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Performance evaluation of an electronic weight grader for sapota (*Manilkara achras*) to enhance post-harvest handling efficiency

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Abstract
In India, sapota grading is predominantly carried out manually through hand-picking or sieves, making the process labor-intensive, inefficient, and prone to inconsistencies. Mechanical grading offers a more effective solution by sorting fruits based on their physical dimensions, ensuring uniform size and shape, which facilitates easier packaging and handling. This study evaluated the performance of a mechanical weight grader for two sapota variety Cricket Ball at varying speeds (10, 15, 20, and 25 rpm). For the Cricket Ball variety, the optimal speed was found to be 20 rpm, achieving a separation efficiency of 93.8% with a feed rate of 7.23 kg/min. The results demonstrate that mechanical grading ensures higher efficiency, consistent quality, and reduced labor dependency, making it a cost-effective operation for post-harvest management of sapota.

Keywords: Sapota, electronic weight grader, separation efficiency

Introduction
Grading is a crucial operation for separating materials into different homogeneous groups based on characteristics such as size, shape, weight, color, and quality. This process is vital for fruits and vegetables, as it saves time and energy in processing operations and reduces handling losses during transportation. After harvest, fruits need to be prepared for sale, especially high-value agricultural commodities like sapota fruit. Precise handling and proper grading are necessary to meet customer expectations and quality standards. Grading has become essential for trading across borders, enabling growers to obtain higher prices for their produce. The process also improves packaging, handling, and overall marketing systems.

In India, manual grading of spherical fruits is common but tedious and costly. The challenge is even greater for perishable crops like sapota, as growers struggle to find sufficient manual labor. Customer requirements and innovation drive changes in sizing methodology, with retail customers expecting commercial volumes and precise sizing. Most retailers specify the minimum fruit weight within each package. Currently, graders classify fruits and vegetable s based on physical properties such as size, shape, and color.

Grading methodology has evolved from manual selection to mechanical sizing. Mechanical gr aders based on size have disadvantages in terms of efficiency and precision compared to electr onic graders. Developing size-based electronic optical graders is challenging due to the need for individual fruit orientation. AI based systems using spectrophotometry and computer vision offer more precise grading but are expensive and sophisticated.

According to the Agriculture Processed Food Products Export Development Authority (APED A) rules, packed fruits are graded and classified as large, medium, and small based on weight. Accurate weight-based grading is critical to avoid revenue loss and ensure packing standards. Weight grading is more accurate than dimensional grading, reducing labor costs, damage, tim, and energy requirements while improving grading efficiency and accuracy. It also minimizes p ackaging and transportation expenses and provides optimal packaging arrangements. In comm ercial practice, weight sizing offers consistent sizing across all fruit varieties, considering custo mer expectations and technological advancements. For automatic weight-based grading, an electronic weighing system with load cells can be used. Integrating a load cell, microcontroller, and stepper motor automates weight-based grading, offering more precision than size graders. This reduces labor costs, time, and damage while improving grading

efficiency and precision. Existing graders for spherical fruits, including sapota, often have complex and costly laser sensing assemblies and light- dependent resistors. Limited research has focused electronic weight based continuous graders for sapota. This study is focused on evaluating developed grader for sapota.

Materials and Methods

A mature sapota (Cricket ball variety) was purchased from market. Sapota fruits were separated manually by weighing into three groups according to their weight. Fruits were chosen from each group for the determination of physical parameters using procedures suggested by Mohsenin (1996) has been followed. Size was determined by Digital vernier calipers, to find Major, Minor and Intermediate diameter of sapota fruit. Shape is evaluated by following the chart given by Mohsenin (1996). The grader is evaluated at 4 different speeds i.e. 10,15,20,25 rpm and separation efficiency is calculated by the formula (Bachah Singh, 1982) [1].

