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Development and performance evaluation of a semi-automatic cashew nut sheller

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ABSTRACT

The present study aims at the development of a semi-automatic cashew nut sheller suitable for the drum roasted cashew nuts incorporating a new shelling mechanism adopting the principle of impulse and tension. This mechanism comprises of a set of seven numbers of chisel shaped pins and a set of five numbers of conical shaped pins through which the impulse and tensile forces were applied simultaneously to crack the nut and release the whole kernel intact. The performance of this sheller was evaluated with three different sizes of nuts at 10.73% moisture content. The result on performance evaluation of the power operated sheller indicated that the shelling capacity was found to vary from 14.44 nuts/min to 14.67 nuts/min with whole kernel recovery varying from 86.92% to 93.67% and the shelling efficiency varying from 86.17% to 88.61%. The result on half split percentage and broken percentage was found to be varying from 5.46% to 6.00% and from 4.00% to 6.92% respectively. On comparison, in the conventional method the average shelling capacity was observed to be 9.74 nuts/min with 86.27% whole kernel recovery, 7.33% half splitted nuts and 6.53% brokens. The cost of operation of the power sheller was found to be Rs 3.10/kg as compared to Rs 3.48/kg in case of the conventional hand beating method. The overall performance of this sheller was found to be satisfactory as compared to the conventional method of shelling drum roasted cashew nuts. However, this sheller can be further modified incorporating an automatic feeding system to place cashew nuts in desired orientation for further enhancement of the shelling capacity with simultaneous reduction in drudgery of working and cost of shelling.

Key words: Cashew nut sheller, half split percentage, shelling efficiency, kernel recovery

Cashew nut (*Anacardium Occidentale* Linn) occupies a significant position among the edible tree nuts in the global market because of its multi dimensional plant food nutrients. India is the largest producer, processor, exporter, importer and second largest consumer of the cashew in the world (Annon. 2004). The cashew nut processing industry in Indian context has been mostly confined to the rural sector, where the conventional manual hand beating method for shelling is predominantly in practice. Shelling of roasted cashew nut is the vital unit operation in cashew nut processing sector where the delicate kernel is recovered as whole from the tough outer shell. Shelling of roasted cashew nut is conventionally accomplished by cracking the nut along its longitudinal axis in manual hand beating method to release the edible kernel. The irregular shape of the cashew nut and the brittleness of the kernel inside the hard shell make the shelling process complicated and results in breakage of kernels leading to reduction of market price and acceptability for export. The cashew nut shell liquid (CNSL) present over the drum roasted cashew nut shell surface causes a blistering effect on human skin, and to avoid that ash is mixed with them before shelling. This method is very tedious; time consuming and labour intensive with lower output capacity and as such lacks desirable quality control standards at international level for export. In this context the mechanization of cashew nut shelling operation needs to be addressed with priority.

Researchers inside India and abroad have worked consistently to develop a good number of cashew nut sheller designs with the objective to remove the drudgery of working with enhancement of quality and quantity in shelling operation. Kumar (1989) developed a continuous semi-automatic cashew nut sheller based on the principle of striking the nuts on hard surface under centrifugal action. Thivavarnvongs (1989) developed a semi-automatic cashew nut sheller consisted of a manual feeding action and subsequent automatic shelling action. Each nut was conveyed to its shelling position on a circular plate on which three sets of clamps and shelling blades are mounted. The sheller gave whole kernel recovery of higher than 80 percent with low investment. Oloso and Clarke (1993) cited different methods of shelling roasted nuts. The Sturtevant (Fletcher) method utilized a centrifuge within which the nuts were thrown against a steel plate at a speed just sufficient to crack the shell without breaking the kernel. Jain and Kumar (1997) developed a semi-automatic cashew nut sheller on the principle of compression and shear. The various mechanical means (manually operated, automatic and semi-automatic) developed so far are yet to be suitably adopted for commercial application. Thus, there remains a certain need to develop a simple, low cost and easily maneuverable technology for shelling roasted cashew nut with higher whole kernel recovery simultaneously taking care for quality control standards and economic feasibility.

