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Comparative evaluation of cashew nut shelling machines

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■ **ABSTRACT :** The study highlights the performance of different shelling machines used in Kokan region of Maharashtra. The effect of cashew nut size on performance of cashew nut shelling machines and there comparative differences between three shelling machines were studied. It was found that, the size of cashew nut had significant effect on the shelling efficiency of machine. The per cent shelling efficiency of the machine increased with increase in size of cashew nut. The manual operated shelling machine showed higher shelling efficiency as compared to traditional and improved power operated shelling machine. It is also observed that the improved power operated machine had lower uncut, breakage, higher whole kernel recovery and cashew nut picking efficiency as compared with traditional power operated and manual shelling machine. Operating cost of manual, traditional and improved power operated cashew nut shelling machine were 7, 3.12 and 2.31 Rs./kg, respectively. Operating cost of improved shelling machine was 66 per cent and 57.4 per cent higher as compared to manual and traditional power operated shelling machine, respectively. Improved power operated shelling machine saved monthly Rs. 21138/- as compared to manually operate shelling machine.

■ **KEY WORDS :** Cashew nut, Shelling machines, Efficiency, Operating cost

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Cashew is often regarded as 'poor man's crop and rich man's food'and is an important cash crop and highly valued nut in the global market (Karthickumar *et al.,* 2014). The cashew (*Anacardium occidentale* L.) has been described as a small to medium-sized tree found in Northern America and Asia (Mitchell and Mori, 1987). It has a long history of cultivation in Central and South America, South-East Asia, India, and tropical Central Africa (Ohler, 1979; Gibbon and Pain, 1985 and Nagy *et al.,* 1990). The worldwide area under cashew was 30.62 lakh hectares. With estimated production of cashew on 20.82 lakh tones. India's share in the world raw nut production contributes to about 25 per cent. The Major contributions within the country are from Maharashtra (32.3%), Andhra Pradesh (16.15%), Orissa (13.7%), Kerala (10.76 %) and Tamil Nadu (9.8%), indicating maximum growth of the crop in the peninsular region (Anjum, 2009). Total area in India under cashew cultivation was about 868,000 ha with annual production of 665,000 tones giving average productivity 860 kg per hectare while the highest productivity was reported in Maharashtra (1500 kg/ha) from 167,000 ha land under cultivation and produced 210,000 tones of raw cashew nut. India processed about 1,138,000 tons of raw cashew nut seeds through 3650 cashew nuts processing mills scattered in many states of country which increased rapidly from 170 in 1959 to over 3650 in year 2008 provided employment to over 0.5

million people of, which 95% were women. India was the first country to enter the global cashew trade. The country processed about 1.14 million tones of cashew nuts; India is the largest producer and processor of cashews in the world (Epitome, 2009).Maharashtra state has total 2200 cashew processing units out of which 1850 are small cottage mills which processed about 200,000 metric tons of raw cashew nut per annum mainly located in Konkan region (Anonymous, 2009).

In cashew industry of Kokan region shelling operation is performed manual as well as power operated machines. Primary investigation of cashew nut industry showed that there were three different grades of cashew nut such as big, medium and small. There were sorted by grader. The big and medium grade cashew generally shelled by automatic shelling machine while the small size grade manually operated machines. The present paper highlighted the performance evaluation of different types of shelling machine used in Kokan region of Maharashtra. It could guide in for improvement and development of new shelling machine.

METHODOLOGY

The present research work was carried out at "Konkan Phalprakriya Sahakari Sanstha, MIDC Valane, Dapoli" Tal: Dapoli Dist: Dapoli State: Maharashtra, India.

