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Performance evaluation of garlic bulb (*Allium sativum*) breaker

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Abstract
After onions, garlic is one of the most popular Alliums in culinary application. The edible part of this plant is a complex bulb. Foods preserved in this manner have a long history in India and other Middle Eastern countries. Peeled garlic cloves are the most common form of garlic consumption, even though that garlic bulbs are also widely farmed. Garlic bulbs are traditionally rubbed between palms, beaten against jute bags, or beaten with a wooden stick to separate the cloves. These conventional approaches require a lot of time and effort. Therefore, the College of Technology and Agriculture Engineering at Rajasthan Agricultural University, Udaipur, creates a machine to separate garlic cloves. The 1.0 hp single phase electric motor powered the breaker's hopper, rotating cylinder, grated concave, aspirator, collection unit, and power transmission unit. The garlic bulb breaker was tested at three different Feed rates (144, 180, and 240 kg/h) and three different roller speeds (260, 390, and 520 rpm). This machine could break 163.80 kg per hour. Using Analysis of Variance (ANOVA), we found that the best performance was achieved at 390 rpm with 180 kg/h feed rate, with 74.16% separation efficiency of single clove attained and little damage to the garlic cloves.

Keywords: Garlic bulb, size reduction, garlic cloves, performance

1. Introduction
When it comes to Alliums, garlic is second only to onion in terms of its widespread use (Kendler, B.S., (1987) [4]. Almost everywhere you go, you'll find garlic being utilized as a flavor or condiment because of its strong and spicy taste (Benjamin, H.S. *et al*. (1983) [2]. In 2013-14, India harvested a total of 19401, 69 metric tons of garlic from 1, 203, 59 hectares (ha), with an average yield of 16, 12 t/ha (NHB, 2015). Garlic cloves that have been peeled can then be used to create a variety of garlic-based value-added goods. The garlic bulb must be broken in order to maximize the efficiency with which the garlic cloves can be extracted. The demand for garlic cloves is extremely high both in the United States and abroad. Commercial quantities of garlic cloves are readily available. One clove can be used to grow new garlic bulbs. The success of seedling growth and establishment is crucial to crop productivity. As a result, having sufficient planting material available during the planting season is crucial. A single garlic bulb can contain anything from six to twenty individual cloves. Garlic cloves are removed from their bulbs by smashing them. Traditional methods for separating garlic cloves involve pressing the bulb of garlic between your palms, against jute bags, or beating it with a wooden stick. The conventional techniques require an enormous amount of time and effort to complete (Mudgal *et al*. 2009) [8]. A mechanical garlic bulb breaker was designed and tested to meet the high demand for garlic cloves.

2. Materials and Methods
Garlic cloves are traditionally extracted from the garlic compound bulb using shearing and impact forces. Based on this idea, the garlic bulb breaker was created.

2.1 Selection and Procurement of Garlic
Since GG-4 is the most popular cultivar among Saurashtra's farmers, we chose it to be the focus of our research (Gujarat). Only the fully developed, cured, whole, and healthy bulbs of garlic were chosen. (Ahmed, J. *et al*. (2001) [1]

2.2 Constructional Detail of the Garlic Bulb Breaker
The existing garlic bulb breaker had the following basic components: a hopper, a hollow rotational cylinder, a grated concave, an aspirator, a collection unit, and a power transmission

unit with a 1.0 hp single phase electric motor. The hopper can store 5 kg of material and has a trapezoidal base (100 mm) and a rectangular top (215 mm). The MS hollow cylinder (500 mm in length, 200 mm in diameter, and 4 mm in thickness) with four corrugated wooden batten (500 mm in length, 50 mm in width, and 20 mm in thickness) at a 90° angle to each other (Manjunatha, M., *et al*. (2014) [7]. For effective bulb breaking, a 6 mm MS plate concave was used, and the clearance between the cylinder and concave was maintained at 25 mm at the top at the feeding end, tapering down to 15 mm at the bottom. The discharge channel featured two 610 mm by 300 mm Gl sheet 20 gauge oscillating screens (Lee, J.S. *et al*. (2007b) [6]. The cleaning holes in the upper and bottom screens were 18.3 mm and 12.3 mm, respectively. The primary frame measured in at 1230mm in length, 580mm in width, and 920mm in height (Lee, J.S. *et al*. (2007a) [5], Mudgal, V.D. *et al*. (2011) [9].

2.3 Experimental Procedure

A first trial was performed after the machine had been cleaned and overhauled to ensure its smooth and trouble-free operation. During the testing, both the operation and the output quality were evaluated closely, and any necessary adjustments were chosen. The garlic bulb breaker's effectiveness was measured after a number of planned adjustments were made.

