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Design and fabrication of pedal operated integrated potato peeler and slicer

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Abstract
The process of peeling and slicing of potatoes are labour-intensive and is a time-consuming operation done manually mostly by woman labour. To reduce the labour, human contamination and time requirement, a pedal operated integrated potato peeling machine with slicing unit was fabricated and its performance was evaluated. The main parts of the machine are a peeling drum, slicing unit, water spraying unit and drive mechanism. The peeling drum with silicon abrasive material coated inside surface rotates and detaches the peel from potatoes by abrasion. The slicing unit slice the peeled potatoes in uniform thickness by using two blades. The water spraying unit washes the potatoes and simultaneously peel is removed from the drum through water outlet.
Peeling and slicing trials were conducted for varying drum loads (200g, 350g, 500g, 650g& 800g), for varying drum speeds (70rpm & 80rpm) and for different peeling durations (15sec, 30sec, 45sec & 60sec) to determine the peeling loss and rate of slicing. It was found that peeling and slicing of potatoes using this machine is associated with minimum material loss. The machine cost is around Rs. 7,110/-. The capacity of this machine is 60 kg's per hour. It is suitable for small scale food processor of potato chips, hotels, restaurants. The estimated cost of peeling and slicing of potatoes is only Rs. 1.43/- per kilogram.

Keywords: Peeler, slicer, pedal operated and abrasion drum

Introduction
Potato (*Solanum tuberosum* L.) is one of the most important Solanaceous tuber crop and grown in more than 125 countries (Tsegaw, 2005. and FAO, 2008) [7, 3]. Potato is consuming almost daily by more than a billion people and used as vegetable, stock feed and in industries for manufacturing starch, alcoholic beverages and other processed product. Its cultivation is mounting strongly in the developing countries accounted for about 31.66%, where the ease of potato cultivation and nutritive content has made it a valuable food security and cash crop for millions of farmers. Potato tuber contains about 80% water and rest is dry matter. Starch is the major component of the dry matter portion accounting for about 70% of the total solids (Dutt, 2008) [2]. It contains starch (13-16%), protein (2%), total sugars (0-2%), fibre (0.6%), lipids (0.1%), vitamin C (31 mg/100 g fresh weight) and ash (1-1.5%) as reported by (Shekhawat in 2001 and Mohammad *et al*. 2017) [6, 5].
The potato ranks fourth after wheat, maize and rice (FAO, 2008) [3] in global production. It is second only to maize in terms of the number of countries that grow potato. Its importance as food is well recognized in European countries. In the developed countries a large portion of potatoes is consumed in the processed form in addition, the potato contains fiber, vitamins and glycol alkaloids in small quantities. French fries and chips arc the most popular processed products of potato. Hence, appropriate processing technology and equipment are essential to produce potato food products. It will help to reduce the losses and generate income and employment in the rural or semi-urban areas (Tyagi *et al.* 2018) [8].
Peeling and slicing are important unit operations of the processing technology. Manual peeling and slicing are possible for any kind of product but, high losses are considerable consumption of time and labour have encouraged the peeling and slicing industries to use other methods. Mechanical, thermal, chemical peelings are conventional methods (Luh and Woodroof., 1988) [4], each of which has its own benefits and limitations. Among the current methods, mechanical method can attract the satisfaction of the consumer as this method possess some important benefits of the ideal method such as freshness of the peeled product. As the mechanical peeling reduces the energy expended and chemical usage to peel the vegetables so, mechanical methods have much scope to research (Bagher Emadi, 2005) [1]. Keeping in view, the satisfaction of the consumers, time consumption for peeling and slicing, drudgery of human

labour, the present pedal operated integrated potato peeler and slicer was developed.

Materials and Methods

A pedal operated integrated potato peeler and slicer was developed at the College of Agricultural Engineering, Sangareddy under Professor Jayashankar Telangana State Agricultural University, during 2019. The developed pedal operated integrated potato peeler and slicer consists of a peeling drum, slicing unit, and water spraying unit. The peeling drum, with protrusion on the inside surface, rotated and detached the peel from the potatoes and simultaneously, the peel was removed from the drum through the peripheral clearance of the drum along with the flow of water. The mitre gears, transmission shafts and chain drives were significant parts of the machine.

