNAM (Anon., 1983). The breakeven point and payback period of the equipment were also calculated.

Statistical analysis:

All the experiments were performed three times. Data were analysed by one way analysis of variance (ANOVA) to test the significance for peeling of multiplier onion.

Results and Discussion

Frictional Properties of Multiplier Onion (Co-3 Variety)

The rolling angle and coefficient of friction of the multiplier onion were recorded based on the different surfaces viz., rubber, plywood and galvanized steel. All the commercial grades viz., 12 mm, 14 mm, 18 mm and 20 mm were evaluated for these parameters. The average values are depicted in the **Table 1**.

It is seen that the rolling resistance increased with the increase in the size of the multiplier onion, whereas the coefficient of friction reduced with the size. Galvanized iron had the least rolling resistance followed by plywood and rubber. The frictional properties are useful to select the optimum peeling media during development of the equipment.

Optimization of Time of Soaking for Ease of Peeling of Multiplier Onion

Soaking of multiplier onion eased the peeling operation. The time required for peeling is given in **Table 2**. From the table it is seen that with the increase in the soaking time the time taken for peeling reduced. Beyond 10 minutes of soaking, there was no significant reduction in the peeling time. Hence, soaking time of 10 minutes was standardized for multiplier onion for mechanical peeling. By visual observation, it was also seen that when the soaking period was more than 10 minutes, there was a tendency of water to diffuse into the outer skin, which was not desirable.

Standardization of the Operational Parameters of Multiplier Onion Peeler

The operational parameters viz., the rpm of peeling drum, and type of abrasive material used on the inner surface of the peeling drum

Table 1 Rolling resistance and Coefficient of friction of multiplier onion of different sizes

Multiplier Onion Size	Rolling resistance, degree			Coefficient of friction		
	Rubber	Galvanized iron	Plywood	Rubber	G.I.	Plywood
12 mm	25.33 ± 0.57	21.07 ± 0.61	22.07 ± 0.23	1.01 ± 0.04	0.89 ± 0.03	0.96 ± 0.03
14 mm	26.15 ± 0.61	22.18 ± 0.47	23.96 ± 0.31	0.93 ± 0.02	0.83 ± 0.02	0.89 ± 0.02
18 mm	28.33 ± 0.55	24.56 ± 0.36	26.84 ± 0.19	0.88 ± 0.01	0.79 ± 0.01	0.83 ± 0.02
20 mm	31.58 ± 0.67	26.15 ± 0.41	30.33 ± 0.23	0.84 ± 0.01	0.74 ± 001	0.80 ± 0.02

Table 2 Optimization of the time of soaking to ease peeling of multiplier operation

Grade	12 mm dry		14 mm dry		18 mm wet		20 mm wet	
ST, min	Quantity (gms)	PT, min	Quantity (gms)	PT, min	Quantity (gms)	PT, min	Quantity (gms)	PT, min
Control	100	8.0[a]	100	7.9[a]	100	7.1[a]	100	7.0[a]
5	100	7.0[b]	100	7.5[b]	100	6.5[b]	100	6.3[b]
10	100	5.5[c]	100	5.3[c]	100	5.1[c]	100	4.7[c]
15	100	5.3[c]	100	5.2[c]	100	5.0[c]	100	4.6[c]
20	100	5.3[c]	100	5.2[c]	100	4.9[c]	100	4.5[c]
25	100	5.2[c]	100	5.0[c]	100	4.8[c]	100	4.5[c]
CD (0.05)		3.87		3.17		0.333		2.18

ST = Soaking time; PT = Peeling time

were standardized by actual experimentation. A batch of two kg of multipler onions with both ends cut and soaked for a period of 10 minutes (Ravindra Naik *et al.,* 2010) were fed in the equipment and operated at different speeds and with different abrasive materials coated on the inner surface of the drum. The equipment was operated for a period of 10 minutes (**Fig. 5**). The data are depicted in the **Figs. 6, 7** and **8**. From **Fig. 6**, it is seen that, for the plastic brushes, the best results were obtained at 300 rpm, where it gave 88 percent peeled, 6 percent unpeeled and 6 percent damaged multiplier onion. In the case of CI abrasive chips, it was 85 percent peeled, 5 percent unpeeled and 10 percent damaged multiplier onion at 300 rpm (**Fig. 7**). The best results were obtained by using rubberized mat, which gave 92 percent peeled, 6 percent unpeeled and 2 percent damaged multiplier onion (**Fig. 8**). In general the best results for all the three materials were obtained at 300 rpm. As the speed increased from 300 to 720 rpm, the percentage damage increased continuously. But at a lower speed of 150 rpm, although the percentage damage was lower or on par with that of 300 rpm, the percentage unpeeled was high. Thus, keeping a balance between the percentage peeled, unpeeled and damaged, the best results were obtained at 300 rpm for rubberized mat surface (**Fig. 9**) and it was adopted in the final design of the equipment

Unpeeled Multiplier Onion Sample Machine Peeled Multiplier Onion Sample

Cost economics of the equipment: Continuous long run trials of the equipment were carried out to obtain the cost analysis of the equipment (**Fig. 10**).