2.4 Performance evaluation (Mudgal, V.D. *et al*. (2009) [8]

The effectiveness of clove separation, output capacity, and loss were used to rate the performance of the garlic bulb breaker. A garlic bulb breaker's separation effectiveness, output potential, and losses were assessed as it was operated at various rotational cylinder speeds and feed rates (in kilograms per hour). Table 1 lists the specifics of various treatment combinations. There are a total of 5 dependent parameters in this study, including single clove separation (%), machine output capacity (kg/h), clumps of 2-3 cloves (%), clumps of 4-6 cloves (%), and damaged/broken cloves (%). There are also a total of 4 independent parameters in this study, including cylinder speed (260, 390, and 520 rpm), feed rate (144, 180, and 240 kg/h), treatment combinations, and number of replication All dependent parameters were calculated using the standard procedure. Three replications of a two-factor, completely random design were used to analyses the observed data. Using a t-test, all of the treatments were compared at a 5% level of significance. ANOVA was conducted for the performance according to various levels of variables.

Table 1: Details of treatment combinations of the cylinder speed and feed rate for obtaining maximum clove separation efficiency of garlic bulb breaker

Sr. No.	Treatment	Cylinder speed (rpm)	Feeding time (s)	Feed rate (kg/h)
1.	T1D1	260	25	144
2.	T1D2	260	20	180
3.	T1D3	260	15	240
4.	T2D1	390	25	144
5.	T2D2	390	20	180
6.	T2D3	390	15	240
7.	T3D1	520	25	144
8.	T3D2	520	20	180
9.	T3D3	520	15	240

3. Results and Discussion

Three different feed rates 144, 180, and 240 kg/h—and three peripheral roller speeds 260, 390, and 520 rpm were used to evaluate the garlic bulb breaker. Two factors were used to analyses the observations made for various treatment combinations to maximize the cylinder speed and feed rate to achieve the highest single clove separation efficiency and machine output capacity. Three replications of a completely random design. ANOVA was conducted for the performance according to various levels of variables. The statistics-based analysis of the data is shown in table-2.

Table 2: Analyzed data showing the effect of cylinder speed and feed rate on separation of garlic cloves.

Variable	Single clove separation, %	Machine output capacity, kg/h	Clumps of 2-3 cloves, %	Clumps of 4-6 cloves, %	Damaged cloves, %
Cylinder speed, T (rpm)					
T1 (260)	53.71	91.69	21.56	15.35	1.17
T2 (390)	73.35	136.36	9.26	4.73	2.71
T3 (520)	41.50	85.69	19.37	20.17	9.04
SEm ±	1.159	2.032	0.068	0.053	0.048
CD	3.444**	6.037**	0.202**	0.158**	0.142**
Feed rate, D (kg/h)					
D1 (144)	57.36	97.90	18.06	11.12	3.34
D2 (180)	56.64	107.80	15.79	13.50	3.94
D3 (240)	54.57	108.03	16.35	15.63	5.65
SEm ±	1.159	2.032	0.068	0.053	0.048
CD	NS	6.037**	0.202**	0.158**	0.142**
Interaction (T x D)					
SEm ±	2.008	3.519	0.118	0.092	0.083
CD	5.965**	10.457**	0.350**	0.275**	0.246**
CV, %	6.19	5.83	1.22	1.19	3.33

3.1 Effect on separation of single clove

According to fig. 1, the treatment T1D1 had the lowest single clove separation efficiency (44.90%) and the treatment T2D1 had the highest single clove separation efficiency (77.64%). However, it was observed from the moving average trendline plot that treatment T2D2 is superior to all other treatments as evidenced by the 74.16% separation efficiency of a single clove, which is consistent with the results of Channabasamma *et al*. (2015) [3].

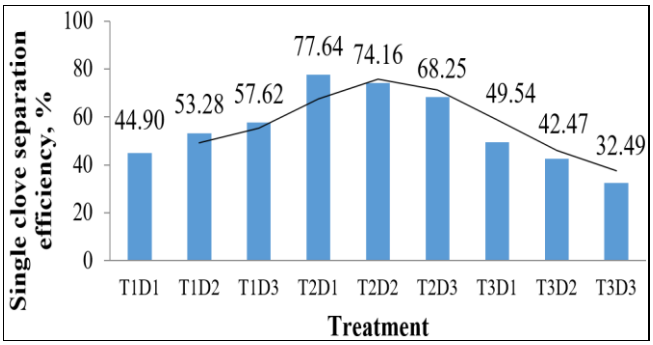

Fig 1: Treatment wise single clove separation efficiency

3.2 Effect on machine outlet

The treatment T2D3 was found to be superior to the other treatments, as shown in fig. 2. The lowest machine output (64.65 kg/h) was obtained in treatment T1D1, and the highest machine output (163.80 kg/h) can be obtained by rotating the cylinder at 390 rpm with a feed rate of 240 kg/h in T2D3.

