

**Ergonomics Evaluation of a Kenaf Stem (*Hibiscus cannabinus*) Decortivating Machine**<sup>1</sup>Raji, Abdul Ganiy Olayinka and <sup>2</sup>Aremu, David Olufemi<sup>1</sup>. Department of Agricultural and Environmental Engineering, Faculty of Technology, University of Ibadan, Ibadan, Nigeria.<sup>2</sup>. Department of Agricultural Engineering, Federal College of Agriculture, Moor Plantation, Ibadan, Nigeria  
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**Abstract:** A kenaf decortivating machine was ergonomically evaluated to assess the anthropological and physiological workload on end-users and determine the levels of injuries and discomfort on operators as a result of machine usage. Twenty five subjects between age range 15 - 20, 21 - 25, 26 - 30, 31 - 35, 36 - 40 and 41 years and above (each numbering 4, 8, 6, 2, 1 and 4 respectively) were selected for this study. The subjects were acclimatized with the experimental procedure before the commencement of the evaluation. Parameters measured included anthropological data (body weight, age, height and arm length) and physiological data (blood pressure and heart beat rate at normal rest position and after machine operation). The oxygen consumption rate and energy expended in operating the machine was also studied. Highest Mean Body Weight was 71.5cm for 26 to 30 years, Highest Mean Arm Length was 81cm from age 41 years and above, the variation in Heartbeat ranges from 6 to 50 beats/Min, Oxygen Consumption was 0.3916L/Min and the Energy Expenditure was 6.226 KJ/Min. The machine operation led to very slight increase in heartbeat rate, energy expenditure and oxygen consumption; the physiological difference at normal rest position and after machine operation was at a safe level for normal living thus, the machine usage is not injurious to end-users.

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**Keywords:** Ergonomics, Kenaf Stems, Decortivating Machine, Anthropology, Physiological

### 1. Introduction

Kenaf plant is cultivated for its fiber in Malaysia, South Africa, Thailand, parts of Africa, and to a small extent in Southeast Europe. The stems produce two fibers, a coarser fiber in the outer layer (bast fiber), and a finer fiber in the core. The leaves are consumed in both human and animal diets, the bast fiber was used for bags, cordage, and the sail for Egyptian boats. The main uses of kenaf fiber have been rope, twine, coarse cloth (similar to that made from jute) and producing kenaf paper which is the most common process to make kenaf paper in using soda pulping before processing the obtained pulp in a paper machine (Kaldor *et al.*, 2002).

Kenaf decortication is the removal and separation of the core fibre from the bast either manually or mechanically. Manual decortication is very slow and time consuming; it is carried out when the harvested stalk is well dried to a stage the kenaf may be easily decorticated with hand while the mechanical decortication though easy is very expensive. Most available kenaf decorticators in Nigeria are imported from developed countries and cannot be afforded by rural farmers; most of the spare parts are not also locally available, in lieu of this, Akande and Aremu (2012) designed, developed and evaluated a motorized kenaf decortivating machine.

However, the ergonomics adequacy of the decorticator has not being determined. Ergonomics evaluation is the human factors engineering which studies the levels of injuries and discomfort caused on end-users as a result of machine usage. In Nigeria, local fabricators of agro-processing equipment have designed and manufactured various improvised versions of many processing machines without due ergonomic considerations. Ergonomics cannot be carried out without anthropometric evaluation in the variation of human body (weight, height, heartbeat rate) and how this contributes greatly to the study in ergonomics evaluation to help either recommend safety act in other to prevent both machine and operator security. The advanced ergonomic aspect of kenaf bicomposite is lightweight, high performance, less expensive and offer safety to workforce from injuries (Rozyanty *et al.*, 2014). Health Safety at Work Act (2015) states that the application of ergonomics is the use of data from studying human body measurement (anthropometrics) in various machine designs, which has contribute to maintenance and repairs, space requirement for operators as well as safety. The main objective of this study was to evaluate the ergonomics adequacy of a kenaf decortivating machine.

