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RESEARCH ARTICLE :

Ergonomic evaluation of pedal operated arecanut dehusker with women workers in the Konkan region of Maharatshtra

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SUMMARY : Dried arecanut are dehusked at farmer's house or at small scale processing units by manual labour using country kitchen tool having a wooden plank and curved MS blade. Traditional dehusking method is time consuming, highly labour intensive, uneconomical and above all very unsafe for fingers and palms. The developed pedal operated arecanut dehusker was evaluated with nine female workers to check the suitability of the machine for women workers. Average age, weight and stature of the subjects were 26.1(± 8.5) years, 46.7(± 9.6) kg and 158(± 6) cm, respectively. While average HR max and VO_2 max were 193.9 (±8.5) bpm and 1.47(± 0.3)l/min, respectively. The mean heart rate, oxygen consumption rate and energy expenditure rate for nine subjects were 136.6 bpm, 0.8 l/min and 16.56 kJ/min, respectively. The work is under 'Very heavy' category (Sen, 1969).

KEY WORDS:
Ergonomic evaluation, Arecanut dehusker

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BACKGROUND AND OBJECTIVES

In India, arecanut was grown on 3.81 lakh ha with production of 4.83 lakh MT and productivity of 1409 kg/ha during the year 2006-07 (Anonymous, 2008). After drying arecanut are dehusked at farmer's house or at small scale processing units by manual labour using country kitchen tool having a wooden plank and curved MS blade. The whole kernel is separated by taking two to three cuts to the dried fruit. As kernel is separated from each fruit individually, this dehusking process is time consuming. In addition to this, the conventional method is highly labour intensive, uneconomical and above all very unsafe for fingers and palms. It is observed that for a single dehusking operation about 35 to 40 per cent of the total cost of processing is involved (Varghese and Jakob, 1998).

In order to increase productivity few scientists developed motorized arecanut dehusking machines. The dehusking machines developed by Balasubramanian (1985); Varghese and Jakob (1998) and Bandit *et al.*

(2009) were suitable for electrified area only. The capacities of the machines were also high and were not suitable for the small and marginal farmers. Effort was made by Baboo (1981) for manual dehusking machine of arecanut but much success was not achieved because of low capacity of machine. In spite of above-mentioned research, mechanical dehusker for small scale dehusking were not commercially available. Also, there was requirement of manual arecanut dehusking machine which was not power dependent and suitable for small and marginal farmers. Considering these points a pedal operated arecanut dehusker was developed at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. It was necessary to conduct ergonomic evaluation of the developed pedal operated arecanut dehusker with women workers.

RESOURCES AND METHODS

Pedal operated arecanut dehusker was consisted of hopper, dehusking cylinder, concave, frame, power transmission arrangement and caster wheel as the major components. The average dehusking efficiency and kernel breakage at 7 m/s peripheral speed and 15 kg/h feed rate were 96.6 per cent and 6.7 per cent, respectively. Basically, this machine was developed to be operated by male workers. While in arecanut dehusking industries both male as well as women are employed.

The ergonomic evaluation of this machine with male workers was already carried out. Accordingly, the mean working heart rate, oxygen consumption rate and energy expenditure rate were 127 (± 8.4) beats/min, 1.3 (± 0.1) lit/min and 27 (± 2.79) kJ/min, respectively.

Ergonomic evaluation of arecanut dehuskar was carried out with nine female subjects (workers). Before actual ergonomic evaluation of developed arecanut dehuskar, calibration of the subjects was undertaken for finding maximum aerobic capacity (oxygen consumption rate at maximum heart rate) also from the calibration chart the oxygen consumption rate of individual subject can be measured indirectly.

Basic physical characteristics of the subjects namely age, weight and stature were measured in the laboratory. The bicycle ergometer (MONARK 839E) was used as loading device and computerized energy measurement system (K4b^2) was used for measuring heart rate and oxygen consumption rate of individual subject.

The average dry bulb temperature and relative humidity during the test were 25^{0}C and 77 per cent respectively. The saddle height of bicycle ergometer was kept such that the subject's leg was almost straight at knee when the pedal was at lowest position. The subject was asked to pedal the bicycle at a pedalling rate of 50 rpm. Pedalling speed was maintained using visual metronome on the bicycle which was continuously visible on the computer screen. The manual protocol was developed in which workload was automatically increased by 15 W at an interval of 2 min through software. Since a sub maximal test was carried out, load was given up to sub maximal load i.e. 75 per cent of maximum heart rate. The maximum HR was calculated by the following relationship.

Maximum heart rate (HR max) = 220 – age (yrs)

The K4b^2 attachment was mounted on the subject, measured the heart rate and oxygen consumption rate simultaneously and recorded automatically breath by breath. This data then filtered using provision in software to get the HR and OCR values at the interval of one minute. Correlations between heart rate and oxygen consumption rate for each subject were developed. The maximum aerobic capacity (VO_2 max) was noted method of extrapolation.

In actual ergonomic evaluation of dehusker, only heart rate was actually measured and oxygen consumption rate was noted form the calibration chart and expenditure rates were computed.

Plate A : Working with pedal operated arecanut dehusker

Energy expenditure rate (kJ/min) = Oxygen consumption rate (lit/min) x 20.88 (calorific value of oxygen is 20.88 kJ/lit).

The dehusking capacity, dehusking efficiency and breakage percentage were for each subject was calculated.

OBSERVATIONS AND ANALYSIS

The details of subjects employed in ergonomic evaluation, regression equation between HR and OCR and VO_2 max were determined which are furnished in Table 1.

