New York Science Journal

Websites:
http://www.sciencepub.net/newyork
http://www.sciencepub.net

Emails:
newyorksci@gmail.com
editor@sciencepub.net

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Ergonomics Evaluation of a Coffee Threshing Machine

[1]Ogunlade, Clement A., [1]Jaiyeoba, K. F., [2]Soji-Adekunle, Ayowumi R., [3]Ezenwogene, R. C., [4]Ifiemi, Tulagha, [5]Fadele, Oluwaseyi, K.

[1]Department of Agricultural Engineering, Adeleke University, Ede, Osun State, Nigeria
[2]Department of Mechanical Engineering, Adeleke University, Ede, Osun State, Nigeria
[3]Department of Agricultural and Bio-environmental Engineering, federal college of Agriculture, Moor Plantation, Ibadan.
[4]Department of Agricultural and Environmental Engineering, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.
[5] Department of Agricultural and Bio-Environmental Engineering, Federal College of Forestry, Mechanisation, Afaka Kaduna, Forestry Research Institute of Nigeria

Abstract: Ergonomics evaluation is the human factors engineering which studies the comfort-ability and injuries caused on end-users as a result machine usage. This study investigated the ergonomics evaluation of a coffee threshing machine including anthropological measurement (body weight, age, height, arm length, body mass index) and physiological evaluation (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 were also studied. 30 subjects were randomly selected within age groups 15-25, 26-35, 36 – 45, 46 -55, and 56 – 60 years with average ages 20, 30, 40, 50 and 60 years respectively. The body mass index of all age groups were normal with only mid age group 60 showing an overweight body mass index also, the physiological test showed that the machine usage has light energy expenditure on humans though mid age group 60 complained of slight pain after the operation of thresher which was reportedly negligible though prolonged use over time may have some detrimental for this age group over a long period of time.
[Ogunlade, CA., Jaiyeoba, KF, Soji-Adekunle, AR, Ezenwogene, RC, Ifiemi, T, Fadele, OK. **Ergonomics Evaluation of a Coffee Threshing Machine.** *N Y Sci J* 2020;13(9):1-6]. ISSN 1554-0200 (print); ISSN 2375-723X (online). http://www.sciencepub.net/newyork. 1. doi:10.7537/marsnys130920.01.

Keywords: coffee thresher, body mass index, ergonomics evaluation, anthropology, physiology, oxygen consumption, energy expenditure

1.0 Introduction

Coffee positions as one of the world's generally significant and broadly exchanged ware crops and its a significant fare result of few nations (Ogunlade *et al.,* 2014). Africa gave the world coffee as far back as pre-fifteenth century Ethiopia. In any case, a juncture of elements—cost, a preference for tea sharpened by many years of British frontier rule—have made the drink not exactly well known with a greater part of Africans. Almost 10% of the coffee in the world originates from the Africa with Nigeria delivering around 2,100 tons of unroasted coffee in 2013—not exactly in 1966 and consuming just 836 tons in 2015 while the French drank 366,000 tons even with her lesser populace (Kristiano, 2016). This is because the nation's economy has been revolved around oil exportation and the inadmissible nature of the nearby handling of coffee in Nigeria (Ogunlade *et al*., 2014). Coffee development in Nigeria is driven by low base impacts, young socioeconomics, progressing urbanization and a rising, yet little, white collar class. Enthusiasm for coffee utilization is growing, yet stays behind that of other hot beverage (Fitch Solution, 2019).