## 2. Material and Methods

**Sampling and Experimentation:** Twenty five subjects (25) were selected within age range 15 - 20, 21 - 25, 26 - 30, 31 - 35, 36 - 40 and 41 years and above (each numbering 4, 8, 6, 2, 1 and 4 respectively with no disability) were selected for this study. All the subjects were physically fit and were not suffering any disability that will disrupt the machine operation. The operators were acclimatized with the experimental protocol before the commencement of the test and were given training on the operational techniques of the machine (Agarwal *et al.*, 2007; Singh, 2013; Aremu, 2015).

**Anthropometrical and Physiological Evaluation:** the anthropometrics evaluation was carried out by measuring the body weights, heights and arm lengths of the subjects using a weighing scale (120kg, 260 lb Capacity, made by Hana Company, China) and meter rule.

Heart beat rates and blood pressures were measured both at rest and after operating the machine using sphygmomanometer (IM-HEM-7121-E-FR-01-08/20132298866-7A). The difference in blood pressure and heart beat rate was obtained as the difference between values at normal rest position before machine operation and values obtained after the operation. The values obtained from measured heart beat rate of the subjects were used to determine the following:

i. Oxygen consumption (OC): the oxygen consumption rate of subjects at their measured heart beat rate after machine operation was estimated using the general equation given by Singh *et al.* (2008).

$$Y = 0.0114X - 0.68 \quad (1)$$

where Y is the oxygen consumption (l/min), X is the heart beat rate after machine operation (beats/min).

ii. Energy expenditure (EE): the energy expenditure was calculated using the formula by Kwatra *et al.* (2010).

$$EE = (0.159xHR) - 8.72 \quad (2)$$

where the HR is the heart beat rate (beats per min), X is the heart beat rate after machine operation and EE (KJ/min).

Muscular stress and discomfort: during the ergonomics evaluation the incidences of pain perceived by each subject was recorded from different parts of the body. It was calculated using five points scale in Table 1 (Kwatra *et al.*, 2010).

## 3. Results

The result of the ergonomic evaluation given in Table 2 shows that the body weight of operators increases with increase in age from age group 15-20 to 31-35 while there was a decline in body weight from age group 31-35 to 41 years and above (Agarwal *et al.*, 2007). The highest mean of body weight was 71.5cm from age group 26-30cm, the highest mean of arm length was 81cm from age group 41 years and above this implies that body weight increases with an increase in age while there was no definite pattern in heights variation within the age groups. The result of physiological and anthropometrical measurement of the subjects both before and after operating the machine is presented in Tables 3-4 and Figure 1.

The forest herbs species in the oak and pine forests belongs to 21 families. The total number of species present in the oak forest and pine forest was 32 and 41, respectively.

Table 2 depicts diversity of the Angiosperm family in both forest sites. In the oak forest, Asteraceae was represented by four species, followed by Lamiaceae (3 spp.), Fabaceae, Orchidaceae, Utricaceae, Zingiberaceae, Apiaceae and Geraniaceae (2 spp. each) and remaining 13 families were represented by one species each. Taxonomically, Asteraceae was the dominant family (with 4 genera), followed by Lamiaceae (with 3 genera), Apiaceae, Fabaceae, Orchidaceae, Utricaceae and Zingiberaceae (with 2 genera each) and remaining 14 families were represented by single genus only.

### Physiological Evaluation of the Subjects:

Table 3 shows the variation in heart beat rate of subjects at normal rest position and after machine operation. It can be observed that there was a slight increase in body heart beat which indicate that more oxygen consumption is required after machine operation (Singh *et al.*, 2008). The highest difference in heart beat before and after machine operation was observed to be between the range of 6 to 22 Beats/Minutes in 15 to 20 years and also the same in 41 years and above respectively. However, the increase in heart beat rate is still within normal body exercise for a healthy living, George (2014) reported that for an average adult of 20-year-old, the maximum heart rate would be 200 bpm, with a target heart-rate zone of 100 to 170 bpm.

