RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 8 | Issue 1 | April, 2015 | 116–120
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ DOI: 10.15740/HAS/IJAE/8.1/116-120

Development and ergonomic evaluation of pedal operated cashew nut desheller

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Received : 18.06.2014; **Revised :** 11.03.2015; **Accepted :** 22.03.2015

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■ **ABSTRACT :** India is the largest producer, processor, exporter, importer and second largest consumer of the cashew in the world. The manual shelling process is done with pedal operated cashew nut sheller in standing posture. The objective of this study was to develop the pedal operated cashew nut desheller in such way that it could operated in sitting postures to reduced the drudgery involved in the deshelling operation. The dimensions in the design of seat were used from available anthropometrics and strength data of women worker of Konkan region. The modified pedal operated cashew nut desheller was ergonomically evaluated on six women ranging from 20 to 45 years. The mean values of working heart rate, corresponding oxygen consumption, energy expenditure, per cent VO_2, ΔHR were 93.56 bpm, 0.39 l/min, 8.31kJ/min, 29.33 per cent, 10.54 bpm which were less than limit of continuous performance (LCP). The operation categorized into 'moderately heavy'. With the help of developed pedal operated cashew nut desheller, kernel recovery of cashew nut obtained 7.68 kg/day. The overall performance of the developed pedal operated cashew nut desheller was good.

■ **KEY WORDS :** Cashew nut, Pedal operated desheller, Ergonomics, Anthropometric data

■ **HOW TO CITE THIS PAPER :** Kadam, V.B., Aware, V.V., Shirsat, N.A. and Shahare, P.U. (2015). Development and ergonomic evaluation of pedal operated cashew nut desheller. *Internat. J. Agric. Engg.*, **8**(1) : 116-120.

India is the largest producer, processor, exporter, importer and second largest consumer of the cashew in the world. Cashew nut is the traditional crop of the Konkan region. In Maharashtra, area under cashew nut cultivation is 1.84 Lha which gives the production 2.24 LT. Maharashtra contributes to 29.74 per cent of annual production of cashew nut in India (Tiwari *et al.*, 2013). Industrially, cashew nut crop facilitates running more than 3550 processing unit in year 2008 in the country providing employment for nearly 5 lakh families in the industrial sector. Over 95 per cent of unit workers are women. The cashew unit has the potential to play a leading role in the social and financial upliftment of people of Konkan region. Many low cost local processing units are being setup to process raw cashew. Around 1850 small units have been setup in Konkan region (Mohod *et al.*, 2010).

There are several unit operations in cashew nut processing industries such as cleaning, roasting, shelling, pregrading, drying, peeling, grading and packaging. All of these operations are carried out by manually and somewhere started by mechanically. Shelling of cashew nut is done by manually or mechanically. The manual shelling process is done with pedal operated cashew nut sheller and in a working day, it opens about 5 kg. of whole kernels throughout day (Anonymous, 2007).

The deshelling performance depends not only on the machine but also on operator. Due to adoption of improper postures during work, the operation may cause

anatomical disorder and it will affect the operator's health. The poor man machine system, resulting in lower output, because the worker may have frequent rest or long rest. The objective of this study was to develop the pedal operated cashew nut desheller in such way that it could operated in sitting postures to reduced the drudgery involved in the deshelling operation.

METHODOLOGY

A good seat should enable the user to change posture at intervals so that different groups of muscles can be called into play. The dimensions in the design of seat were used from available anthropometrics and strength data of women worker of Konkan region (Anonymous, 2006) and dimension of seat selected as per (IS 12343:1998) for this purpose as given in Table A. The seat was developed at workshop CAET, Dapoli.

Ergonomical evaluation of developed machine with ergonomic design features :

The modified pedal operated cashew nut desheller was ergonomically evaluated on six women ranging from 20 to 45 years considering that the subjects should be true representative of the user. The experiment conducted at M/S Vishwas cashew, Asond Tal. Dapoli, district Ratnagiri. The mean age of selected women subject was 32.83 years having weight and height 45.33 kg. and 147.60 cm, respectively.