A batch of 2 kg of multiplier onion could be peeled in 2 minutes, giving the capacity of the equipment as 50-60 kg/h. The fixed cost was Rs. 5,450/year ($109/year) and working cost Rs. 20,625-22,000/year ($375-

Fig. 5 View of the multiplier onion peeler

Fig. 6 Performance evaluation of batch type multiplier onion peeler with plastic brushes as abrasive peeling media

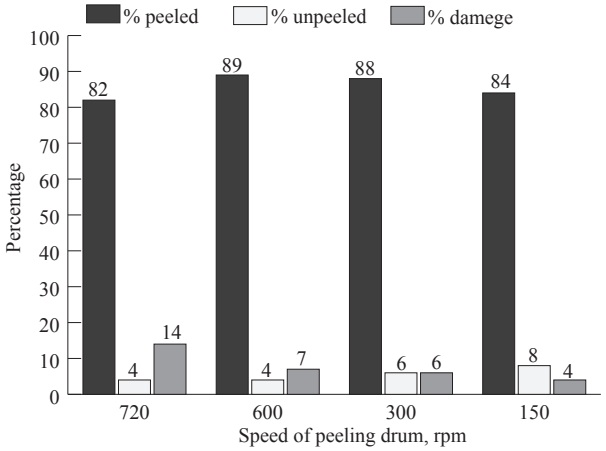


Fig. 7 Performance evaluation of batch type multiplier onion peeler with CI chips as abrasive peeling media

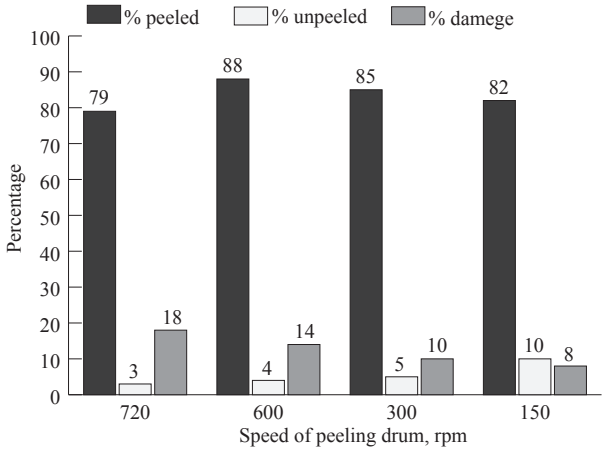
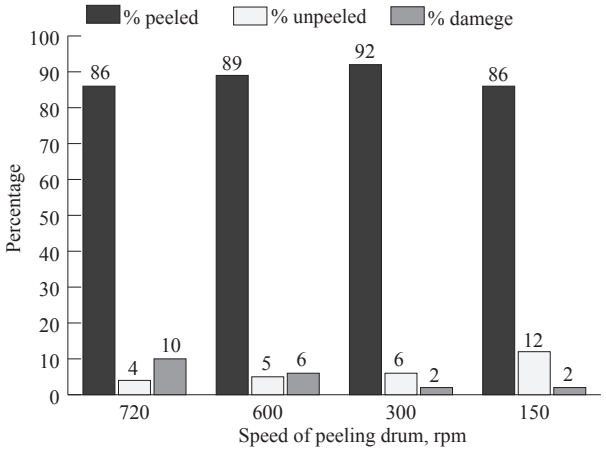


Fig. 8 Performance evaluation of batch type multiplier onion peeler with rubberized mat as abrasive peeling media



400/year). The cost of peeling was Rs. 1,250 per tonne ($25 per tonnes). The savings in cost and a savings in time was about 68 and 69 percent, respectively. The breakeven point of the developed multiplier onion peeler was 38.50 percent of annual utility and the payback period was 1.40 year. Thus, this equipment could be adopted by small and medium multiplier onion processing industries

Conclusion

Soaking time of 10 minutes was standardized for soaking of the multiplier onion for mechanical peeling. The best results were obtained by using a rubberized mat, which gave 92 percent peeled, 6 percent unpeeled and 2 percent damaged multiplier onion (**Fig. 8**). A peeling drum with 300 rpm gave the best results for all the three materials. A multiplier onion (Onion aggregatum) peeler of 50-60 kg/h has been developed with these optimized parameters for small and medium processing industries. The peeling efficiency was 92 percent with unpeeled and damaged percentage to the tune of 6 and 2 percent, respectively.

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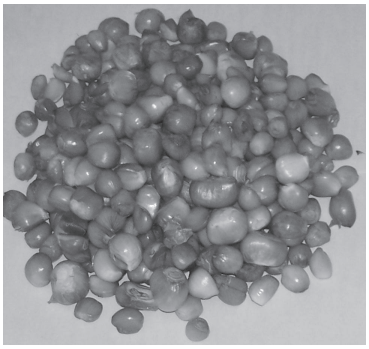
Fig. 9 Unpeeled and machine peeled multiplier onion samples



Unpeeled multiplier onion sample

Machine peeled multiplier onion sample

Fig. 10 Continuous long trials of batch type multiplier onion peeler with centrifugal discharge