**Table 1: Intensity of incident Pain**

Score	Intensity of pain
5	Very Severe
4	Severe
3	Moderate
2	Mild
1	Very mild

**Table 2: Anthropometrical Evaluation of the Subjects**

Age	Mild age	No of subjects	Anthropometric parameter	Range	Mean	S.D
15-20	18	4	Weight (kg)	48-62	55	7
			Height (cm)	149-179	164	15
			Arm length (cm)	60-70	65	5
21-25	23	8	Weight (kg)	59-71	65	6
			Height (cm)	158-161	159.5	1.5
			Arm length (cm)	68-83	75.5	7.5
26-30	27	6	Weight (kg)	68-75	71.5	3.5
			Height (cm)	149-172	160.5	11.5
			Arm length (cm)	30-108	69	6
31-35	33	2	Weight (kg)	68-71	69.5	1.5
			Height (cm)	167-179	173	6
			Arm length (cm)	64-85	74.5	10.5
36-40	38	1	Weight (kg)	64-72	68	4
			Height (cm)	140-191	165.5	25.5
			Arm length (cm)	76-86	81	5
41 & above	41	4	Weight (kg)	62-71	66.5	3.35
			Height (cm)	153-166	159.5	6.5
			Arm length (cm)	68-89	78.5	10.5

**Table 3: Physiological Evaluation of the Subjects**

Age Group	No of subjects	Blood pressure at normal rest position (mmHg)	Blood pressure after machine operation (mmHg)	Difference
15-20	4	72/107	78/117	6/10
		49/105	59/120	10/15
		100/30	130/70	30/40
		105/49	121/59	16/10
21-25	6	140/85	160/100	20/15
		110/80	130/110	20/30
		135/90	160/120	25/30
		140/70	150/90	10/20
		100/60	130/80	30/20
		40/60	70/100	30/40
26-30	8	110/70	150/90	40/20
		125/75	140/100	15/25
		130/70	150/100	20/30
		110/80	140/90	30/10
		73/60	83/80	10/20
		115/55	137/70	22/15
31-35	2	80/60	130/90	50/30
		100/60	120/90	20/30
		100/60	110/90	10/30
36-40	1	110/50	150/70	40/20
		155/90	170/110	15/20
41 and above	4	60/80	100/110	40/30
		110/50	160/60	50/10
		80/90	110/100	30/10
		110/40	130/70	20/30

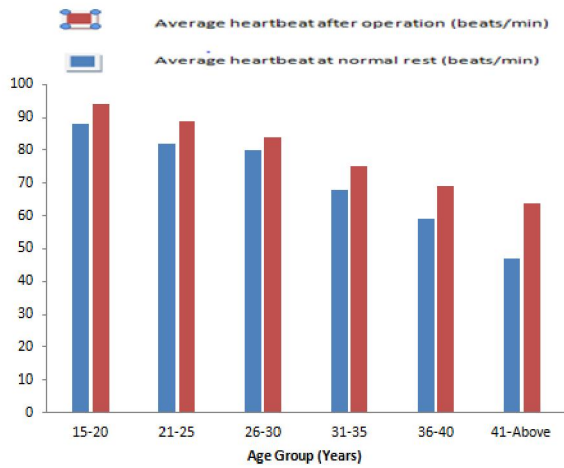
**Heart Beat Rate:** Table 4 shows the variation in heart beat rate of the subjects, in which high increase in the heart beat rate after the machine operation was observed (Singh *et al.*, 2008), the highest heart beat

rate was 94 Beats/Min, the oxygen consumption was 0.3916 L/Min and the energy expenditure was 6.226 KJ/Min.

**Table 4: Physiological Evaluation of the Subjects (Heart Beat Rate)**

No of subjects	Mid age	Oxygen consumption (L/min)	Energy expenditure (L/min)
4	18	0.3916	6.226
6	23	0.3346	5.431
8	27	0.2776	4.636
2	33	0.1750	3.205
1	38	0.1066	2.251
4	41	0.0496	1.456

**Relationship between age groups and heart beat rate after machine operation:**



**Figure 1: Relationship between age groups and heart beat rate after machine operation**

Figure 1 shows that the heart beat increases with an increase in blood pressure and age of subjects as shown in Tables 3 and 4, this signifies that there is physiological difference in the body of subjects while at normal rest position and after machine operation (Singh *et al.*, 2008); long usage of the machine is likely to cause some discomfort, stress and fatigue in machine operators. More oxygen was consumed by all the age groups because of maximum energy expended in operation.