Shelling machines :

Three different types of shelling machines were selected for study based on availability in respective industry. The machines were improved automatic shelling machine, traditional automatic shelling machine and manualy operated shelling machine. As described earlier the manual shelling machine was used for small size cashew nut, improved and traditional machine were used for medium and big size cashew nut.The manual operated machine consisted of M.S. material body, which was operated by pedal and hand (Plate A). The automatic power operate traditional shelling machine consisted of hopper, picking unit, cutting blade, belt,pulley power transmission, 0.5 hp electric motor (44 rpm) and having capacity of 20 kg/hr (Plate B). The automatic improved power operated shelling machine also consists of hopper,picking unit, cutting blade and electric motor (0.5 HP) with speed reduction gear unit (50 rpm) and having capacity 30 kg/hr. The working principal of both traditional and improved machine was same, the major differences between these two machines was power transmission system and modified frame work.

Plate A : Manually operated shelling machine

Plate B : Automatic traditional power operated shelling machine

Plate C : Automatic improved power operated shelling machine

Size of cashew nut :

The cashew nut after steaming was used for shelling operation. Therefore, the cashew nuts after steaming were taken and it allowed for cooling and drying in atmospheric condition. After cooling it passes through electric motor operated grader which sorted the cashew nut as per the size.It categorized the cashew nut in three different grades as big, medium and small.30 samples of each grade were taken for determination of physical properties of cashew nut. With help of digital vernier caliper the different dimensions of cashew nut as length, width and thickness were measured.

Performances evaluation of shelling machines :

Manually operated cashew nut shelling machine:

To operate manual cashew nut shelling machine there was need of two workers. The first worker to operate the shelling machine and second worker for separate out nut from shell. It was also same for improved and traditional power operated shelling machine. Therefore, only cutting operations of machine were referred for analysis of results. Randomly three female workers were selected from respective industry**.** Each worker was given the sample of ½ kg of cashew nut without sorting. The total time required for shelling was noted.

Traditional and improved cashew nut shelling machine :

Selected 25 kg of cashew nuts sample (*i.e.* big, medium, small and without sorting). Also, the cashew nut poured into hopper of shelling machine. After cutting operation separates the whole kernel, broken, shells, rejections were separated and weighed.Three observations were taken for each size. With help of following formulae the percentage of whole kernels recovery, breakage, uncut and shelling efficiency of machine were calculated.

Shelling efficiency:

$$\text{Shelling efficiency} = \frac{(1000 - \text{Weight of unshelled cashew nut) (g)}}{1000} \times 100$$

Whole kernel recovery:

$$\text{Whole kernel recovery} = \frac{\text{Whole kernel weight (g)}}{\text{Weights of whole kernel (g)} + \text{breakages (g)}} \times 100$$

Breakage :

$$\text{Breakage} = \frac{\text{Broken kernel weight (g)}}{\text{Weights of whole kernel (g)}} \times 100$$

Uncut :

$$\text{Uncut} = \frac{\text{Weight of uncut cashew nuts (g)}}{1000} \times 100$$

Cashew nut picking efficiency :

$$\text{Picking efficency} = \frac{\text{No. of cashew picked in 100 stoke}}{100} \times 100$$

Cost analysis:

The cost analysis of all the machines was done by B.I.S. Code (9164-1979). The cost analysis included the fixed cost, variable cost and operating cost of each machine.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

The size of cashew nut :

It observed that, the average length,width, thickness and geometric mean diameter of large cashew nuts were 38.8, 30.87,19.70 and 27.55 mm, respectively. The average length of medium size cashew nut was 34.13 mm, width was 26.65 mm, thickness was 18.76 mm, and geometric mean diameter was 24.85 mm. Similarly, average length, width, thickness and geometric mean diameter of small cashew nut were 28.45, 22.08, 15.95 and 20.56 mm, respectively**.**

Table 1 : Average dimensions of cashew nut

Size of cashew nut	Dimensions of cashew nut (mm)			
	L	B	T	$(LBT)^{1/3}$
Large, (30 nos.)	38.83	30.87	19.70	27.55
Medium, (30 nos.)	34.13	26.65	18.76	24.85
Small, (30 nos.)	28.45	22.08	15.95	21.56

Performances of shelling machine :

Improved power operated machine :

The whole kernel recovery was higher for big size cashew nut as compareed with medium and small size cashew kernel *i.e.* 97.22, 97.04 and 90.35 per cent, respectively. It proved that, the kernel recovery was

maximum for big size cashew nut as compared with medium and small size cashew nuts.