Coffee is one of the most valuable primary products in global trade for agricultural produce. It is predominantly grown by 25 to 30 million smallholder producers in about 80 countries in the tropics (CIRAD, 2009; Orr and Ndhlovu, 2005; FAO, 2006). Coffee is ranked second in value only to oil as a source of foreign exchange in many of the major producing countries (Aderolu *et al.,* 2014). Despite its significance in the world trade, marketing of coffee encountered a downward trend in the last few decades due mainly to low prices in the international market (Aderolu *et al.,* 2014); the prices fell by about 30% between 1996 and 2001 in France (CIRAD, 2009), due to surplus in production, increase in supplies and stable consumption thus causing immense hardship to countries where coffee is a key economic activity

hence, the major challenge of a farmer goes beyond planting to harvesting but maintaining proper post harvest handling to avoid losses between maturity and consumption or sale which is a frequently serious problem, especially for the small farmer, and a major contributing factor to the world food problem (Anon, 2020). Nearly all small farmers in the developing countries harvest their cereal crops and beans by hand and thresh them later. Threshing consists of separating the seeds from the seedheads, cobs or pods by beating, trampling or other means. Threshing could be achieved traditionally (by pounding, beating, and animal trampling etc) or mechanically (using tractor or motor-driven stationary threshers which come in many models with varying outputs and capacities). Traditional threshing is very tedious except for small quantities and kernel damage is on the high unless care is taken while mechanical threshing is an improved method which cleans the threshed grain by the use of shaking screens and/or blower fans. Mechanical threshers vary in design and configuration, some are pedal-powered (built as one piece and attached to a bicycle), some are animal powered while some are mechanically driven.

Ergonomics evaluation is the human factors engineering which studies the comfort-ability and injuries caused on end-users as a result 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 (Jekayinfa, 2007; Dewangan *et al.,* 2010; Singh, 2013). In a bid to reduce post-harvest losses, labour cost, high energy input and generally encourage coffee production in quality and quantity to meet international and market requirement, Ogunlade *et al.* (2014) designed, constructed and evaluated the performance coffee thresher with an average efficiency and capacity of 83% and 3532kg/hr (3.5tonnes/hr) respectively the machine has not been ergonomically evaluated and the overall evaluation of machine include both performance and ergonomics evaluation hence, this study was aimed at ergonomics evaluation of a coffee thresher.

2.0 Materials And Methods

Sample Preparation

Coffee seeds were procured from Obudu, in Cross River State, Nigeria. The seeds were cleaned and sorted manually to remove defective ones and any other foreign material.

Machine Description

The thresher was developed from indigenous materials and could thresh parchment coffee and clean the beans simultaneously, it operates mechanically with the aid of a two-stroke internal combustion engine (Tigmax Petrol engine, Gx 160, 5.5 hp). The thresher consists of 7 major units including frame, threshing drum and concave, blowing fan, reciprocating screen, grain outlet, transmission system (Figure 1 shows the orthographic projection of the coffee thresher).

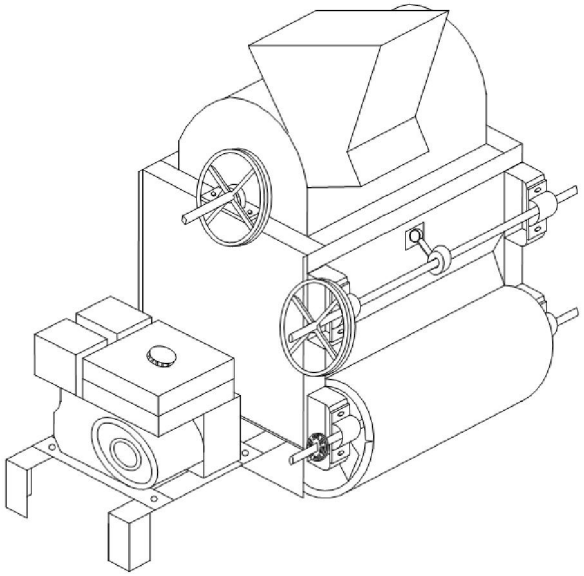

Figure 1: Orthographic Projection of the Coffee thresher *(Ogunlade et al., 2014)*