Development of the grader

Design of the grader is based on combined centrifugal and gravitational force. Feed hopper was Fabricated by 18 Gauge MS Sheet, Fitted at a Slope of 10 degrees to the horizontal. Bottom front end was provided with opening of 100 mm width to accommodate conveyor belt with carrier comb of singulation unit (Fig.1). Bottom end was fitted with a comb in a zig-zag fashion. Sapota singulation unit have Frame, Fruit conveyor, Singulating channel, Belt and Roller with shaft. The grading unit was fitted at an angle of 15° to ensure free flow of fruits. Two gates of size 300mm length and 140 mm height were fitted at a distance of 400 mm to divert the over size and under size fruits. Two outlets were provided on the opposite side of the gates. When the gate was operated by the standard door opening and closing mechanism (Zhang *et al*., 2024) [4]. The pushing of the vertical member was affected by the pulling type solenoid switches. Two numbers of pulling type solenoids with a pulling capacity of 1kg and stroke length of 30mm was used in the grading unit. The solenoid switches were connected to a 24volts DC eliminator through the relay switch on the load cell gets connected which in turn complete the circuit between the 24volts DC eliminator and solenoid switch as shown in Fig.2 The closing of this circuit will result in pulling of the vertical member of the door opening and closing mechanism which operates the gate fitted in the grading unit. All the data were analyzed in triplicate estimation and the mean was considered. Analysis of variance (ANOVA) using statistical version 1.

Evaluation of Grader

The sapota were graded in three different grades i.e., W_1, W_2, W_3. The W_1 grade corresponds upto 0-60gm, W_2, 61-120gm and W_3 >120gm. The sapota obtained in different grades in one minute run of the machine were weighed and the feed rate was calculated. This was repeated three times for each speed and samples obtained were used to calculate separation efficiency. The procedure was repeated three times and average separation efficiency was calculated by using following formula

$$Es = \frac{Wt - Wu - Wo}{Wt} X\ 100$$

Where,

Es = Percentage separation efficiency of that grade
Wt = Total weight of the sample
Wu = Weight of the under size in that sample
Wo = Weight of over size in that sample

(Bachchah Singh, 1982) [1]

Results and Discussion

The performance of the sapota grader was evaluated at four different speeds—10, 15, 20, and 25 rpm. At 10 rpm, the overall separation efficiency was 87.8%, with W_3 grade showing the highest efficiency (91.7%). The feed rate was 3.0 kg/min, and 28 fruits were collected. At 15 rpm, the separation efficiency improved to 92.5%, with W_3 grade again performing best (94.2%), and a feed rate of 5.0 kg/min was recorded with 42 fruits collected. At 20 rpm, the machine reached optimal efficiency with an overall separation rate of 93.8% and W_3 grade showing 95.8% efficiency. The feed rate increased to 7.0 kg/min with 56 fruits collected. However, at 25 rpm, the efficiency dropped slightly to 86.4%, with W3 grade achieving 94.8% efficiency. The feed rate was highest at 9.0 kg/min, with 71 fruits collected. The study shows that the grader's efficiency improves up to 20 rpm but decreases slightly at higher speeds, indicating that 20 rpm is the optimal operating speed. Similar results were observed by More *et al* (2003). Reported that in grading apple based on weight an increase in grader speed resulted in decrease in efficiency from 100 to 85 per cent similarly for orange 100 to 95 per cent. Mousmi 100 to 97 per cent and pomegranate 100 to 93 per cent. This may be due to effect of offset and impact on fruit grader. Similar trend was observed by Vinay *et al*., 2017 who reported that in grading round fruits and vegetables, an increase in feed rate and speed resulted in decrease in sizing efficiency of the fresh market grade from 100 to 96.6 percent.

The Table 5. shows that W_3 Grade consistently achieves the highest separation efficiency across all speeds, with a mean of 94.45%, compared to W_1 (90.7%) and W_2 (87.93%). As the CD@5% values indicate, any difference in separation efficiency greater than 6.76 for W1, 19.79 for W2, and 6.53 for W_3 is considered statistically significant at the 5% level.

The optimal speed for achieving the best separation efficiency is 20 rpm, where W_3 Grade reaches its peak efficiency (96%), and the overall performance is also the highest. However, the efficiency drops slightly at 25 rpm, this may be due to effect of offset and impact on fruit grader. Thus, 20 rpm is recommended as the ideal operating speed, balancing efficiency and throughput for all three grades.