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MATERIALS AND METHODS

Mechanism of cashew nut shelling

Cashew nut is an axi-symmetric body about its longitudinal axis, which facilitates to split the outer brittle shell into two halves releasing the whole kernel intact. Attempts were made to create a plane of rupture along this axis by application of impulsive force followed by a tensile force in a direction perpendicular to the longitudinal axis. Accordingly, the cashew nut was held in dorso-ventral position over a set of five conical shaped pins on its bottom surface. The impulsive force was applied to a predetermined depth by a set of seven chisel shaped pins on the top concave surface along the longitudinal axis. The tensile force was applied in a direction perpendicular to the longitudinal axis to split the nut along the plane of rupture, created earlier. The loading points on the cashew nut surface were selected so as to define the contour of the nut with minimum number of locations along the natural line of cleavage. The chisel shaped pins were selected to produce a wedging effect when used for applying impulsive force, where as the conical shaped pins are selected to grip the nut. The pins on the curved plate and the flat plate were mounted individually in separate compartments.

Development of a semi-automatic cashew nut sheller

A semi-automatic cashew nut sheller was developed, based on the principle of impulse and tension. The basic functional requirements for the power operated sheller was to simplify the two-stage shelling operation explained in the above mentioned newly conceptualized mechanism which could be accomplished in one stroke of operation where the tensile force should be applied simultaneously with the application of impulse. The major components of the semi-automatic cashew nut sheller are illustrated in Fig 1, which consists of main frame, power supply system, top shelling assembly, bottom holding assembly, spring loaded actuating assembly, spring loaded sliding assembly, shelling unit and fulcrum unit. The power supply system basically comprised of a prime mover, a speed reduction unit and a power transmission unit. A single phase electric motor of 1.0 hp was used as the prime mover considering the losses in the power transmission process. Accordingly, a worm gear box of 1.0 hp capacity was used for speed reduction as the desired velocity ratio would be of the order 70:1. For transmission of power from the worm gear box, a cam and roller follower assembly was attached which could transform the rotary motion of the power source to reciprocating oscillatory motion.

Operation of the semi-automatic cashew nut sheller

The prime mover is switched on to start the machine and the operator has to place a nut on the bottom holding assembly in between two side support plates and pull the mechanical lever forward. The power is transmitted to the gear box through the front flange and the belt–pulley drive. The cam assembly is rotated by the worm gear to conduct the shelling operation. As the cam rotates, the spring loaded actuating assembly helps the top shelling assembly to result in the impulse action followed by the tensile action to complete shelling of the nut. The next stroke of operation starts again with the placement of another cashew nut in between the side supports. The depth of penetration of the pins through the shelling unit and the holding unit are adjusted as per the size of the cashew nut. For a particular grade of the cashew nut this arrangement can be fixed and can be adjusted when the grade is changed.

Performance evaluation of semi-automatic cashew nut sheller

The performance evaluation of the semi-automatic cashew nut sheller was conducted at a Cashew Nut Processing Unit near Bhubaneswar through two major tests namely preliminary test and actual test. The preliminary tests were conducted to optimize the machine parameters to determine the depth settings of the chisel and conical shaped pins to complete the shelling operation successfully. Subsequently, actual tests were conducted in relation to the three sizes of the drum-roasted cashew nuts on the basis of the length of the nuts (S_1<30 mm, S_2 = 30-35 mm and S_3>35 mm). During testing, the numbers of shelled, partially shelled and unshelled cases were counted to find out the shelling capacity, shelling percentage and shelling efficiency. After shelling, the number of whole kernels, half split kernels and broken kernels were also counted to calculate the whole kernel recovery, half split percentage and broken percentage. The cost of operation of the power sheller was calculated using standard procedure; so also the cost of cashew nut shelling in conventional method for comparing the economics of use.

RESULTS AND DISCUSSION

The results on performance of semi-automatic cashew nut sheller in relation to three different sizes of the nuts have been presented in Table 1. The results with regard to the capacity of the machine, expressed in nuts/min were found to be statistically significant at 5.0 percent level. The highest and lowest capacity of 14.79 nuts/min and 14.46 nuts/min were achieved with size S_3 and size S_2 respectively. The results on capacity of the machine expressed in kg/h with relation to the nut size were found to be statistically significant at 5% level. The results on shelling capacity(kg/h) of the machine was observed to be 3.08, 4.01 and 5.87 kg/h in case of nut size S_1, S_2 and S_3 respectively. The highest and lowest capacity was observed with size S_3 and S_1 respectively because the average unit weights of size S_3 and S_1 were 5.56 g and 3.32 g respectively.