The calibrations of selected subjects were conducted in laboratory on bicycle ergometer at average dry bulb temperature 29ºC and relative humidity 78 per cent. Correlation between heart rate and oxygen consumption rate at specified sub maximal workloads were developed and the regression line was extrapolated to the age predicted maximum heart rate and VO_2 max corresponding to HR max was noted. The mean value of predicted maximum heart rate of selected subjects was 185.14 bpm and average value of VO_2 max of all selected subjects were 1.31 l/min.

Heart rate and oxygen consumption :

Heart rate was measured by using polar heart rate monitor and oxygen consumption was predicted from calibration chart.

At the time of trial heart rate monitor was used for recording heart rate values in bpm. Each subject was given 30 minutes rest on stools before starting of work. Each trial was started taking 5 min resting heart rate data of the subject. The average resting heart rate was computed and recorded for each subject. After resting each subject was asked to perform deshelling operation for 20 minutes, during that period heart rate values were recorded.

Energy expenditure :

The energy cost of operation of the selected

Table A : Anthropometric dimensions used for seat design

Sr. No.	Name of the part	Anthropometric dimensions are used	Dimensions of women in Konkan region (mm)	Dimensions used for modifying seat (mm)
1.	Seat height	Popliteal height, 5th percentile	356	320-450
2.	Seat length	Buttock popliteal length, 5th percentile	384	380
3.	Seat pan width	Hip breadth sitting, 95th percentile	343	400
4.	Back rest height	Elbow rest height, 95th percentile	282	300
5.	Back rest width	Interscye breadth, 95th percentile	312	300
6.	Back rest inclination	Trunk thigh angle is in comfort range	95-105^0	103^0
7.	Hand lever height	Sitting acromion height, 5th percentile	463	430-300
		Elbow rest height, 95th percentile	235	
8.	Handle length	Should not obstacle to operator		230
9.	Handle diameter	Middle finger palm grip	30	30
		Grip diameter (inside)	39	
10.	Pedal length	Foot length	242	250
11.	Pedal width	Foot width	104	110

machines was computed by multiplying the oxygen consumed by the subject during the trial period with calorific value of oxygen as 20.88 kJ/lt. (Nag *et al.*, 1980; Zakiuddin and Modak, 2010) for all the subjects.

Acceptable work load (AWL) :

Maximum aerobic capacity :

The acceptable workload (AWL) for Indian workers was the work consuming 35 per cent of VO_2 max. To ascertain whether the operation of the selected machines was within the acceptable workload (AWL), the VO_2 max for each treatment was computed and recorded.

Limit of continuous performance :

To have a meaningful comparison of physiological response Δ values (Increase over resting values) for heart rate (work pulse) were calculated (Tiwari and Gite, 1998). For this, the average values of the heart rate at rest level and at working condition were used.

Overall discomfort score :

Overall discomfort rating is the subjective, self reported estimates of effort expenditure might be quantified using ratings of perceived exertion. For the assessment of overall discomfort rating a 10 point psychophysical rating scale (0 - no discomfort, 10 extreme discomforts) was used which is an adoption of Corlett and Bishop (1976).

Body part discomfort score :

To measure body part discomfort (Corlett and Bishop, 1976) technique was used. The subject was asked to mention all body parts with discomfort, starting with the worst, the second worst and so on until all parts have been mentioned. The number of different groups of body parts which are identified from extreme discomfort to no discomfort represented the number of intensity levels of pain experienced. The body part discomfort score of each subject was measured by multiplying by the number of body parts corresponding to each category. The total body part score for a subject would be the sum of all individual scores of the body parts assigned by the subject. The body discomfort score of all the subjects is to be added and averaged to get mean score.

