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RESEARCH ARTICLE

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Design and evaluation of electronic weight grader for sapota [*Manilkara achras* (Mill).Fosberg] grading

SYED MAZARA ALI, S. C. MANDHAR AND AMBRISH GANACHARI

ABSTRACT

The investigation was carried out to develop weight grader for sapota [*Manilkara achras* (Mill).Fosberg]. Weight grader fitted with singulation unit is found to be more precise than any other. Since singulation unit will feed the fruits individually to electronic balance, single fruit grading can be achieved. The singulation unit fed the fruits to the load cell individually, where in fruits were weighed and carried to the grading unit, which actually consists two gates which were operated electronically using the signal generated by the load cell depending on fruit weight.The overall separation efficiency of the grader was found to be 93.8%.Separation fficiency of W3 grade (>120g) was found to be best .The speed was optimized for 20 rpm,which gives best overall efficiency.The cost of grading for cricket ball was found to be low *i.e.* Rs.0.06 / kg in comparison with cost of manual grading (Rs 0.4/kg).

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Key words : Electronic Weight grader, Singulation unit, Overall Separation efficiency

INTRODUCTION

Sapota [*Manilkara achras* (Mill).Fosberg] is a native of tropical America, having originated in Mexico of Central America. It is a delicious fruit, also known as chikoo, zapota etc.Sapota belongs to the family of Sapotaceae. Sapota is a good source of digestible sugar, protein, fat, fibre, calcium, phosphorus, iron and other minerals. India is the largest producer of sapota with 30 to 40 thousand hectares. The average yield per tree is 2500 to 3500 fruits weighing around 150 to 300g under Bangalore condition.Vyas and Shah (2004) have developed on farm sapota grader. The grader was capable of fruit grading to 3 sizes. The overall grading efficiency was found maximum at 14rpm, which was about 90%. Advantages of mechanical grading are Systematic grading can be achieved, a continuous mechanical fruit grader can be integrated with any other processing operations like fruit packaging, peeling etc. Saves time and energy utilization to process the individual produce and reduces produce handling time and thus reduces post harvest losses. An objective of the work is to develop and evaluate weight grader for sapota.

Address for correspondence :
SYED MARARA ALI, Department of food process Engineering, S.R.M. University, KATTANKULATHUR (T.N.) INDIA
Email : majru12@gmail.com

Authors' affiliations :
S.C.MANDHAR AND AMBRISH GANACHARI, Department of food process Engineering, S.R.M. University, KATTANKULATHUR (T.N.) INDIA
Email : majru12@gmail.com

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 choosen from each group for the determination of physical parameters using procedures suggested by Mohensin (1996) has been followed.Size was determined by Digital vernier calipers, to find major, minor and intermediate diameter of sapota fruit. Shape was evaluated by following the chart given by Mohensin (1996).The grader is evaluated at 4 different speeds *i.e.* 10,15,20,25 rpm and separation efficiency was calculated by the formula (Singh, 1982).

$$E_s = \frac{W_t - W_u - W_o}{W_t} \text{ where}$$

E_S = Overall separation efficiency, %

W_t = Total weight of the sample, g

W_u = Weight of under size in particular sample, g

W_0 = Weight of oversize in particular sample, g

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 100mm width to accommodate conveyor belt with carrier comb of singulation unit (Fig.1). Bottom end was fitted with a comb in a zigzag

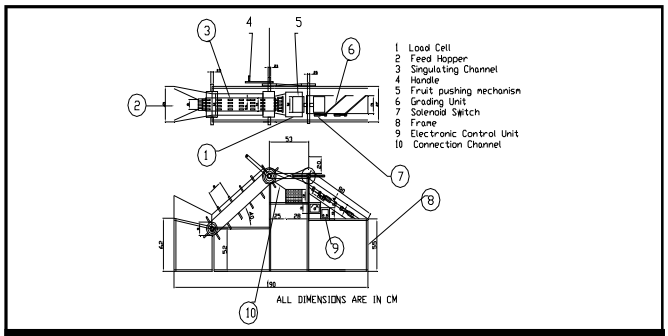

Fig. 1 : Schematic diagram of electronic weight grader for sapota

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 140mm height were fitted at a distance of 400mm 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.,* 1995). The pushing of the vertical member was effected 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