Material selection

Material selection is utmost importance to ensure that the components to be fabricated have the desired performance requirements. Since different components of the pedal operated integrated potato peeler and slicer will be subjected to varying loads, speeds, torque and frictional effects, materials with appropriate engineering properties must be chosen.

Peeling Drum and Shaft Assembly

The peeling drum was made from a mild steel metal sheet. The sheet was cut in to the dimension of 942 x 400mm. The sheet is then folded into a cylindrical shape and then welded along the edges and is joined using electric arc welding. The drum was coated inside with silicon abrasive material, which was purchased from the market.

Also, a circular base was made by cutting out the circular shape from mild steel and then welded along the edges to join circular shape base to the cylindrical drum by using electric arc welding and silicon abrasive material is coated inside the drum to peel off the potatoes. A hole of diameter 2.5cm was drilled in the circular base to mount the shaft. Such that one end is connected to the flanged bearing and another end is connected to rotating blade. A bevel gear of 2.5cm diameter is attached to the peeling shaft to run the mechanism. A door of dimensions 160x100mm is provided to collect the peeled potatoes.

Slicing Unit and Shaft Assembly

This consists of the slicing disc, two blades and the shaft. The slicing unit, disc and shaft are made of mild steel metal. A circular disc of 30cm is cut using sheet cutters and two stainless steel blades of length 25cm each are fitted to the disc facing in opposite direction to slice the peeled potatoes.

A hole of diameter 1.5cm was drilled in the slicing disc to connect the shaft through a nut bolt. Such that one end of shaft is connected to the slicing disc and another end is connected to bevel gear. So that two bevel gears are interlocked in perpendicular direction.

Main frame

Angular iron made of mild steel was used. Four lengths of 62cm each were cut to make legs of the frame for comfortable operation and also four lengths of 60cm each, were cut to support i.e., two for the top length and the remaining two for the peeling compartment. Five pieces of 32cm each were cut to support flange bearing and two pedestal bearings of 2.5cm diameter each. These parts were carefully welded using electric arc welding.

Chain and Sprocket wheel mechanism

This assembly consists of two sprocket wheels of different of teeth's and chain. These components have been purchased from the market as they are readily available and costly to make them in the workshop. Two sprockets of 18 and 60 teeth were selected.

A small sprocket of 18 teeth's and having diameter of 6cm is fitted to the slicing shaft. Large sprocket of 60 teeth's and having diameter 23cm is fitted to the bicycle. The two sprockets are connected with the help of chain mechanism. The power is transmitted from one sprocket to another through chain mechanism when pedals are operated. Care was taken so that the chain is enough to rotate.

When pedals are operated the power is transmitted to slicing shaft to peeling shaft with the help of chain and sprocket mechanism. This enables the peeling blade and slicing disc to rotate. Simultaneously the potatoes in the drum rotates due to rotating motion of the peeling shaft and then peeling takes place due to the inner silicon abrasive material of the drum. These are seat out through the outlet. The peeled potatoes are then allowed to the slicing unit through a pipe when door was opened. Due to the rotation of the slicing blades, the potatoes are sliced into thin layers and collect from the bottom.

Water supply system

It consists of a plastic water tank with tap and supporting frame. The supporting frame is connected to the main frame through nuts and bolts. Water tank is placed in the supporting frame at a height of 60cm above the drum through which the water is jetted into the peeling drum to facilitate the peeling and cleaning of the potatoes efficiently.

Principle of operation

Every component of the pedal operated integrated potato peeler and slicer was fabricated in such a way as to give strength and stability to the system during operation for efficient output. The machine was operated by the pedal and sprocket mechanism.

The developed pedal operated integrated potato peeler and slicer consists of a peeling drum, slicing unit, and water spraying unit. The peeling drum, with protrusion on the inside surface, rotated and detached the peel from the potatoes and simultaneously, the peel was removed from the drum through the peripheral clearance of the drum along with the flow of water. The peeled potatoes are entering into the slicing unit where slicing of potatoes takes place. The mitre gears, transmission shafts and chain drives were significant parts of the machine.