Similarly it was found that the shelling efficiency increased as size of size of cashew nut increased. The highest shelling efficiency *i.e.* 95 per cent was found for big size cashew nut as compared with 92.70 and 74.66 per cent for medium and small size cashew nut, respectively. The unshelled cashew kernel as well as breakage percentage of small size cashew nut was higher as compared with big and medium size cashew nut. It resulted that, the size of cashew direct affected on shelling efficiency of machine. Also it was found that the, differences in the kernel efficiency and shelling efficiency is large for small size cashew nut, it happened due to large quantity of unshelled and breakage of small cashew nut. The Fig.1 shows the clear visualization of above results.

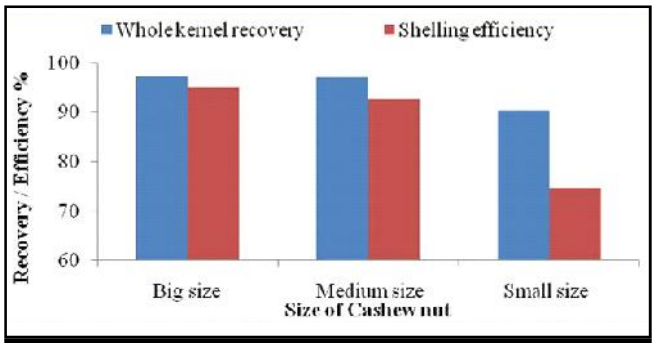

Fig. 1 : Effect of size of cashew nut on shelling efficiency and whole kernel recovery

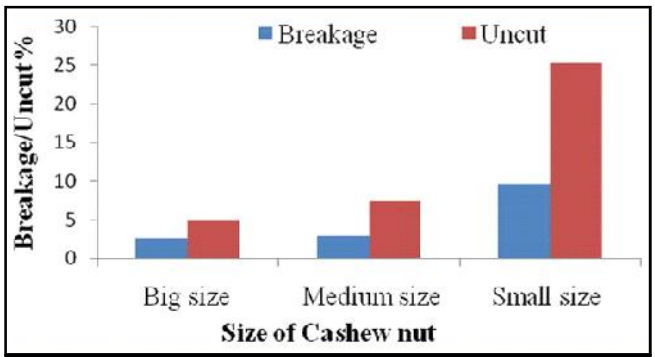

Fig. 2 : Effect of size of cashew nut with breakage and uncut

The uncut was found to be 5, 7.8 and 25.3 per cent for big, medium and small size cashew nut, respectively. The above graph showed that, the breakage and uncut of improved power operated shelling machine, increased with the decrease in size of cashew nut kernel. It happened due to small size cashew nut drop directly from the cutting chamber without any obstruction, which resulted, increase the uncut percentage nut.

The breakage was found to be 2.7, 2.9 and 9.6 per cent for big, medium and small size cashew nut, respectively. The higher breakage was found for small size cashew nut, it happens due to effect of high bonding energy between cashew nut shell and kernel. Also, the smaller size of kernel shows greater shell surface area. It indicated that the higher bonding energy between kernel and cashew shell. If such types of cashew nut come in contact with high impact cutting blade which increases the breakage.

Comparative performances of shelling machines without sorting of cashew nut :

It was found that, the highest shelling efficiency was found for manual operated shelling machine. It happened due to human interferences in the shelling operation. In traditional and improved power machine operated machine did not content any human interface. So, it showed lower shelling efficiency as compared with manual shelling machine.

The whole kernel recovery was found to be 92.5, 97.3 and 97.5 per cent, respectively for manually operated, traditional power operated and improved power operated shelling machine. There was no any major difference observed between traditional and improved power operated machine because the working principal of both shelling machine was same.