Ergonomics Evaluation

30 individuals (subjects consisting of 16 males to 14 females) were randomly selected within the age range of 15 to 60 years (being the adulthood to retirement age). The subjects were given proper orientation on the machine usage before being made to operate the machine in carrying out the ergonomic evaluation process which include anthropometrics and physiological evaluation.

i. Anthropometrics Evaluation: this was carried out by measuring the body weight, height and arm length of the subjects using a floor weighing scale (200 kg Capacity, 1g sensitivity made by Hana Company, China) and meter rule. Also, the Body Mass Index (BMI) of each subject was calculated as the ratio of weight of each subject to the square of the height of the subject (kg/m^2). Table 1 was used to interpret the BMI obtained for each respondent.

Table 1: Interpretation of Body Mass Index (BMI)

S/N	Classification of BMI	Interpretation
1	BMI < 18.5	Below normal weight
2	BMI > = 18.5 and < 25	Normal weight
3	BMI > = 25 and < 30	Overweight
4	BMI > = 30 and < 35	Class I obesity
5	BMI > = 35 and < 40	Class II Obesity
6	BMI > = 40	Class III Obesity

Source: CDA (2020)

ii. Physiological Evaluation: blood pressure and heart beat rate of the subjects were taken before and after the thresher was operated using a sphygmomanometer (KRIS-ALOY CE 0483, Capillare 3, 5 mm± 0.1 300 mmHg) with a stethoscope. Differences in blood pressure and heart beat rate were compared before and after the operation of the thresher.

iii. Oxygen Consumption: the oxygen consumption rate of subjects at their measured heart beat rate after machine operation was estimated using Equation 1 (Singh *et al.,* 2008, Aremu, 2015) as:

$$Oc = 0.0114\,HBR - 0.68 \quad (1)$$

Where: Oc is the oxygen consumption (L/min), HBR is the heart beat rate after machine operation (beats/min)

iv. Energy Expenditure: this was obtained using Equation 2 (Kwatra *et al.,* 2010), the values obtained were compared and categorized as per standard values (Nag *et al.,* 1980) as presented in Table 2:

$$EE = (0.159\,x\,HBR) - 8.72 \quad (2)$$

Where: EE is the energy expenditure (kJ/min), HR is the heart beat rate (beats/min).

v. Muscular Stresses and Postural Discomfort: Muscular stresses during the ergonomics evaluation were measured by recording the incidences of pain perceived by the subjects from different part.

vi. s of body. Intensity of pain in body parts of the body was measured on a five-point scale given in Table 3.

Table 2: Categorization of Agricultural work

Variable	Light	moderate	heavy	Extremely heavy
Energy cost (kJ/min)	< 9.10	9.11-18.15	18.16-27.22	> 27.23

Source: Nag et al. (1980)

Table 3: Severity of Pain from Machine Operation

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

Source: Kwatra et al. (2010)

Statistical Analysis

Multiple linear regression at 95% level of confidence and descriptive statistics were used for analyzing the data obtained from the ergonomics evaluation of the thresher in accordance with Ogunlade and Aremu (2020).

Results

The ergonomics evaluation of a coffee thresher was investigated; the anthropometric and physiological characteristics of subjects before and after operation of the coffee thresher is reported in Table 3 and 4 while Figure 2 a and 2b shows the heart beat rate before and after operation of the coffee thresher, oxygen consumption and energy expended in the course of operating the thresher

Discussions

The body mass index (BMI) of subjects ranged from 21.6 to 28.4 for age groups 15 – 25 and 56 – 65 years respectively. The body mass index of the subjects used for the ergonomics evaluation were normal for mid age groups 15 – 25, 26 – 35, 36 – 45, 46 – 55 while age group 56 – 65 with the mid age of 60 years shows an overweight body mass index; this could be due to the ageing process of this age group.

