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Design and Fabrication of Garlic Peeler

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***Abstract*—** *Garlic is an important and economical plant. It has many uses in medicinal, culinary and ayurvedic purposes. Garlic peeling is a tedious, time consuming and laborious work. So far, traditional peeling methods are used for garlic peeling. These methods are observed to be unhygienic, laborious and caused high damage to garlic segments. Mechanical peelers available are costly and not affordable to small scale industries. Since, the traditional methods are laborious and mechanical methods are costly there is a need to develop low cost, mechanical peeler that will reduce the drudgery.*

Angular iron and flat iron was used for main frame and supporting the main units. A food grade rubber and mild steel pipe was used for rubber roller. Iron bar was used for shaft. A wire mesh was used as screen. Dimensions of garlic segments were measured using digital vernier callipers and weight of each garlic segment was measured using electronic balance. Moisture content, orthogonal dimensions, weight, geometric mean diameter, sphericity, equivalent mean diameter, shape factor, terminal velocity and drag coefficient of garlic segments were found.

Moisture content of garlic segments was 59.36±0.87% (w.b). At this moisture content, average length, width and thickness of garlic segments were found to be 25.818 3.743 mm, 10.116 2.209 mm and 7.34 1.638 mm, respectively. Average weight of individual garlic segments were found to be 1.159 g. Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of garlic segments were found out to be 12.422 mm, 0.481, 13.03 mm and 0.218, respectively. The terminal velocity and drag coefficient were 18.941 m/s and 0.416 at moisture content of 59.08 ± 0.82% (w.b.). Cost of peeler was estimated to be about ₹ 10,005/-.

***Keywords*— Garlic, peeler, cylinder-conclave.**

I. INTRODUCTION

Garlic *(Allium sativum* L.), an underground perennial bulb, is an important vegetable spice belonging to the family of Liliaceae. The bulb is a cluster of 12 or more segments called cloves, which are swollen leaf bases. Cloves, as well as, whole bulb are surrounded by a thin papery white skin. Cloves are the economical and edible part of garlic plant. Garlic is widely used for culinary and medicinal purposes. It is a strong source of phenolic compounds, phosphorous, sulphur, zinc, selenium and vitamin A and C and also low levels of calcium, sodium, ferrous, manganese and vitamin B (Grégrová *et al*., 2013*)*.

Garlic is cultivated for centuries all over the world including Asia. India is one of the leading producers of garlic with an area of 238.760 thousand hectares producing 3221.380 thousand tons during the year 2013-14 (Spice Board of India, 2014). As per Spice Board of India, Gujarat stood first by producing 277.455 thousand tons of garlic during the year 2011-12. Madhya Pradesh, Uttar Pradesh, Rajasthan, Assam, Punjab and Maharashtra are other leading garlic producers in the country.

Garlic is consumed as green, as well as dried in the spice form and as an ingredient to flavour the vegetarian, non-vegetarian dishes and pickles. Good tasty pickles, chutneys, curry powders are prepared from garlic cloves. It is also used to disguise the smell and flavour of salted meat and fish. Dehydrated garlic in powdered or granulated form is being used in place of fresh bulbs in many countries (Mishra *et al*., 2014).

Garlic processing involves bulb breaking, peeling, dehydration, grinding and other unit operations. Garlic peeling is one of the most important and essential key unit operations prior to any subsequent processing activity. During garlic peeling, the thin membranous skin, inedible part is to be removed off from the segments. Typical size of the cloves makes the peeling to be very tedious and time consuming operation. Traditional peeling methods,

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including hand peeling, flame peeling, oven peeling and chemical peeling (Dhananjay *et al*., 2015).

An efficient peeling device is, therefore, required to gently peel off the skin from garlic clove without any adverse effect on its shape, structure and aroma. Many researches had worked on development of machine operated garlic peeler. Manjunatha *et al*. (2012) developed machine operated garlic peeler by using cylinder and concave concepts. The machine is power consuming, heavy and costly to consumer acceptability. To overcome these problems and cater the needs of garlic peeling in an easier manner, this study was undertaken with the main objective of development of a garlic peeler. Small capacity, hand operated, operator friendly garlic peelers are very much essential to consumers. To meet this objective, work has been undertaken to fabricate hand operated garlic peeler and to a) Study of physical characteristics of garlic segments or cloves b) Selection of engineering materials for fabrication of garlic peeler and c) Design of hand operated garlic peeler. The proposed development of a garlic peeler could alleviate the problems faced by traditional garlic peeling methods and aid in boosting the processing and export of garlic and its products. The machine will be reducing the time of peeling of garlic.