Force required operating the pedal and handle :

There were two types of operations in deshelling of cashew nut one of them was cutting and another was opening the cut shell. Cutting was done by pressing the cutter lever in downward direction by pedal and splitting of shell was done by lifting hand lever in upward direction. The actual effort required in pulling of hand lever and pushing the foot operated pedal of cashew nut desheller was measured using Novatech load cell. The load cell was placed between the foot pedal and blade operating lever with the help of hook. The load cell measured the force in kg which was given by the foot.

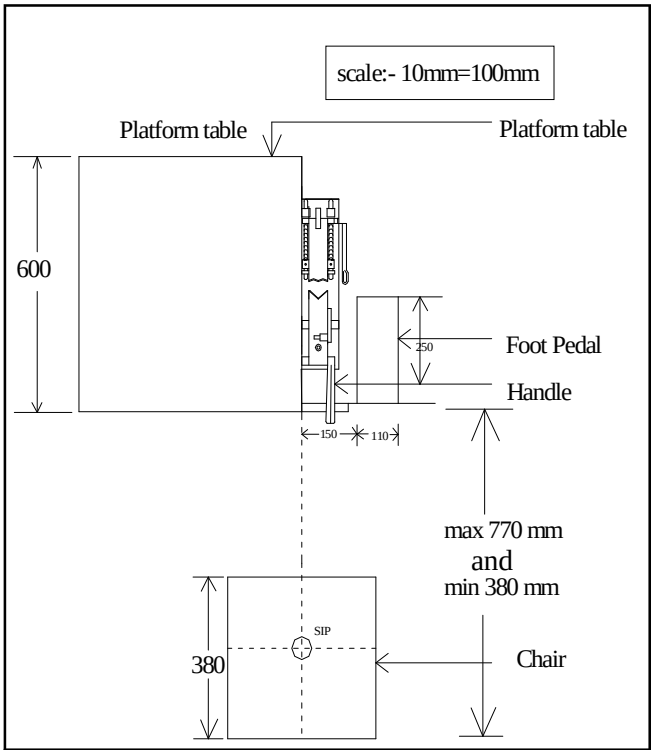

Fig. A : Top view of workplace layout of modified cashew nut desheller

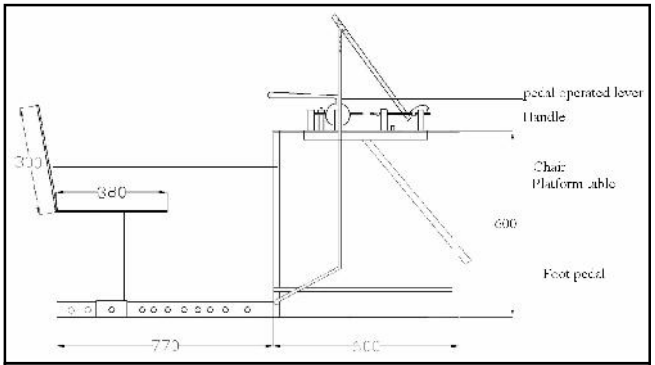

Fig. B : Side view of ergonomically modified cashew nut desheller with chair

Performance evaluation of pedal operated cashew nut desheller :

The machine output was affected by the skill of operator. The mean values of deshelling capacity (whole kernel) in kg/day, whole kernel per cent, breakage per cent and Rs./day/operator were calculated (Fig. A and B and Plate A).

Plate A : Modified pedal operated cashew nut desheller

RESULTS AND DISCUSSION

The heart rate readings of subjects from 6th to 15th minute were considered for the calculation of the energy cost of operation of pedal operated cashew nut desheller. It is revealed from Table 1 that the mean value of working heart rate of all the selected subjects was 93.56 bpm and the mean value of corresponding oxygen consumption was 0.39 l/min. The average value of energy expenditure of all selected subjects was 8.31kJ/min which indicated that the cashew nut deshelling operation 'moderately heavy'. The mean value of per cent VO_2 for pedal operated cashew nut desheller was 29.33 per cent which were below the acceptable limit. The mean value of ΔHR was 10.54 bpm which was less than limit of continuous performance (LCP).