It was observed that the heart beat rate of subjects increases with age from mid age to 50 years

and declined for age group 60; this also could be caused by aging; it was also observed that the heart beats increases with an increase in blood pressure and age of the subjects as shown in Table 5 and Figures 2a and 2b, this implies that there was a physiological difference in the normal heart beat and blood pressure at normal rest position and after machine operation, a similar trend was observed many researchers (Balansakri *et al.,* 2003; Shrimali, 2005; Singh and Gite, 2006; Singh *et al.,* 2007; Yadav *et al.,* 2007; Singh, 2009; Aremu *et al., 2015)*

The energy expended in machine operation ranged from 0.0578 – 2.728 kJ/min for mid age group 50 and 40 respectively. The values obtained shows that the machine operation and usage of the coffee thresher has light energy expenditure and load on humans (Table 2). Moreover, mid age group 60 complained of slight pain after the operation of thresher and this was caused by several bending of the back and neck to feed the machine and collect threshed seeds though the pain was reportedly slight and eligible but prolonged use over time may have some detrimental for this age group.

Table 4: Anthropometrics Evaluation of the Subjects

Age Group (yr)	Mid Age	No of Subjects	ANTHROPOMETRICS						PHYSIOLOGICAL CHARACTERISTICS		
			Anthropometrics parameter	Range	Mean	S. D.	Average Group BMI (kg/m^2)		Blood pressure at normal rest position (mmHg)	Blood pressure after machine operation (mmHg)	Difference
15 – 25	20	6	Weight (kg)	34-49	43	4.7	21.6	Normal Weight	115/60	130/65	15/5
			Height (cm)	107–168	141	13.5			150/100	160/100	10/0
			Arm Length (cm)	45– 62	56.5	3.9			115/55	137/70	22/15
26 – 35	30	9	Weight (kg)	45– 89	57	5.3	23.7	Normal weight	140/100	134/70	6/30
			Height (cm)	57 – 166	155	17.9			100/50	130/70	30/20
			Arm Length (cm)	53 – 77	67	2.1			140/100	134/70	6/30
36 – 45	40	7	Weight (kg)	63 – 97	66	4.3	24.2	Normal weight	120/60	160/100	40/40
			Height (cm)	94 – 164	165	19.7			115/55	137/70	22/15
			Arm Length (cm)	68 – 85	78	11.8			110/70	130/90	20/20
46 – 55	50	5	Weight (kg)	67 – 99	87	9.5	23.6	Normal weight	114/59	120/65	6/6
			Height (cm)	163 - 174	172	1.2			115/60	130/65	15/5
			Arm Length (cm)	67 – 78	74	2.4			110/70	130/90	20/20
56 - 65	60	3	Weight (kg)	75 – 89	85	4.9	28.4	Overweight	140/100	134/70	6/30
			Height (cm)	152 – 183	173	11.5			100/60	150/90	50/30
			Arm Length (cm)	70 -91	85	7.1			100/50	130/70	30/20

Table 5: Physiological Evaluation of the Subjects (Heart Beat Rate)

Mid age	No of subjects	Average Heart beat (beats/min)		Oxygen consumption (L/min)	Energy Expenditure (kJ/min)
		Normal rest position	After operation of machine		
20	6	48	61	0.0154	0.979
30	**9**	63	69	0.1066	2.251
40	**7**	69	72	0.1408	2.728
50	5	74	77	0.1978	0.0578
60	**3**	60	65	0.0496	1.615