II. MATERIALS AND METHODS

Materials used were garlic segments, angular and flat iron, galvanized iron sheets, iron rods, bearings, wire mesh, blower, handle and pulley.

Fresh, well matured and cured garlic were procured from local market of Bapatla, Guntur Dist., A.P. Bulbs were broken by hand and uniform sized segments are graded manually after blowing the thin papery skin of segment. Materials used for fabrication of peeler were procured from local hardware stores of Bapatla, Guntur Dist., A.P.

Moisture content of garlic segments was measured by hot air oven method. Three samples of garlic segments of 15 g each were taken into moisture boxes and placed in hot air oven (Yorco, Model: YSI-431) at 100-105ºC with lid open for 2h which was cooled in a desiccator with closed lid for 15 min later. Weight of the sample was taken when weight remained constant (AOAC, 2000). And calculated by using formula

$$MC = \frac{\text{Initial Weight of Sample-Final weight of sample}}{\text{Initial weight}} \times 100$$

Dimensions of garlic segments were useful in designing peeling machine as size affects the cylinder-concave clearance. To determine these dimensions, ten groups of samples consisting of 100 garlic segments were randomly selected. Ten segments were selected from each group and the three principal dimensions (length, width and thickness of garlic segments) were measured using digital vernier callipers with an accuracy of 0.1 mm.

The Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of the garlic segments were calculated using the following formulae.

$$\text{Geometric mean diameter } (D_g) = (LWT)^{1/3}$$

$$\text{Sphericity } (\phi) = \frac{(LWT)^{1/3}}{L}$$

$$\text{Equivalent mean diameter } (D_e) = \frac{(6\,V_{single})^{1/3}}{\pi^{1/3}}$$

$$V_{single} = \frac{100\ grain\ weight}{PD\ X\ 100}\ 10^6$$

$$\text{Shape factor } (Z) = \frac{\pi}{6}\ \frac{D_g{}^3}{D_e{}^3}\ \phi$$

Where
Dg = Geometric mean diameter (mm)
L = Longest intercept (mm)
W = Longest intercept normal to L (mm)
T = Longest intercept normal and W (mm)
De = Equivalent mean diameter (mm)
Vsingle = Volume of single particle (mm^2)
PD = Particle density (kg/ m^3)
ϕ = Sphericity
Z = Shape factor

The terminal velocity of garlic segments was measured in wind tunnel using a verticular column duct. This method produced air current in a vertical duct of diameter 39.07 mm, using centrifugal pump, for garlic segments to be floated. A tube of diameter 82.97 mm was attached at axis of centrifugal pump. The vertical duct has the provision for varying air stream. For each test, a small sample was placed in the duct and air velocity was increased gradually till the segments get suspended. Then the velocity of air in the tube at the point of suction was measured using digital anemometer. Velocity of air in the vertical duct was measured using

$A_1 V_1 = A_2 V_t$

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where,
A1 = cross sectional area of tube (m2)
V1 = velocity of air in the tube (m/s)
A2 = cross sectional area of vertical duct (m2)
Vt = terminal velocity of air in the vertical duct (m/s)
Drag coefficient was calculated using the following formula

$$C_d = \frac{2\,mg\,(\rho_p - \rho_a)}{V_t^{\,2}\,\rho_a\,\rho_p\,A_p}$$

where,
m = Mass of single particle (kg)
g = Acceleration due to gravity (m/s^2)
Vt = Terminal velocity (m/s)
p = Particle density (kg/m^3)
a = Density of air (kg/ m^3)
Ap = Projected area of particle (m^2) = $\frac{\pi}{4} D_e^{\,2}$
De = Equivalent mean diameter (m)

III. MATERIALS USED IN FABRICATION OF GARLIC PEELER

Hand operated garlic peeler consisted of hopper, cylinder-concave unit and blower. Peeler works on the principle of the cylinder-concave mechanism. The cylinder surface covered with rubber and it was called as rubber roller. Rubber roller (cylinder) rotated against a fixed screen which was attached to the fixed concave as a result of which the garlic segment got peeled off primarily due to shearing action with slight compression.

Hopper, a rectangular box with one side vertical and other, tapered towards the bottom was designed to facilitate easy flow. The feed hopper was made from 1mm galvanised iron sheet. Length of hopper was 180 mm, breadth 100 mm and a height of 170 mm and 100 mm on either sides of hopper. Bottom opening was 50 mm wide with a length of 180 mm. This arrangement will uniformly spread segments on cylinder to rub against concave. Hopper was facilitated with a galvanized iron sheet was facilitated to regulate flow of segments into cylinder.