**Anthropometrics evaluation of the subjects after machine operation:** Table 5 shows that the body weight of operators increase in age groups 15-20 to 21-25 years while there was a decline in body weight from age groups 26-30 to 41 years and above (Agarwal *et al.*, 2007). The highest body mean weight was 80.5cm from age group 15-20 years and 31-35 years which means that it increase with age and there was no specific pattern in its variation within the age groups.

**Table 5: Anthropometrics evaluation of the subjects after machine operation**

Age	Mild age	No of Subjects	Anthropometrics Parameter	Range	Mean	S.D
15-20	16	4	Weight (kg)	47-63	56	5
			Height (cm)	155-163	159	3
			Arm (cm)	69-86	79	7
21-25	24	8	Weight (cm)	50-69	60	6
			Height (cm)	165-200	190	11
			Arm (cm)	67-79	73	4
26-30	28	6	weight (cm)	68-75	71.5	3.5
			Height (cm)	149-172	160.5	11.5
			Arm (cm)	130-108	69	6
31-35	33	2	weight (cm)	68-71	69.5	1.5
			Height (cm)	167-179	173	6
			Arms (cm)	64-85	34.5	10.5
36-40	38	1	Weight (cm)	59-61	60	1
			Height (cm)	180-187	184.5	2.5
			Arm (cm)	75-80	77.5	2.5
41 & above	40	4	Weight (cm)	68-85	71.5	8
			Height (cm)	168-189	178	7.7
			Arm (cm)	68-91	78	8

**Table 6: Physiological Evaluation of the Subjects**

Age Group	No of subjects	Blood pressure at normal rest position (mmHg)	Blood pressure after machine operation (mmHg)	Differences
15-20	4	120/60	160/100	40/40
		150/100	160/100	10/10
		100/50	130/70	30/20
		115/60	130/65	15/5
21-25	6	130/50	150/70	20/20
		114/59	120/65	6/6
		105/60	129/90	24/30
		100/60	150/90	50/30
		100/60	140/90	40/30
26-30	8	115/55	137/70	22/15
		146/75	176/95	30/20
		130/70	140/90	10/20
		110/60	140/90	30/30
		160/90	170/100	10/10
		73/60	83/80	10/20
		110/80	130/110	10/30
		125/90 73/60	135/100 113/90	10/10 40/30
31-35	2	125/50	140/100	15/50
		132/69	162/85	30/16
36-40	1	165/70	180/90	15/20
41 and above	4	110/90	140/110	30/20
		125/80	155/100	30/20
		102/65	122/85	20/20
		102/80	122/90	20/10

**Physiological Evaluation of the Subjects after machine operation:** Table 6 shows the blood pressure of subjects at normal rest position and after operating the machine. The high difference between blood pressure at normal rest position and blood pressure after machine operation by the subjects shows that the usage of the decorticator cause some physiological defect, the increase in the heart beat signifies that more oxygen is needed to cater for the

increase in the blood pressure during the machine operation (Singh *et al.*, 2008). The highest difference in heart beat rate after the machine operation was 6 to 50 Beats/Minutes.

The heart beat rate of the subjects as shown in Table 7 increased after the machine operation (Singh *et al.*, 2008). The highest heart beat rate was 0.4030 L/Min by the youngest operator and energy expenditure was 6.385 KJ/Min.

**Table 7: Physiological Evaluation of the Subjects (Heart Beat Rate)**

No of subjects	Mild age	Average heart beat at normal rest (beats/min)	Average heart beat after operation (beats/min)	Oxygen consumption (L/min)	Energy expenditure (L/min)
4	16	87	95	0.4030	6.385
6	24	84	85	0.2890	4.795
8	28	78	81	0.2434	4.159
2	32	67	69	0.1066	2.251
1	35	63	65	0.0610	1.615
4	40	40	63	0.0380	1.297

### Conclusions

The anthropological and physiological workload, the levels of injuries and discomfort of a kenaf decorticating machine on end-users and machine operators was determined. The anthropological and physiological deviation as a result of machine usage was found suitable for the age range of subjects. The overall performance of the kenaf decorticating machine was satisfactory.

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