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Development of Wood Apple Pulp Scooping Mechanism

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ABSTRACT

The physical properties of wood apple were measured to develop wood apple scooping mechanism. The developed of wood apple scooping mechanism consists of following components (i) scooping tool, (ii) fruit holder, sliding mechanism, (iv) pulp discharge chute and (v) driving mechanism. The scooping mechanism was evaluated for scooping of wood apple fruits with two scooping tools *viz.*, 4 blades tool and 6 blade tool and at 3 rotational speeds*viz.*, 350 rpm, 400 rpm, 450 rpm. The mechanism was observed to perform best with 4 blades scooping tool at the operating speed of 400 rpm. The best performance for pulp recovery percentage and rate of scooping were found to be 83.84 % and 37.80 Kg/h, respectively.

Keywords-- Physical Properties, Pulp Recovery Percentage, Rate of Pulp, Scooping

I. INTRODUCTION

Wood apple (Limonia acidissima L.) is one of the important, underutilized and indigenous fruit plant belongs to family Rutaceae. Wood apple has great demand as a medicinal fruit. Thoughit is useful, is underutilized because of its hard shell. (Khan *et.al*, 2019). The fruit exhibit excellentnutritional and medicinal properties. The ripe fruit contain sweet aromatic pulp (70%) which has protein (2.2%), carbohydrate (22.1%), fat (3.3%) and ash (1.3%) and provides 127 Kcal energy per 100 g fruit (Ghosh *et. al*., 2010). The brown pulp of wood apple has a slightly sour taste on itsripe. The colour at the ripen stage becomes dark brown. Wood apple is rich in acid, minerals and pectin. Wood apple pulp contains about 74 % of moisture and 7.4 % of carbohydrates (Khan *et.al*,2019).

Coming to the pulp scooping process, the fruits have both pulp and shell together and theprocess of wood apple scooping is done manually. Separation of pulp is one of the tedious tasks. Scooping is the operation of removal of pulp from shell. It has an objective of separating the pulpfrom shell. The manual scooping process involves use of spoon in kitchen. The wood apple pulp processing industries need pulp in bulk quantity. The scooping with spoon become labour intensive, time consuming and uneconomical to the processing industry. Once the pulp extraction is performed, the pulp can be used for further processing.

The wood apple fruits are found all over the plains of India, southern Maharashtra, West Bengal, Uttar Pradesh, Chhattisgarh, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Karnataka, Kerala and certain regions of Western Himalayas. The wood apple is not under regular orcharding, however, along the border of fields, roads, railway lines and banks of the river, etc. are the common places where the plants are found as stray plant. (Kumar and Deen, 2017). A mature tree bears 200-250 fruits/tree (Amin *et.al*, 2017).

By traditional method of pulp scooping process, the demand of pulp is difficult to meet economically due to time and energy constrains. By considering all these points, there is need to develop a mechanism to scooped good quality pulp from wood apple fruit halves for further processing or value addition. Hence a wood apple scooping mechanism is proposed to bedeveloped.

II. MATERIALS AND METHODS

The mechanism was fabricated and developed for the scooping of pulp with seeds from thewood apple halves. The wood apple pulp scooper was developed and fabricated in the Section of Agricultural Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The various physical properties of matured wood apple fruit were measured in order to develop various components of the wood apple scooping mechanism and were as follows

i. Scooping tool
ii. Sliding mechanism
iii. Fruit holder
iv. Pulp discharge chute
v. Driving mechanism

Specification and Requirements

The following specifications and requirements considered for the developing of the woodapple scooping mechanism:

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- The effort required to scoop the wood apple must be reduced significantly;
- There must be little to no contacts with moving parts;
- The machine must be semi-autonomous after the half-cut wood apple is fixed to the fruit holder;
- The machine must be capable of running at relatively high speed;
- The machine must be robust.

Development of Wood Apple Scooping Mechanism

Scooping Tool

The wood apple scooping mechanism consisted of a scooping tool fitted to MS shaft. The scooping tool consist of ss hollow pipe have length 90 mm and diameter 19 mm on which blades are fixed which is made of stainless-steel sheet having vertical length of 45 mm and horizontal length of 28 mm. The scooping tool with varying number of blades were fabricated such 4-blade tool and 6-blade tool. A shaft of 364 mm length and 12 mm diameter made up of mild steel was mounted on a main frame with the help of pillow block bearing. The scooping tool was fixed on the MS shaft with the help bolt. The MS shaft was driven by belt and drive mechanism with necessary speed reduction ratio.

Fruit Holder

Fruit holder consists of spring loaded 3 fingers for holding of half-cut wood apple while scooping. The fingers with SS were fabricated based on the structure and the diameter of wood apple halves. The studies regarding the physical properties of these fruits showed a significant difference in their diameters. The holder was developed to maintain the half-cut wood apple fruit in place adequately and the time taken to mount the wood apple is relatively shorter. The fruit holder was attached on the sliding mechanism along the axis of scooping tool. And scooping can be done easily without manual handling in order to reduce drudgery in operation.