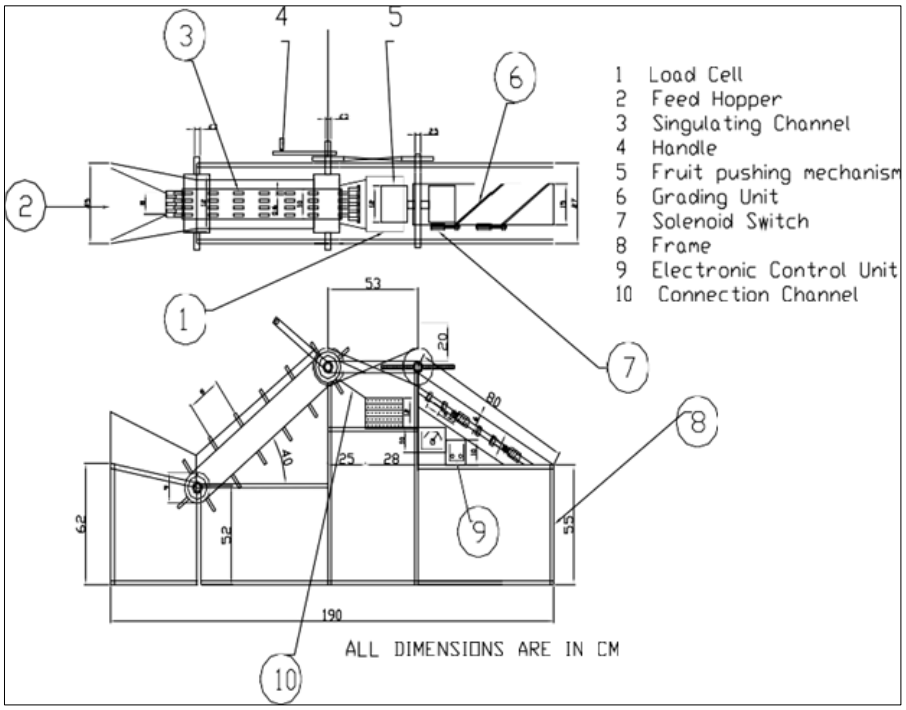
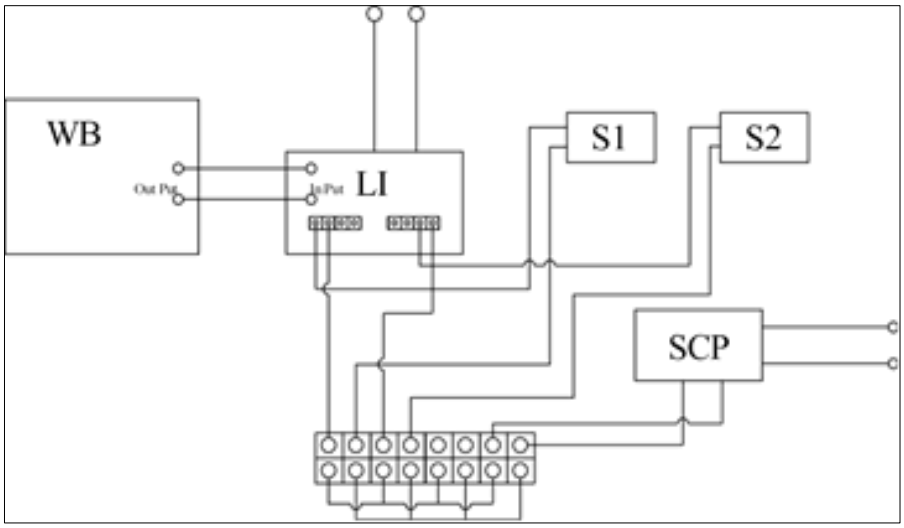


Fig 1: Schematic diagram of Electronic weight grader for sapota



WB - Weighing Balance L1 - Load Indicator
S1 - Solenoid Switch 1
S2 - Solenoid Switch 2 SCP - Solenoid Control Panel
PDP - Power Distribution Panel