Rubber roller consisted of a hollow mild steel tube with both sides closed with caps. Total length of tube was 220 mm with a diameter of 62.5 mm. A food grade silicon rubber of 180 mm length and 6 mm thick was covered on the tube. Thin wires of 1 mm thickness were glued along the length of rubber at a distance of 10 mm apart as shown in fig.1

Iron shaft was welded to caps of cylinder to attach on frame using bearings. Shaft was designed to fit the requirements of different drives. One end was facilitated with provision for attaching handle for imparting drive. Other end was made to 20 mm diameter to attach pulley to transfer drive to blower.

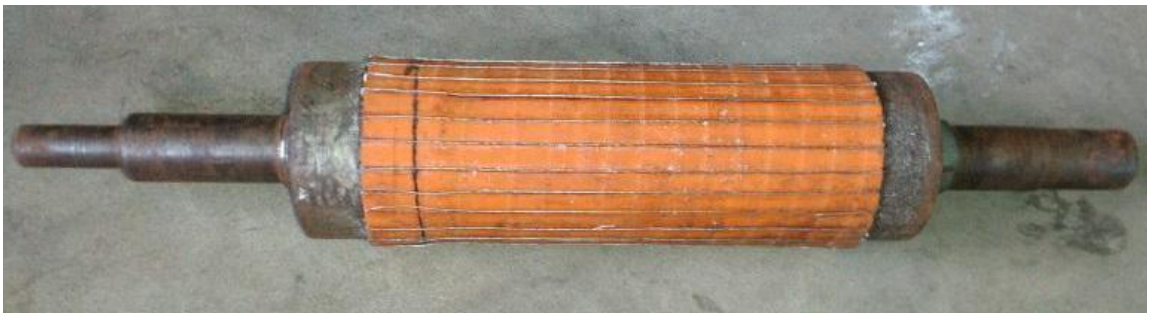

Fig.1: Rubber roller and shaft

Concave was made up of flat iron of 25mm width and 3mm thick rods. A frame of dimensions 225mm length and 200mm breadth was made using flat iron and rods were wielded across the frame at a distance of 10mm. The frame was bent on anvil to match the curvature of rubber roller.

A wire mesh of thickness 1 mm with an opening size of 1 mm^2 was used as screen for abrasion surface. It was cut into 230 × 200 mm and fastened on concave.

Main frame of the garlic peeler was a trapezoidal structure made of angular iron. Height of the main frame was 580mm. The bottom rectangular frame of main frame was 400 × 470mm. The upper frame was 300 × 370mm. The frame was designed by looking into convenience of operator and to accommodate exit chutes and blower.

Blower used was a smithy blower made of cast iron. The blower had a circular mouth outlet. The drive to it was taken from shaft of cylinder. The pulley of blower was 25 mm in diameter where as shaft was 50 mm.

IV. FABRICATION OF MACHINE

Main frame of garlic peeler supported three units, i.e, feeding unit, concave-cylinder unit and blower. Angular iron was arc wielded according to the said dimensions to

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main frame. Angle frame of 80 mm height and 200 mm length bent in C-shape was wielded to two opposite sides of top face of frame. This angle frame was wielded such that, leaving horizontal face for fitting bearings by fasteners.

Feeding unit consists of hopper that was spot welded to a side of cylinder- concave unit. A feed regulator of thin flat sheet was provided to manage and avoid spillage of segments. It was a 1mm thick galvanized iron sheet that could be moved up or down to open or close the hopper opening upon feed requirement. A small galvanized iron plate was placed slanted between hopper opening and concave. This provision allowed flow of segments into the clearance between concave and rubber roller. It prevented jumping of segments off the roller. Hopper was placed slightly to a side in slanting position.

Cylinder-concave (Fig.2) unit consisted of rubber roller, concave, wire mesh and cylinder. A shaft passed through the rubber roller and extended from caps of roller for other provisions. This shaft was passes through 32mm diameter bearings (Fig.3) situated on either side on angle frames. Wire mesh was fastened on to the concave. Concave-screen was placed beneath rubber roller. The clearance between roller and concave was fixed as 20mm on the feeding side and at the outlet side it can be adjustable from 8 to 12mm by the nut and screw mechanism provided beneath the concave. Clearance between concave and rubber roller was fixed using two wooden pieces of thickness 8mm and 20mm. A 20mm wooden piece was placed on the roller near inlet of cylinder while 8mm was placed on the roller near the bottom outlet. These pieces were then tied with a rope to keep them in place. Concave was then adjusted and arc wielded at that position on the top side. At the bottom screw and nut arrangement was provided so as to vary the clearance between concave and roller. The clearance could be decreased by rotating the screw clockwise and increased by rotating the screw anti-clockwise. The concave and nut-screw mechanism was supported by two rings made of flat iron placed on either side of rubber roller.