(a) (b)

Fig 1: Fabrication of pedal operated integrated potato peeler and slicer (a) front view, (b) side view

Experimentation methodology

It has been observed during the preliminary trials that various factors influenced the peeling and slicing operation of the potatoes. The parameter such as peeling duration, shaft speed, sphericity of the potato and input feed rate effected the most on peeling and slicing.

To understand the effect of these parameters. Experiments were carried out, the independent parameters and dependent parameters thus selected are given in Table 1.

Table 1: List of variables selected for experimentation

Variables	units	Levels
Independent variables		
1. Input mass	g	200, 350, 500 and 650
2. Rpm of the shaft	rpm	70 and 80
3. Operating time	s	15, 30,45 and 60
Dependent variables		
1. Peeling loss	g	

Results and Discussions

Pedal operated integrated potato peeler and slicer machine was designed and fabricated. The design specifications of the machine were presented in Table 1. Experiments on peeling and slicing of potatoes are conducted by varying loads and speeds for different durations. The developed machine was evaluated to optimize the peeling loss and slicing thickness.

Effect of shaft speed and peeling duration on peeling loss

As the peeling duration varied from 15sec to 60sec for varying shaft speed from 70rpm to 80rpm based on gender at constant load of 203.7g, 357.4g, 505.7g and 654.6g, the peeling loss increased from 1.37g to 22.72 g and 4.05 g to 24.91g, 0.95g to 18.52g and 5.12g to 40.08g, 2.13g to 21.11g and 1.44g to 29.96g and 3.22g to 24.77g and 2.23g to 30.65g respectively Fig. 2. The peeling loss thus increased with increase in the shaft speed and peeling duration at a constant load.