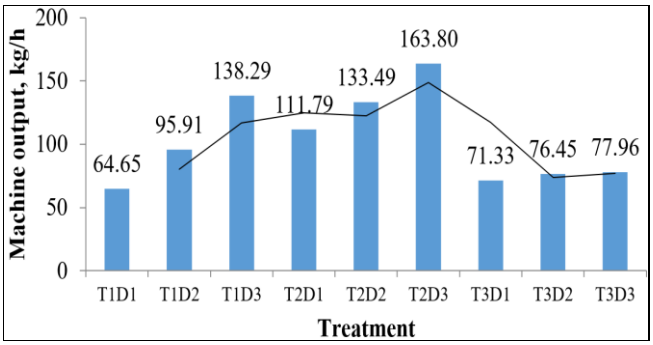

Fig 2: Treatment wise machine output obtained

3.3 Effect on clump of 2-3 cloves

The treatment T2D1 produced the lowest percentage of clumps of 2-3 cloves (7.69%), while the treatment T1D1 produced the highest percentage of clumps of 2-3 cloves (26.20%). However, the treatment T2D2 was judged to be superior to the other treatments, and as can be seen in fig. 3, the clumps of 2–3 cloves grew when the speed and feed rate exceeded 390 rpm and 180 kg/h, respectively.

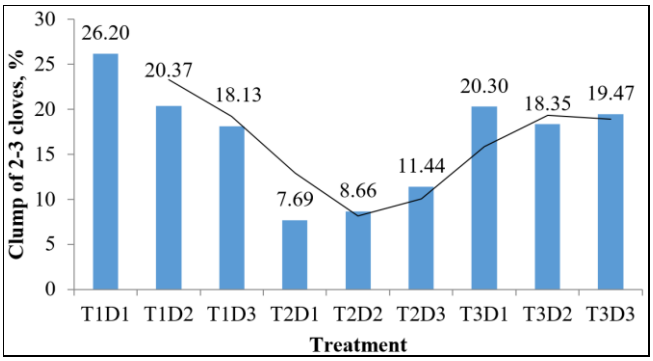

Fig 3: Treatment wise clump of 2-3 cloves obtained

3.4 Effect on clump of 4-6 cloves

The treatment T2D1 produced the lowest percentage of clumps of 4-6 cloves (3.27%), while the treatment T3D3 produced the highest percentage of clumps of 4-6 cloves (27.29%). However, the treatment T2D2 was judged to be superior to the other treatments, and as shown in fig. 4, speed above 390 rpm and feed rate above 180 kg/h increased the clumps of 4-6 cloves.

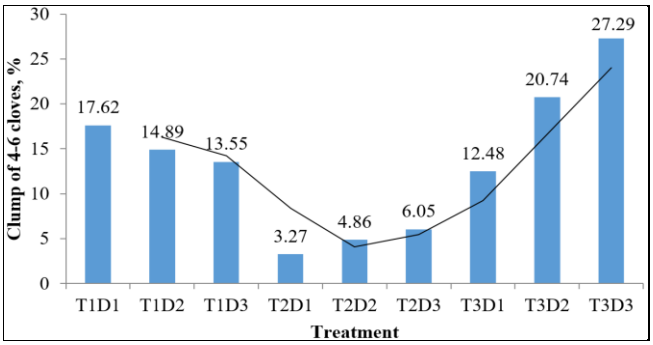

Fig 4: Treatment wise clump of 4-6 cloves obtained

3.5 Effect on damage of cloves

The figure 5 showed that either an increase in cylinder speed or an increase in feed rate resulted in a greater percentage of garlic cloves being damaged. However, it was noted that after receiving treatment for T2D2, there was a significant increase in clove damage.

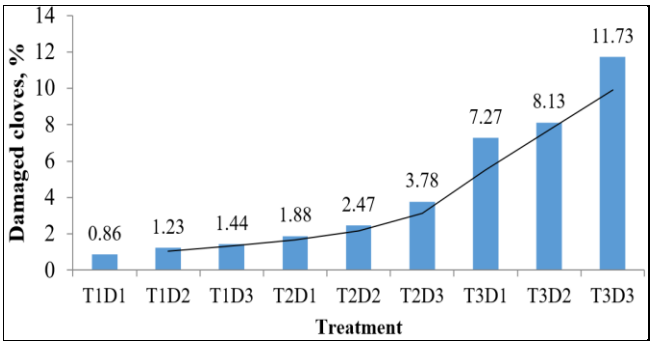

Fig 5: Treatment wise damaged cloves obtained

4. Conclusion

Therefore, it can be inferred from the current study that the garlic bulb breaker's cylinder speed of 390 rpm and feed rate of 180 kg/h can produce the maximum number of single cloves, the least amount of clumps of 2-3 and 4-6 cloves, and the least amount of damage to the garlic cloves.

5. Acknowledgement

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