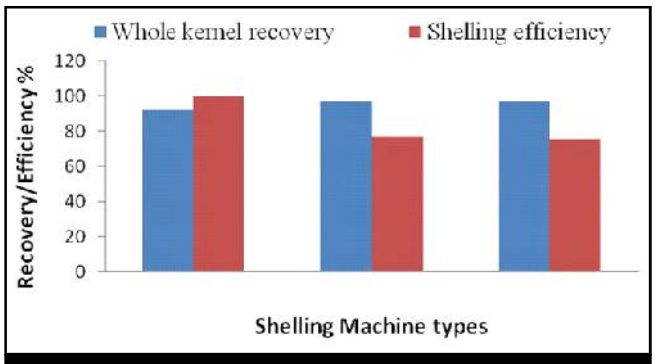

Fig. 3 :

The breakage was found to be 7.5, 2.7 and 2.5 per cent, respectively for manual, traditional power operated and improve power operated shelling machine. Similarly

the uncut was found to be 23.06 and 24.30 per cent, respectively for traditional power operated and improved power operated machine. Due to human interferences in manual operated shelling machine there was none of unshelled kernel remains,it showed zero uncut cashew nut.

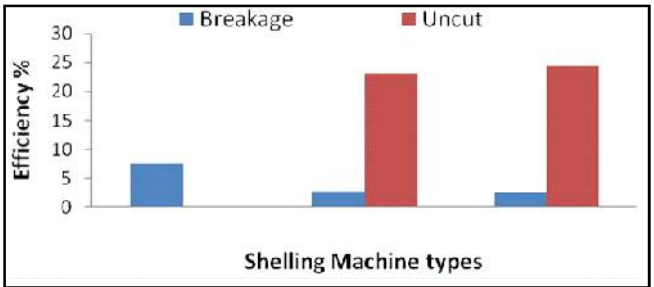

Fig. 4 : Comparison between different types of shelling machine with breakage and uncut

The Fig. 5 shows, the relation between picking efficiency and hopper fill in percentage or weight of cashew nut. If hopper fills with 100 (15 kg) per cent it shows higher picking efficiency. As soon as hopper start empties it decreasing the picking efficiency of improved shelling machine. The picking efficiency for hopper fill 100 (15 kg), 66.66 (10 kg) and 33.33 (5 kg) per cent was found to be 95, 90.83 and 77 per cent, respectively. As quantity of cashew nut decreases from hopper it reduces the angle of repose between hopper and cashew nut, resulted decreases the picking efficiency of cashew nut metering.

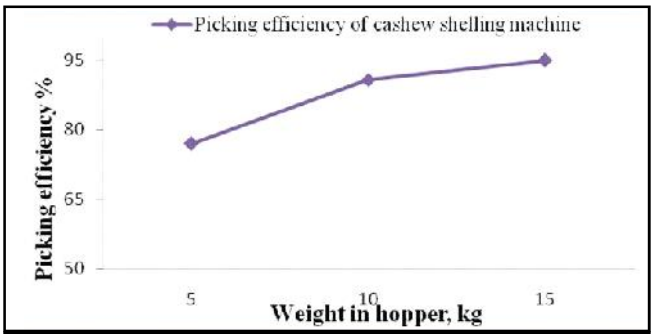

Fig. 5 : Effect of weight in hopper with picking efficiency of improved power operated shelling machine

It was observed that the average speed of the workers for shelling large size of the nuts is 44 nuts/min, medium size nuts 51 nuts/ min and for small size nuts 41 nuts/min. Hence, the shelling capacity of the medium size cashew nuts 51 nuts/ min is more than that of large size and smaller size nuts. And it was observed that shelling of small size cashew nut is difficult as compared to large and medium size cashew nut.

Operating cost of shelling machine :

Operating cost for manually, traditional and improved power operated shelling machine was found to be 27.91, 62.45 and 69.44 Rs/hr, respectively. From the data it is concluded that the operating cost per kg for manual, traditional and improved power operated machine was found to be Rs. 7, 3.12 and 2.31, respectively.