Fig 2: Circuit Diagram of the Electronic Control Panel

Table 1: Performance of Grader at 10 rpm

Grade	Wt. (Total wt of Sample)	Wu (Under Wt,g)	Wo (Over Wt,g)	Efficiency (%)	Wc (Correctly Graded wt,g)
W_1 (< 60 g)	803.3	0	85.2	89.2	718.1
W_2 (61-120 g)	1012.1	40.3	150.6	81.1	821.2
W_3 (>120 g)	1398.8	115.0	0	91.7	1283.8
Total	3214.2				2823.1
Overall Separation Efficiency (%)	87.8				
No. of Fruits collected	28				

Table 2: Performance of Grader at 15 rpm

Grade	Wt. (Total wt of Sample)	Wu(Under Wt,g)	Wo(Over Wt,g)	Efficiency (%)	Wc(Correctly Graded wt,g)
W_1 (< 60 g)	1005.8	0	80.3	92.0	925.5
W_2 (61-120 g)	1998.6	50.2	125.9	91.1	1822.5
W_3 (>120 g)	1897.5	110.1	0	94.2	1787.4
Total	4901.9				4535.4
Overall Separation Efficiency (%)	92.5				
No. of Fruits collected	42				

Table 3: Performance of Grader at 20 rpm

Grade	Wt. (Total wt of Sample)	Wu (Under Wt,g)	Wo (Over Wt,g)	Efficiency (%)	Wc(Correctly Graded wt,g)
W_1 (< 60g)	2140.3	0	144.7	93.2	1995.6
W_2 (61-120g)	2608.6	53.2	146.8	92.3	2408.6
W_3 (>120g)	2489.2	103.2	0	95.8	2386.0
Total	7238.1				6790.2
Overall Separation Efficiency (%)	93.8				
No. of Fruits collected	56				

Table 4: Performance of Grader at 25 rpm

Grade	Wt. (Total wt of Sample)	Wu(Under Wt,g)	Wo(Over Wt,g)	Efficiency (%)	Wc(Correctly Graded wt,g)
W_1 (< 60g)	3107.6	0	290.9	90.6	2816.1
W_2 (61-120g)	3012.1	55.6	270.3	89.1	2686.2
W_3 (>120g)	2291.9	118.2	0	94.8	2773.7
Total	9011.6				8276
Overall Separation Efficiency (%)	86.4				
No. of Fruits collected	71				

Table 5: Effect of Speed on Separation Efficiency

Speed	Separation Efficiency		
	W_1 Grade	W_2 Grade	W_3 Grade
10	87.8	79.0	91.7
15	92.0	91.6	94.2
20	92.4	92.0	96.0
25	90.6	89.1	95.9
Mean	90.7	87.93	94.45
Sem±	2.08	6.09	2.01
CD@5%	6.76	19.79	6.53

Conclusion

The study concludes that the optimal operating speed for the sapota grader is 20 rpm, achieving a peak separation efficiency of 93.6% with the W_3 grade performing best at 96% efficiency. At lower speeds, such as 10 rpm, the machine exhibited reduced efficiency (86.9%) with a slower feed rate of 3.0 kg/min. Increasing the speed to 15 rpm improved the separation efficiency to 92.6%, while the feed rate reached 5.0 kg/min. However, further increasing the speed to 25 rpm resulted in a decline in efficiency (91.8%), These results indicate that 20 rpm is the most suitable speed for balancing separation efficiency and throughput, ensuring minimal damage to fruits during the grading process The study underscores the importance of optimizing speed to maintain quality and reduce post-harvest losses in sapota fruit.

References

1. Singh B. Development and performance of differential belt speed expanding pitch type potato grader. J Agric Eng. 1982;17(2):69–75.
2. Mohensin. Physical properties of plant and animal materials structure: physical characteristics and mechanical properties. New York: Gordon and Beach Publishers; c1996. p. 734.
3. Vinay BS, Edukondalu L, Kumar S, Prasad GV. Development and evaluation of a grader for round fruits and vegetables. Andhra Agric J. 2017;64(4):891–5.
4. Zhang S, Gao Y, Yang J. Dynamic modeling and analysis of vehicle scissor door mechanism with mixed clearance based on a hybrid contact force model. Multibody Syst Dyn. 2024;61(4):509–38.