Average age, weight and stature of the ten female subjects were 26.1 (± 8.5) years, 46.7 (± 9.6) kg and 158 (± 6) cm, respectively. While average HR max and VO_2 max were 193.9 (±8.5) bpm and 1.47 (± 0.3) l/min, respectively.

The relationship between HR and OCR is shown in Fig. 1.

The subject wise derails abloyt workinh heart rate (WHR), working Oxygen consumption rate (WOCR), work pulse, BPDS and ODR are depicted in Table 2.

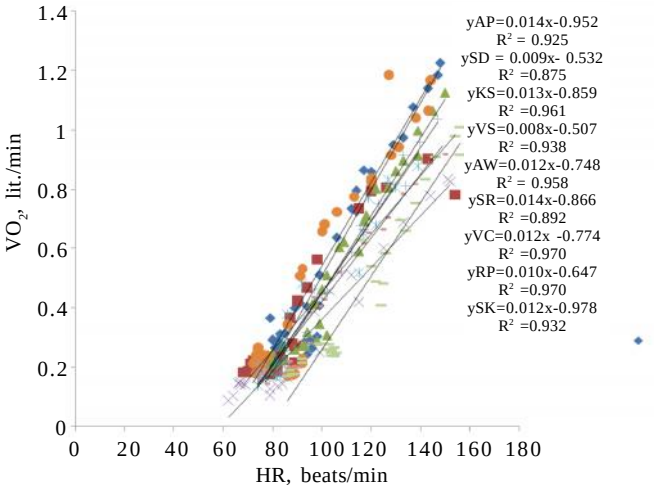

Fig. 1 : The relationship between HR and OCR

Table 1 : Details about subject, regression equation and VO_2 max

Sr. No.	Subject code	Age (yrs)	Weight (kg)	Height (cm)	Maximum heart rate (bpm)	VO_2 max, l/min	Regression equation	R^2
1.	AW	43	41	148	177	1.31	y= 0.012x-0.748	0.98
2.	VS	39	34	150	181	0.941	y=0.008x-0.507	0.93
3.	SK	22	45	167	198	1.39	y= 0.012x-0.978	0.93
4.	SD	22	38	160	198	1.25	y=0.009x-0.532	0.88
5.	SR	22	52	164	198	1.91	y=0.014x-0.866	0.89
6.	AP	22	50	159	198	1.79	y=0.014x-0.952	0.92
7.	KS	22	67	158	198	1.70	y=0.013x-0.859	0.96
8.	VC	22	49	157	198	1.60	y=0.012x-0.774	0.97
9.	RP	21	44	159	199	1.35	y=0.010x-0.647	0.97
	Average	26.1 (± 8.5)	46.7 (± 9.6)	158 (± 6)	193.9 (± 8.5)	1.47 (± 0.3)		0.94 (± 0.03)

Table 2 : Subject wise physiological parameter, BPDS and ODR while using pedal operated arecanut dehusker

Sr. No.	Subject Code	Resting HR	Working HR	Working OCR	Energy expenditure rate	Work pulse (LCP as 40 beats/min)	BPDS	ODR
		(bpm)	(bpm)	(l/min)	(kJ/min)			
1.	AW	97.0	146.0	0.94	19.58	49(>LCP)	25	5
2.	VS	64.0	127.0	0.51	10.62	63(>LCP)	20	6
3.	SK	91.0	127.0	0.55	11.10	36(<LCP)	20	5
4.	SD	85.0	136.5	0.70	14.53	51.5(>LCP)	22.5	6
5.	SR	91.4	130.0	0.95	19.39	38.6(<LCP)	27.5	4
6.	AP	92.2	123.8	0.76	15.84	31.61(<LCP)	25	5
7.	KS	98.2	139.9	0.94	19.66	41.8(>LCP)	25	6
8.	VC	84.1	139.0	0.92	18.78	54.9(>LCP)	25	5
9.	RP	96.7	161.0	0.96	19.57	64.3(>LCP)	27.5	4
	Average	88.8 (±10.6)	136.6 (±11.7)	0.80 (±0.2)	16.56 (±3.7)	47.8(>LCP)	24.06 (±2.8)	5 (0.8)

The mean heart rate, oxygen consumption rate and energy expenditure rate for nine subjects were 136.6 bpm, 0.8 l/min and 16.56 kJ/min, respectively. The work is under 'Very heavy' category (Sen, 1969). The work pulse was 47.8 bpm, as LCP was 40 bpm, the work was above LCP indicating that the proper rest was required with the determined working time. The values of Body Part Discomfort Score (BPDS) and Overall Discomfort Rating (ODR) were 24.06 and 5, respectively.

The subject wise details about dehusking rate (kg/h) and kernel broken percentage are given in Table 3.

Table 3 : Subject wise details about dehusking rate and kernel broken percentage

Sr. No.	Subject code	Dehusking rate, kg/h	Per cent broken
1.	AW	6.2	6.5
2.	VS	7.1	4.8
3.	SK	9.6	7.0
4.	SD	8.4	6.2
5.	SR	7.8	8.0
6.	AP	7.8	7.8
7.	KS	8.6	6.6
8.	VC	9.2	7.2
9.	RP	8.5	5.8
	Average	8.1	6.7

The average dehusking rate was 8.1 kg/h while the kernel broken percentage was 6.7. The dehusking capacity is about same as that of traditional method. However, considering the safety to palms and figures, pedal operated arecanut dehusker seems to be better option.

Conclusion :

Traditional method of dehusking is time consuming, drudgeries and unsafe to palms and figures. The new generation is no longer ready to continue the work of their family members. Hence one of the better option for them to continue the arecanut dehusking work is mechanization that to be affordable considering the limitations of electricity and investment capacity. The above mentioned difficulties in the arecanut dehusking can be answered by the pedal operated dehusker to some extent.

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