The results on shelling percentage in relation to the three different nut sizes under the experiment were found to be statistically significant. The average value of shelling percentage achieved by the machine with size S_1, S_2 and S_3 was observed to be 85.57%.The performance of the power sheller with respect to whole kernel recovery in relation to the nut size was observed to vary from 88.00% to 95.40%. The results on shelling efficiency of the power sheller with nut sizes S_1, S_2 and S_3 were observed to be 76.00, 82.00 and 79.30% respectively. The results on splitted half percentage with respect to three different nut sizes during shelling using

the power sheller were observed to vary within the range from 6.60% to 3.90% with mean value of 5.07%; but were not significant statistically. This may be due to the fixed clearance between the two side plates in the shelling unit and variation in the nut size within a grade under consideration. Since the depth of penetration by the chisel shaped pins is fixed prior to start of shelling operation, so the variation in nut size would have resulted the splitted halves. The results on broken percentage in relation to the three different nut sizes were found to vary within 6.30% to 2.20% with mean value of 4.70%; which were not significant statistically. This may be due to the variation in the nut size among the nuts within one grade and the fixed clearance in between the side plates and also the arrangement for fixed depth of penetration with the chisel shaped pins.

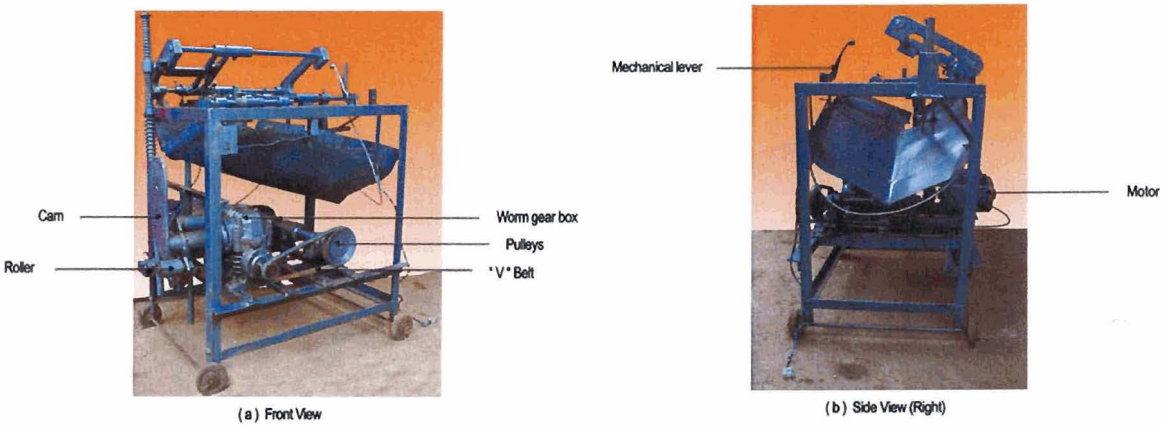

Fig. 1: Semi-automatic cashew nut sheller

Table 1: Performance of semi-automatic cashew nut sheller

Performance parameters	Roasted Cashew Nuts			Mean	SEm(±)	LSD(0.05)
	Size-1 (>30 mm)	Size-2 (30-35 mm)	Size-3 (<35 mm)			
Capacity, nuts/min	14.48	14.46	14.79	14.58	0.05	0.15
Capacity, kg/h	3.08	4.01	5.87	4.32	0.03	0.08
Shelling percentage	85.50 (9.27)	85.50 (9.27)	85.60 (9.28)	85.57 (9.28)	0.06	0.16
Whole Kernel Recovery,%	88.00 (9.40)	95.40 (9.79)	91.00 (9.57)	91.47 (9.59)	0.05	0.14
Shelling Efficiency,%	76.00 (8.74)	82.00 (9.10)	79.30 (8.93)	79.10 (8.92)	0.08	0.21
Half splitted percentage	6.60 (2.54)	3.90 (2.10)	4.10 (2.14)	5.07 (2.34)	0.18	NS
Broken percentage	6.30 (2.60)	2.20 (1.64)	5.60 (2.47)	4.70 (2.28)	0.19	NS

The results on performance evaluation of the semi-automatic cashew nut sheller indicated that the effect of nut size on capacity of the sheller expressed either in nuts/min or kg/hr was significant. It was observed that there was no significant effect of nut size on splitted half percentage and broken percentage. However, the effect of nut size on shelling percentage, whole kernel recovery and shelling efficiency was found to be significant statistically. The cost of shelling by the power sheller was calculated to be Rs 3.10 as compared to Rs 3.48/kg in case of conventional hand beating method.

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