Total cost of shelling machine :

Total cost of shelling per day using improve and manual operated shelling machine for 240 kg kernel was found to be 555.40 Rs./day and 1260 Rs./day. It daily saved Rs. 704.60 and monthly Rs. 21138.

Conclusion :

– The highest shelling efficiency was found for manual operated shelling machine (100 %) followed by traditional power operated shelling machine (77.20 %) and improved power operated machine (75.77 %).

– The highest whole kernel recovery was found for improved power operated machine (97.40 %) followed by traditional power operated shelling machine (97.30 %) and manual operated shelling machine (92.47 %).

– The lowest breakage was found for improved power operated machine (2.50 %) followed by traditional power operated shelling machine (2.68 %) and manual operated shelling machine (7.52 %).

– The lowest uncut was found for manual operated shelling machine (00 %) followed by traditional power operated shelling machine (20.06 %) and improved power operated machine (24.30 %).

– Picking efficiency of improve power operated shelling machine was decreased as weight from hopper decreases.

– In improved power operated shelling machine the breakage was found higher for small cashew nut. Operating cost for manual, traditional and improved power operated cashew nut shelling machine was found to be 7 Rs./kg, 3.12 and 2.31 Rs./kg.Operating cost of improved shelling machine was 66 per cent and 57.43 per cent less as compare to manual and traditional power operated shelling machine.

Table 2: Operating cost of shelling machine

Detail	Manual operated	Traditional power operated	Improved power operated
Purchase cost (C), Rs.	5000/-	100000/-	120000/-
Salvage (S), Rs. 10 per cent of C	500/-	10000/-	12000/-
Life	1500	1500	1500
Fixed cost			
Depreciation, Rs. per year	750/-	15000/-	18000/-
D=(C-S/L)			
Interest, Rs. per year	275/-	5500/-	6600/-
10 % on (C+S)/2			
Insurances, Rs. per year	44.5/-	1100/-	1320/-
2 % on (C+S)/2			
Housing, Rs. per year	33.37/-	825/-	990/-
1.5 % on (C+S)/2			
Total fixed cost per year, Rs.	1102.87/-	22425/-	26910/-
Total fixed cost per h, Rs.	4.41/-	14.95/-	17.94/-
Variable cost			
Repair and maintenances	1/-	20/-	24/-
5 % on C, Rs./h			
Labour cost	22.5/-	22.5/-	22.5/-
1 man in all cases @180 for 8 hr			
Electricity charges, Rs./h	----	5.00/-	5.00/-
Total variable cost, Rs./h	23.5/-	47.50/-	51.50/-
Total operating cost A+B, Rs./h	27.91/-	62.45/-	69.44/-

Table 3 : Operating cost in terms of capacity

Sr. No	Method/mode	Cost, Rs./h	Shelling cost Rs./kg kernel
1.	Manual shelling	27.97/-	7/-
2.	Power operated shelling	69.44/-	2.31/- (67 % less)

Table 4 : Daily economics with use of power operated and manual shelling machine

Sr. No	Particulars		Detail
Power operated shelling machine			
1.	Shelling capacity, kg kernel/h		30
2.	Shelling capacity, kg/day		240
3.	Operating cost, Rs./h		69.44/-
4.	Shelling cost, Rs./kg		2.31/-
5.	Total cost of shelling per day using power operated machine (for 240 kg kernel)		555.40/-
Manual operated shelling machine			
6.	Shelling capacity, kernel/h		4
	Shelling capacity, kg/day		32
7.	Women days required for 240 kg kernel if manually done, nos.		7
8.	Total cost of shelling (for 240 kg kernel) if manually done, Rs.		1260/-
		Net saving Rs./day	704.60/-
		Saving Rs./month	21138/-

– Improved power operated shelling machine save monthly Rs. 21138 as compared to manually operated shelling machine.

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