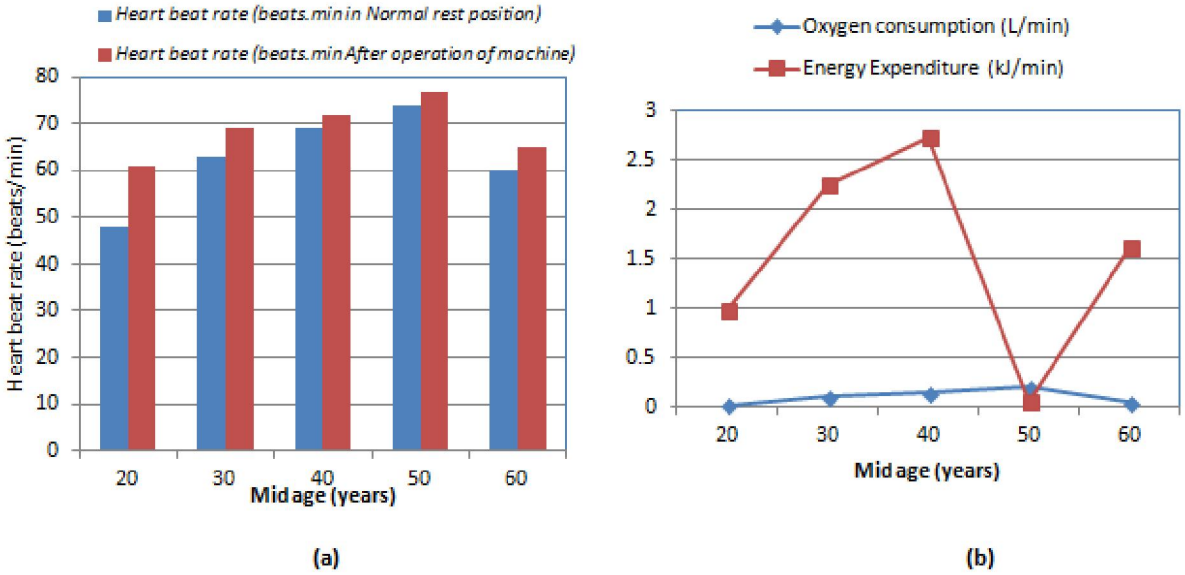

Figure 2: (a) – Heart beat rate; (b) – oxygen consumption and energy expended in operating the coffee thresher

Conclusion

This study investigated the ergonomics evaluation of a coffee threshing machine including anthropological measurement (body weight, age, height, arm length, body mass index) and physiological evaluation (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 were also studied. 30 subjects were randomly selected within age groups 15-25, 26-35, 36 – 45, 46 -55, and 56 – 60 years with average ages 20, 30, 40, 50 and 60 years respectively. All age groups respectively showed normal body mass index except the mid age group 60 which showed an overweight body mass index also, the physiological test showed that the machine usage has light energy expenditure on humans though mid age group 60 complained of slight pain after the operation of thresher which was reportedly negligible though prolonged use over time may have some detrimental for this age group over a long period of time.

References

1. Aderolu, I. A., Babalola, F. D., Ugioro, O., Anagbogu, C. F., Ndagi, I., Mokwunye, F. C., Mokwunye, I. U., Idrisu, M. and Asogwa, E. U. (2014). Production and marketing of Coffee (Coffea robusta) in Kogi State, Nigeria: Challenges and recommendation for intervention. Journal of Social Science Research, 3(2): 207 - 215.
2. Anonymous (2020). Traditional field crops. Available online at www.nzdl.org/gsdlmod?e=d-00000-00---off-0hdl--00-0----0-10-0---0---0direct-10---4-------0-l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00 & -00 & cl=CL1.17 & d=HASH7d14cf32e41fd9a480587.11.2 & x=1
3. Aremu, A. K. (2015). Ergonomics Evaluation of a Manually Operated Multi-purpose Juice Extractor. Proceedings of The IRES 8th International Conference of Food and Agricultural Engineering, London, United Kingdom, 30th Aug. 2015, ISBN: 978-93-85465-83-3. PP 27-32 (United Kingdom).
4. Balansakri, P. K., R. Manian and K. Kathirvel. Energy cost and discomfort rating for selected tractor operation. *37th Annual Convention of ISAE,* FMP-HE-6. 2003, 339-343.
5. CDA (2020). Body Mass Index (BMI) Calculator. Canadian Diabetes Association. Availale online at https://www.diabetes.ca/managing-my-diabetes/tools---resources/body-mass-index-(bmi)-calculator#:~:text=Body%20Mass%20Index%20is%20a, range%20is%2018.5%20to%2024.9. Retrieved 14th August, 2020.
6. CIRAD (2009). All you need to know about coffee. Agricultural Research for Development (CIRAD) http://www.cirad.fr/en/publications-resources/science-for-all/the-issues/coffee/the-issues