In modified cashew nut desheller, the perceived exertion scale was just more than light discomfort. This was might be due to sitting posture. The mean value of overall discomfort ratings was 3.83 which indicated that the operation with modified cashew nut desheller was more than light discomfort. The BPDS of all the subjects for pedal operated cashew nut desheller with ergonomic design features was 14.38. It was found that subjects experiencing very light discomfort in shoulder, knees, elbow and foot. Sitting postures reduced the muscular

Table 1 : Ergonomical parameter of all participated subjects in the study

Sub No.	WHR, bpm	VO_2, l/min	EER, kJ/min	VO_2 max (%)	ΔHR bpm	ODR	BPDS	Force kg	
								Pedal	Handle
1.	98.50	0.45	9.39	30.20	5.34	4	14.66	7	5
2.	81.80	0.51	10.64	29.31	16.64	3	21	7	4
3.	83.60	0.41	8.56	43.61	7.60	3	12	7	4
4.	103.10	0.72	15.03	34.28	9.10	5	12	6	4
5.	94.60	0.14	2.92	15.73	17.60	3	12	8	6
6.	99.80	0.16	3.34	22.85	6.97	5	14.66	9	5
Mean	93.56	0.39	8.31	29.33	10.54	3.83	14.38	7.33	4.66

Table 2 : Performance evaluation of pedal operated cashew nut desheller

Sr. No	Parameters	Mean
1.	Duration of deshelling, h	4.66
2.	Deshelling of raw nut, kg/day	31.77
3.	Whole kernel recovery, kg/day	7.68
4.	Whole kernel, %	94.70
5.	Breakage, %	5.28
6.	Energy cost for deshelling, kJ/kg	296.66
7.	Heart rate expenditure for deshelling, beats/kg	3443.89
8.	Oxygen consumed for deshelling, l/kg	14.21
9.	Total income per day, Rs./day	69.19
	Considering deshelling rate @ Rs. 9 /kg for whole kernel	

effort of lower leg and lower back and thigh. The mean force required for pressing the foot pedal was 7.33 kg and for lifting the hand lever was 4.66 kg.

Performance evaluation of pedal operated cashew nut desheller :

The mean value of duration of deshelling of cashew nut per day of all selected subjects was 4.66 h as shown in Table 2. The deshelling capacity of raw cashew nut of all selected subjects varied from 27 to 34 kg/day and the mean value of deshelling capacity was 32.29 kg/day. The mean value of deshelling capacity was 31.77 kg/day. The mean of whole kernel recovery of deshelled cashew nut was found 7.68 kg/day. Energy cost of all selected subjects for deshelling of cashew nut was 296.66 kJ/kg (Ghatge *et al*., 2014 and Swain *et al*., 2009).

The physiological cost of deshelling operation in terms of heart rate and oxygen consumption were varied from 2829 to 4340 beats/kg and 5 to 27 l/kg, respectively. The mean values of physiological cost in terms of heart rate and oxygen consumption for deshelling of cashew nut were 3443.89 beats/kg and 14.21 l/kg, respectively. Total income of the subjects for deshelling of cashew nut varied from 59 to 74 Rs/day. The mean value of total income of subjects was 69.19 Rs./day.

Conclusion :

The deshelling efficiency of the developed pedal operated cashew nut desheller was found satisfactory. With the help of developed pedal operated cashew nut desheller, while kernel recovery of cashew nut obtained 7.68 kg/day. Energy cost of operation was 296.66 kJ/kg. The overall performance of the developed pedal operated cashew nut desheller was good.

Acknowledgement :

The authors are thankful to M/s Vishwas Cashew, Asond, Dapoli, District Ratnagiri, for co-operation. The authors are grateful to Project Co-ordinator, All India Co-ordinated Research Project on ergonomics and safety in agriculture, Indian Council for Agricultural Research, New Delhi, for their encouragement and providing necessary facilities for the present work.

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