Sliding Mechanism

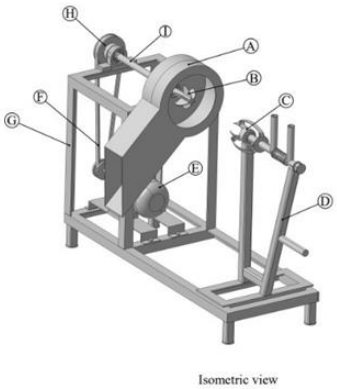
The base frame of sliding mechanism which is rectangular in shape was made of 4 MS angle having dimension 32 x 32 x 5 mm. The length and breadth of the base frame of the sliding mechanism is 334 mm and 150 mm. The breadth side slides on the MS angle of the main frame with angle in angle mechanism. The 2 hollow MS square pipe were attached to the length sides ofbase frame of sliding mechanism having height 460mm. On front angle of length side of sliding frame, hollow square pipe fixed with 90° inclination and on back angle with 73 ° from horizontal. The Fruit holder was mounted on the MS square bars. The handle is provided to give forward and backward movement to sliding mechanism.

Pulp Discharge Chute

Wood apple pulp discharge chute was made of SS sheet. It consists of circular drum and pulp conveying chute. The circular drum provided around the scooping tool for easy collection ofpulp and to avoid losses of pulp while pulp scooping. The diameter of circular drum was 235 mm and it is made with inner and outer circular ss sheet. The inner circular ss sheet cut with diameter of 75 mm to pass MS shaft for fitting of scooping tool and the outer circular ss sheet cut with diameter of 175 mm to pass wood apple halves which is fixed in fruit holder for pulp scooping. The pulp conveying chute conveyed the scooped pulp to the container. It having width of 100 mm and inclined below the blade at an angle of 35°.

Driving Mechanism

The pulp scooping mechanism was fitted with 0.5 hp single phase variable speed motor of 1410 rpm. The provision was made at base point for moving the motor to provide required belt tension. The scooping mechanism is driven by motor with the help of 'V' belt and pulley. The pulley was fixed on the mechanism having size 51 mm and 101.91 mm diameter. The pulleys were used to transfer power from motor to scooping tool of mechanism through V- shape a rubber belt. The smaller pulley fixed on motor shaft and larger pulley fixed on load shaft. The assembly of the belt and pulleys was covered with guard which was made from perforated MS sheet of 2 mm thickness.



Isometric view

Sr. No.	Particular	Name of Part
1	A	Pulp discharge chute
2	B	Scooping blade
3	C	Fruit holding shaft
4	D	Sliding mechanism
5	E	Motor
6	F	Power transmission belt
7	G	Main frame
8	H	Pulley
9	I	Shaft

Wood Apple Pulp Scooping Mechanism

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Performance Evaluation of the Wood Apple Scooping Mechanism

The developed wood apple scooping mechanism was tested as per the standard procedure for combinations of various treatments as given below (Table 1). The wood apple fruit was fed towood apple cutting machine where it cut the fruit into two halves. After the cutting one half of fruitwas fed to wood apple scooping mechanism. The pulp along with seeds was scooped out from fruitand collected in the container. The same procedures were followed for all the trials and were carried out with 3 replications to overcome the experimental errors.

Table 1: Experimental design

Independent Parameter	Levels	Dependent Parameter	Replication
Scooping tool	T1 (4 blades)	1. Pulp recovery percentage	3
	T2 (6 blades)	2. Rate of pulp scooping	
Rotational speed	S1 (350 rpm)		
	S2(400 rpm)		
	S3(450 rpm)		

After recording all the observations dependent parameters like pulp recovery percentageand rate of pulp scooping were measured by using the following formulae.

$$1)\ \text{Pulp recovery percentage (\%)} = \frac{S1}{S1+S2} \times 100$$

$$2)\ \text{Rate of pulp scooping (Kg/h)} = \frac{Total\ weight\ of\ pulp\ scooped\ (Kg)}{Time\ taken\ for\ scooping\ (h)}$$

Where, S1= weight of the pulp collected from pulp discharge chute (g) S2= weight of the pulp remaining in the fruit after scooping (g)

Statistical Analysis

The result of the wood apple scooping mechanism performance for different treatment of wood apple scooping were analyzed using 2 factors experiment in Completely randomized design with 3 replications by using Minitab software.

III. RESULT AND DISCUSSION

Performance Evaluation of the Wood Apple Scooping Mechanism

The performance evaluation of the developed wood apple scooping mechanism was conducted with wood apple halves. The wood apple scooping mechanism was tested for its performance with 2 different scooping tools and three operating speeds with three replications. For each trial a half of fruit was fed and various observations were recorded. The performance parameters namely pulp recovery percentage and rate of pulp scooping for two scooping tool andthree operating speeds were tested and results were tabulated in Table 2.