7. Dewangan, K. N., Owary, C. and Datta, R. K. (2010). Anthropometry of male agricultural workers of North-eastern India and its use in design of agricultural tools and equipment. *International Journal of Industrial Ergonomics* 40(2010): 560-73.
8. FAO 2006. Enhancement of Coffee Quality: Socioeconomic Study. LMC International with ProForest. Food and Agriculture Organization of the UN (FAO), Rome. 104pp.
9. Fitch Solution (2019). Nigeria Coffee Market Outlook: Instant Is King, Café Culture At Nascent Stage. https://www.fitchsolutions.com/corporates/retail-consumer/nigeria-coffee-market-outlook-instant-king-cafe-culture-nascent-stage-18-06-2019. Accessed 13th August, 2020.
10. Jekayinfa, S. O. (2007). Ergonomic evaluation and energy requirements of bread-baking operations in South Western Nigeria. Agricultural Engineering International: the CIGR Ejournal Manuscript EE 07 002. Vol. IX. June, 2007.
11. Kristiano Ang (2016). Nigerians are developing a taste for coffee. https://qz.com/africa/829903/nigerians-are-developing-a-taste-for-coffee/
12. Kwatra, S., Deepa, V. and S. Sharma (2010). A comparative study on the manual beating of paddy and manually operated paddy thresher on farm women. *J. Hum Ecol, 2010, 32 (3): 183-187.*
13. Nag, P. K., N. C. Sebastian, M. G. Mavlankar (1980). Occupational workload of Indian agricultural workers. *Ergonomics,* 1980, 23 (2): 91-102.
14. Ogunlade, Clement; Aremu, David O.; Akinyele, Oluwaseun A. and Babajide, Nathaniel A. (2014). Design, Construction and Performance Evaluation of A Coffee (Coffea Arabica) Threshing Machine. Int. Journal of Engineering Research and Applications, 4 (5): 56 - 64.
15. Orr, A.W. and Ndhlovu, M. 2005. Smallholder Coffee in Zambia: A socio-economic field report. Working paper A1163/1. 20pp .
16. Shrimali, H. (2009). Ergonomical studies on agricultural foot sprayer. Unpublished Ph. D. (FMPE) Thesis. CTAE Library, MPUAT, Udaipur. 2005.
17. Singh, S. P. (2009). Physiological workload of women workers in operation of manual rice transplanters. *Gender, Technology and Development,* 2009, 13(2): 271-284.
18. Singh, S. P. (2013). Ergonomical evaluation of hand operated maize dehusker-sheller with farm women. *Agric Eng Int: CIGR Journal, 2013, Vol. 15, No 2.*
19. Singh, S. P. and L. P. Gite. Ergonomical assessment of hand operated paddy winnower by women workers. *Journal of Agricultural Engineerring,* 2007, 44(4): 67-71.
20. Singh, S. P., Gite, L. P., Manjumber, J. and N. Agarwal (2008). Aerobic capacity of Indian farm women using sub-maximal exercise technique on tread mill. *Agricultural Engineering International: the CIGR E-Journal, X* 2008.
21. Singh, S. P., L. P. Gite and N. Agarwal (2006). Ergonomical assessment of manually operated seed drills for farm women. *Journal of Agricultural Engineering,* 2006, 43 (1): 42-48.
22. Yadav, R., M. Patel, S. P. Shukla and S. Phund (2007). Ergonomical evaluation of manually operated six row paddy transplanter. *International Agricultural Engineering journal,* 2007, 16 (3-4): 147-157.

8/20/2020