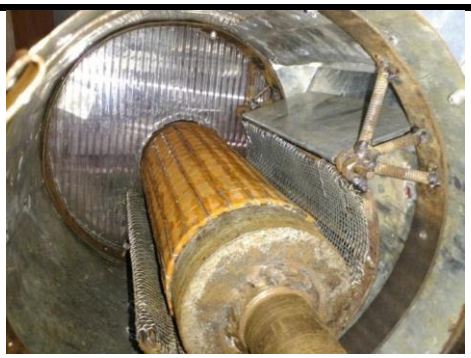

Fig.2: Cylinder-concave unit

Fig.3: Bearing

One side of shaft was facilitated for handle attachment to give drive, whereas, other side was for pulley. The whole concave and rubber roller unit was housed inside a cylinder of diameter 210mm and 270mm length. To support and hold the cylinder in place, flat iron was bent to cylinder shape and arc wielded to main frame.

Blower was placed at a height of 120 mm from the bottom frame. Chutes were made of 1 mm thick galvanized iron sheet. A chute was spot wielded to cylinder at the outlet, with a dimension of 170 × 50 mm at the top and then, it was tapered to 80 × 50 mm. This chute was attached to another chute coming from blower of 420 × 50 × 50 mm. At a distance of 80 mm from blower another chute of 130 × 80 × 50 mm was welded.

Garlic segments were fed into hopper, which flow through the clearance between concave and rubber roller. After undergoing abrasion, peeled and unpeeled segments along with peel flow through the chute into the chute from blower. Here the peel was blown away by air while peeled and unpeeled segments roll down into the outlet chute. Unpeeled garlic segments were manually separated from peeled segments and were fed again into the hopper. Fig. (4) and Fig. (5) are the front and side views of peeler, respectively.

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Fig.4: Garlic Peeler (Front view)

Fig.5: Garlic peeler (Side view)

V. RESULTS AND DISCUSSION

Moisture content of garlic segments was found to be 59.36 ± 0.87% (w.b.). Average length, width and thickness of garlic segments were found to be 25.818 3.743, 10.116 2.209 and 7.34 1.638 mm, respectively, at moisture content 59.36±0.87% (w.b.). This helped in determining the clearance space between concave and rubber roller. Average weights of individual garlic segments were found to be 1.159 g at a moisture content of 59.36±0.87% (w.b.).

Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of garlic segments were found out to be 12.422 mm, 0.481, 13.03 mm and 0.218, respectively, at moisture content of 59.36±0.87% (w.b.). At moisture content 59.08±0.82% (w.b.), terminal velocity and drag coefficient were calculated to be 18.941 m/s and 0.416, respectively. The terminal velocity is useful parameter in designing blowers for aeration and separation of lighter materials like peel, husk etc.

Cost of Peeler

Cost of peeler was ₹ 10,005/- The cost of each material used is given in

Sl. No	Material	Cost (₹)
1	Shaft	260
2	Mild steel cylinder	430
3	Caps	330
4	Handle	200
5	Pulley	150
8	Bearings	900
9	Angular Iron	750
10	Flat Iron	750
11	Galvanized iron sheet	1,500
12	Wire (3 mm)	250
13	Wire mesh	515
14	Fastners	200
15	Blower	650
16	Rubber	1,000
17	V-Belt	120
18	Fabrication labor charges	2,000
	Total	**10,005/-**

VI. SUMMARY AND CONCLUSIONS

Moisture content of garlic segments was 59.36±0.87%(w.b). At this moisture content, dimensions of garlic segments were measured using digital vernier callipers and weight of each garlic segment was measured using electronic balance. Average length, width and thickness of garlic segments were found to be 25.818 3.743, 10.116 2.209 and 7.34 1.638 mm, respectively. Average weight of individual garlic segments were found to be 1.159 g. Geometric mean diameter, sphericity, equivalent mean diameter and shape factor of garlic segments were found out to be 12.422 mm, 0.481, 13.03 mm and 0.218, respectively. The terminal velocity and drag coefficient were 18.941 m/s

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and 0.416 at moisture content 59.08±0.82% (w.b). Cost of peeler was estimated to be around ₹ 10,005/-.

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