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Table 2: Pattern of dependent parameters observed in performance evaluation of wood apple scooping mechanism

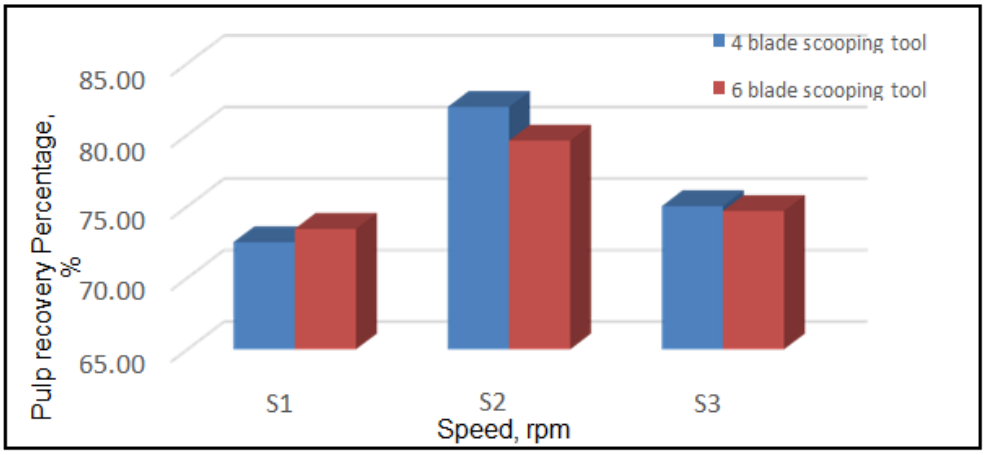
Treatment no.	Tool	Speed	Pulp recovery (%)	Rate of pulp scooping
1	T1	S1	72.49	27.98
2		S2	81.95	35.29
3		S3	75.01	29.53
4	T2	S1	73.41	26.48
5		S2	79.59	32.69
6		S3	74.67	28.85

Where,

T1 – 4 blades scooping tool
T2 – 6 blades scooping tool
S1 – 350 rpm
S2 – 400 rpm
S3 -450 rpm

Pulp Recovery Percentage

The data presented in the Table 4.1 observed that different scooping tools and operating speeds had higher significant effect over the pulp recovery percentage of the wood apple scoopingmechanism. The 4-blade scooping tool operated at speed of 400 rpm showed the highest extraction efficiency of 81.95 % compared to all combinations. Because, of the number of blades provided for wood apple pulp scooping. The wood apple scooping mechanism had shown the highest pulp recovery percentage as lesser number of blades presented on scooping tool. Because, of the wood apple consist of sticky pulp which is adhered to the blades.



Rate of Pulp Scooping

The mean rate of pulp scooping of wood apple pulp scooping mechanism with different type of scooping tools namely 4 blade tool and 6 blades tool were 30.93 Kg/h and 29.34 Kg/h respectively. The highest rate of pulp scooping of wood apple pulp scooping mechanism was

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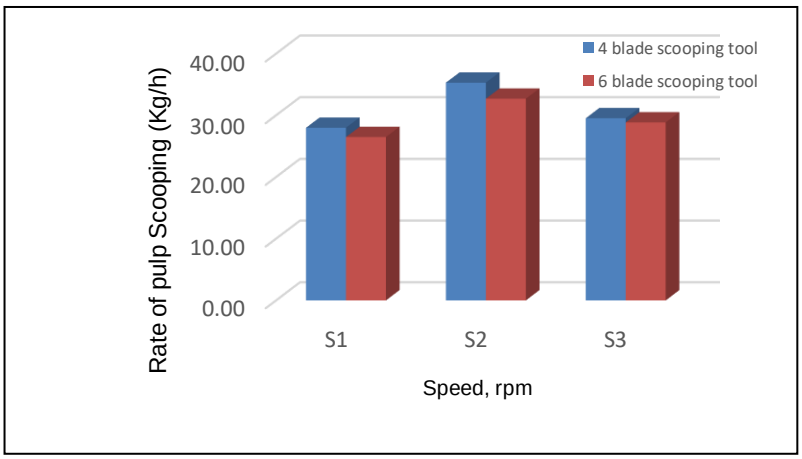
found for 4 blade scooping tool 35.29 Kg/h at operating speed of 400 rpm. The lowest rate of pulp scooping of 26.48 Kg/h was observed for 6 blades tool at operating speed of 350 rpm.



IV. CONCLUSION

By considering the performance of each treatment, pulp recovery percentage and rate of pulp scooping and physical performance during the operation were observed to optimize the design and operational parameters. By analyzing the overall wood apple scooping process, the 4 blades scooping tool at 400 rpm operating speed was recommended as the best combination for scooping of wood apple based to extract good quality pulp for further value addition.

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