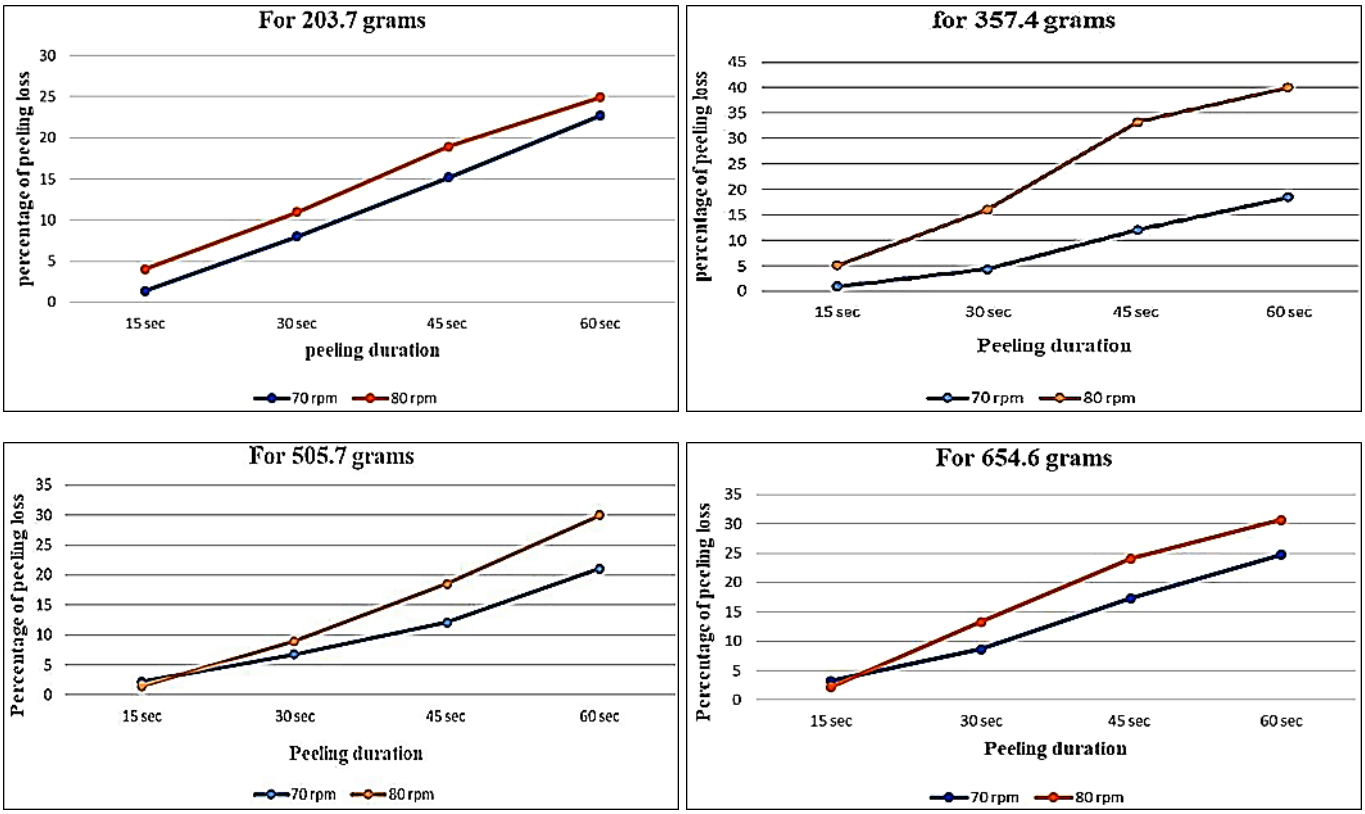

Fig 2: Effect of shaft speed and peeling duration on peeling loss of potato at constant load of 203.7g, 357.4g, 505.7g and 654.6g respectively

Effect of shaft speed and peeling duration on sphericity

As the peeling duration varied from 15sec to 60sec for varying shaft speed from 70rpm to 80rpm based on gender at different loads of 203.7g, 357.4g 505.7g and 654.6g, the sphericity of potatoes are decreases as duration of peeling increases. But at a certain time sphericity of potatoes decreases as time increases due to loss of flesh in potatoes.

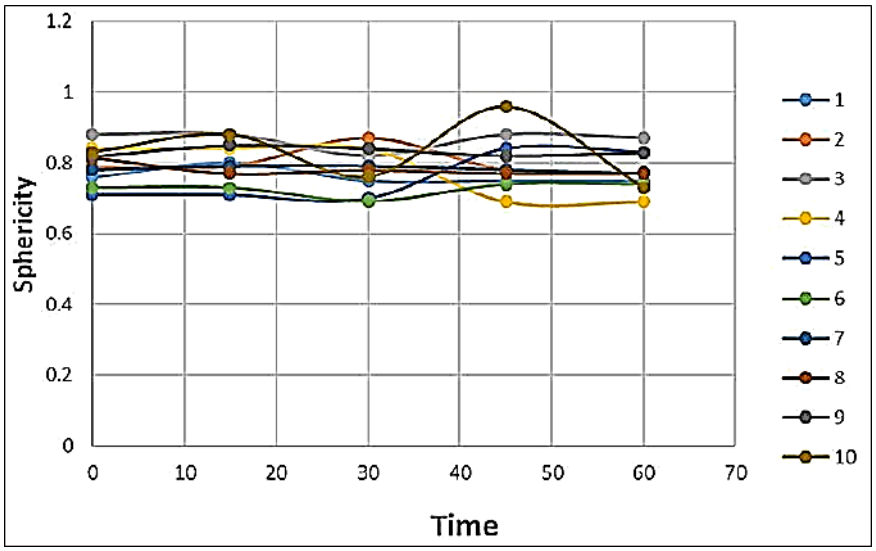

Fig 6: Effect of shaft speed and peeling duration on sphericity of potatoes

Conclusion

The peeling and slicing losses decreased with increasing the drum load and increased with increasing the peeling duration at uniform speed. From the observations, it has been found that at a speed of 70rpm for a load of 350g for duration 30sec is the best combination because of minimum peeling loss and higher slicing rates. Hence, it is concluded that for this pedal operated integrated potato peeler and slicer machine 350g load is recommended at 70rpm for duration of 30sec for best results as more potato can be processed.

The cost of fabrication of the pedal operated integrated potato peeler and slicer machine has been estimated to be Rs. 7,110/. An economic analysis was calculated for peeling and slicing potatoes by comparing the machine cost with traditional hand peeling and slicing.

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