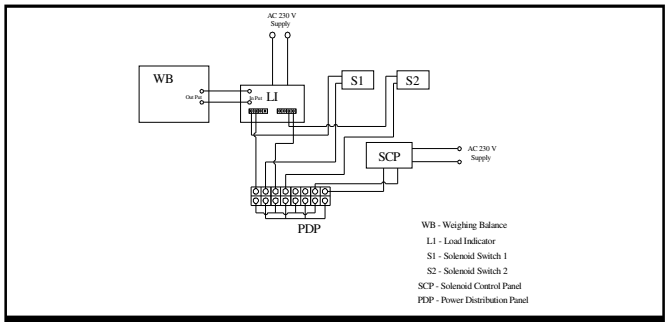

Fig. 2 : Circuit diagram of the electronic control panel

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 taken into account.

RESULTS AND ANALYSIS

Results indicated for size of the fruit that major diameter of sapota (cricket ball variety)in various weights was found to be in the range of 4.85 cm to 8.34 cm,similarly intermediate diameter 4.59 to 7.71cm, and minor diameter between 3.91 to 8.48 cm as the standard for fruits and vegetables (Mohensin,1996). The shape of cricket ball was found to be round. This property was used in designing singulation unit for sapota. It was observed that sphericity value of sapota fruit ranged from 0.91 to 0.98 and an average of 0.95.This value being closer to one, it was to be inferred that the fruit could considered as spherical object. This explains the ease of rolling of the fruit on the grader. The average weight of cricket ball variety was found to be 155.9g.The fruit weight varied from 42.1g to 290.5g.The variation in the weight of the fruit is in agreement with Laxminarayana and Rivera (1979).This property is used in setting up limits in load cell. True density ranged from 0.97to 1.05g/cc.Volume of the fruits in the representative size group of cricket ball fruit ranged from 43 to 275cm^3 .This property helped in design of containers for bulk handling of the fruit.

Surface area of sapota ranged from 45 – 290cm^2.The angle of repose of sapota fruit in their natural heaped position was found to be 24degrees. This property was useful in finalizing the angle for singulation unit, since singulation unit is mounted at an angle of 40degrees to horizontal there was no rollback of fruits during carrying. The moisture content on wet basis for sapota fruit was found to be 77.7%.This property ensures free flow of fruits over grader, which could affect capacity and efficiency of the machine. Firmness of fruit at harvest differed among various weight groups. The firmness was found to be in the range of 5.75 to 7.0 kg/cm2.This property also explained ease of rolling of fruit on the grader (Table 1)

Grader was evaluated at 4 different speeds. The overall separation efficiency of the grader for 20 rpm for sapota (cricket ball variety) was found to be 93.8 %.(Fig 6, Table 2).The feed rate was 430kg/hr and separation efficiency of W3 grade (>120g) at this speed

Table 1: Physical properties of sapota (Variety-cricket ball)

Grade	Weight (g)	Major dia. (cm)	Minor dia. (cm)	Inter Mediate dia (cm)	Sphericity	Volume cm^3	True density (g/cm^3)	Surfacearea (cm^2)
W_1	42.1	4.85	3.91	4.59	0.91	43	0.97	45.50
W_2	105.6	6.35	6.46	5.92	0.98	130	1.03	140.00
W_3 >120 g	290.5	8.34	8.48	7.71	0.98	275	1.05	290.75

* W=Weighed range of fruit

Table 2 : 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
Overallv Separation Efficiency (%)				93.8	
No. of Fruits			56		

was found to be best as 95.8% (Fig 5). Capacity of the grader for cricket ball variety was 0.43ton/hr.

The results pertaining to interaction effect of speed with different grades to determine the efficiency of separation was carried out (Table 3).It was noticed that significant differences among the grade with differing speed on its separation efficiency.In the studied 3 grade,grade W_3(>120g) has showed significant differences(p=0.05).Nonetheless it was also observed that significant differences with reference to different

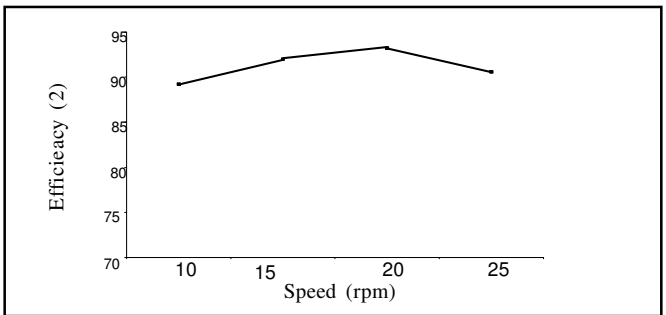

Fig. 3 : Effect of speed on seperation efficiency for W1 (>60gm)

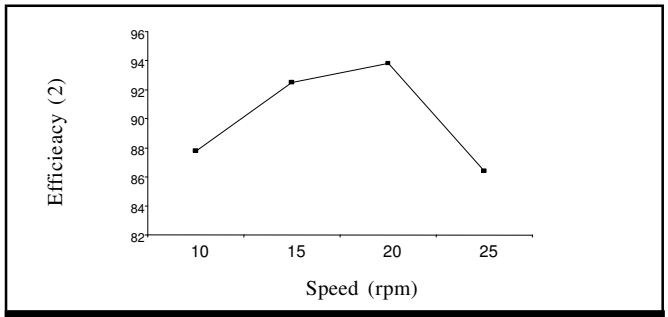

Fig. 5 : Effect of speed on separation efficiency for W3 (>120gm)

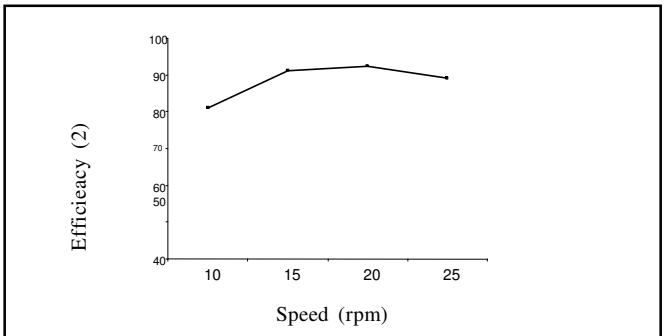

Fig. 4 : Effect of speed on separation efficiency for W2 (61-120 gm)

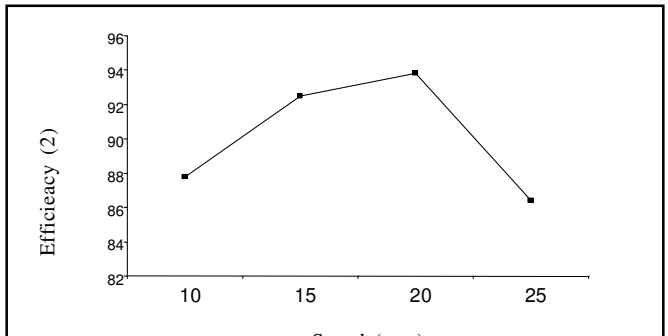

Fig. 6 : Effect of speed on overall separation efficiency

speeds.The separation efficiency was seemed to be higher and significant in speed RP_3 compare to RP_2,RP_1 and RP_4.

Table 3: Interaction effect of speed with different grades on its separation efficiency

Grade	Rp_1	Rp_2	Rp_3	Rp_4	Mean
W1 (< 60 g)	88.3	91.2	92.5	90.6	90.65
W2 (61-120 g)	79.9	89.9	91.4	89.0	87.55
W3 (>120 g)	90.7	92.8	95.7	95.3	93.62
Mean	86.3	91.30	93.20	91.63	90.60
		SEm±		CD(p=0.05)	
Grade		0.4		1.3	
Speed		0.5		1.5	
Grade X Speed		0.8		2.7	

Rp_1 – Speed at 10 rpm, Rp_2 – Speed at 15 rpm
Rp_3 – Speed at 20 rpm, Rp_4 – Speed at 25 rpm

Conclusion:

Grading of sapota in India is, however, still done manually either by hand picking or through sieves. The efficient grading operation on the basis of physical dimensions of sapota can be made with the help of mechanical sapota grader. Some fruits have consistent shape so that they can be conveniently weighed and sorted. The result is a product that is consistent in volume and shape and pack easily. The developed weight grader should operate at the optimum speed of 20 rpm for sapota of cricket ball variety, to achieve best combination of speed and overall separation efficiency.*i.e* 93.8 per cent. The cost of grading is also economical which is about 0.0611/ kg.This is about one sixth of cost of manual grading through scares labour.

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