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Fabricate and ergonomic evaluation of manually operated drumstick cutter

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Abstract
Harvesting of drumstick pods by traditional methods such as use of hook and bamboo, climbing labour on tree is difficult task. In order to reduce losses during harvesting of drumstick and to maintain fruit quality, judgmental visibility in selective cutting, and damage to the drumstick during the harvesting, long working hours and uncomfortable posture of worker, a manually operated Cutter was developed. The device consisted of clutch lever, a clutch wire, an extension mechanism, a cutting mechanism. During operation, it was observed that field capacity of manually operated drumstick cutter was 0.0072 ha/hr.

Anthropometric data of age group operators of (25-40 years) were determined. Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score of physiological and postural parameters of age groups were determined during working on manually operated drumstick cutter at agriculture working field. In Ergonomic evaluation Heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score were varied from 98 to 120 b/min, 0.450 to 0.670 l/min, 10 to 17 kl/min and 22.12 to 49.43, respectively for age groups (20 to 35) years of workers during working on manually operated drumstick cutter. Maximum of heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score were found 120 b/min, 0.70 l/min, 17 kJ/min, 49.43, for worker age of 31-35 year, on manually operated drumstick cutter. Minimum of heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score were found 98 b/min, 0.450 l/min, 10 kJ/min, 22.12, for worker age group of 20 to 23 years on manually operated drumstick cutter.

Keywords: heart rate, ergonomics, anthropometric parameter, energy expenditure and body part discomfort score

1. Introduction
Drumstick is one of famous vegetable crop in India. Drumstick scientifically called as Moringa oleifera is commonly known as Shevga (Marathi); Sanjna, Suhujna (Hindi); Murunga, Murangai (Tamil) are mention for drumstick tree. Moringa oleifera is a small, graceful, deciduous tree with sparse foliage, often resembling a leguminous species at a distance, especially when in flower, but immediately recognized when in fruit. The drumstick is rich in A, B, C, D, and E vitamins. They are rich in minerals such as calcium, phosphorus, potassium, copper, iron, magnesium, silica. Drumstick also contains alpha-linolenic acid, amino acid, plant-based omega-3, carotenoids along with nutraceutical properties, compared with other vegetable and fruits. The development of Indian agricultural sector depends on the development of farm mechanization, so that there should be introducing such a machinery and equipment to fulfill the need of the labor which is major problem now a days, and also reduces the human drudgery and the product damages. (Amruta *et al.*, 2015) [2].

The ergonomics is the scientific discipline mainly concerned with understanding of the interaction of humans, and the scientific design profession that applies theory, principles, data and methods to design and improve the work system involving machine or job with human as an integral system. The role of ergonomics is to impress the both methods for important benefit to the farm workers Most designers of agricultural equipment give the attention to improve the efficiency and durability but less attention is given to operators, comfort and well-being. With advanced technology, human factor has to be given utmost priority. Hence, there is an urgent need to critically analyze these agricultural tools or equipment ergonomically in order to improve man-machine system efficiency without compromising performance (Kumar and Parihar, 2015).

Manual operated drumstick cutter was fabricated to evaluate physiological and postural responses of labors. The aim of this study was to be determined modified manually drumstick

cutter, anthropometric parameters, physiological and postural parameters of different age group of operators.

2. Material and Methods

The study was conducted in the following manner

1. Fabricate of manually operated drumstick cutter
2. Determination of anthropometric data of selected subject

2.1 Materials Used for manually operated drumstick cutter

The Drumstick cutter is designed taking into consideration the socioeconomic conditions of the rural population. The materials selected for the design of various components were those available in the local markets in the region. It was important that the device be very simple, light in weight, adjustable in height, cheap, or else the rural population might not adopt it. Fabrication was done in the Agricultural Engineering workshop of the University with locally available materials. Two cutting mechanisms *viz*. Hold and pull type and Impact cum shearing action have been provided to enable to cut all drumstick pods from a tree.

Main frame: The frame was made of steel pipe with attachment of cutting tool on top position of pipe. The length of main frame MS pipe 3 meter and width of MS pipe 22 mm.

Cutting system: Two fruit cutting mechanism have been provided. First system consists of a specially fabricated scissor made of high-grade metal. The rear end of the cutter is connected to the user by a clutch wire (used in scooter) that can be pulled against the spring to affect the cutting. In the second system, a sharp curve notch made of metal is fastened with the help of screw at the end of the main frame.

Pipe: The length pf pipe is 3 meter. The base diameter of this assembly is 1inches. This pole assembly was ideal for many reasons. Primarily, the overall length would provide enough reach for an 5 foot person to be able to reached at the required heights. Also, this pole assembly is very light in weight (no greater than 3 kg) and does not feel awkward when handling.

Lever: The lever is provided to operate the cutting mechanism. It consists of steel cable having one end is connected to the cutting mechanism, and another end connected to the free end of extension pipe. The cutting mechanism operated by pulling cable in a downward direction when the pods is in cutting zone. Cable takes its original position due to the action of spring fitted on the cutting mechanism.

2.2 Measurement of anthropometric data of selected subjects

For conducting any ergonomic study, collection of anthropometric data is one of the most important steps to be carried out. Anthropometry is the branch of human science that deals with the data described by the size of human body measurements including body dimensions and other physical measurement of human body. One of the most important applications of anthropometric measurement in ergonomics is the design of working space and the development of industrialized products such as tool and implements.

In order to record various data, we firstly need the basic measurement instrument for recording the height, weight and anthropometric related data.

The instrument, equipment and subjects required in the reading session are follows:

1. Integrated composite anthropometer – (for measuring multiple body dimension)
2. Weighing scale – (for measuring human body weight)
3. Heart rate monitor – (for measuring heart rate)

2.3 Selection of age subjects

Conducting experiments for ergonomic study, selection of subjects plays an important role. The selected subject should be physically and medically fit for carrying the experiments. For this study, different age subjects were selected from the available workforce of different age varied from 20-35 years as given table: 1

Table 1: Details of selected different age subjects

SI. No.	Age group (years)	BMI
1	20-23	23.03
2	24-27	20.82
3	28-31	21.25
4	32-35	27.00

The first step is to find the weight and height of subjects and find out the body mass index of each them. Their health was determined by finding the body mass index is formula given

$$BMI = \text{Weight (kg)} / [\text{Height (m)}]^2$$

The selected different age of subjects for conducting experiments should be physically fit. There should not be any chronic diseases or illness and handicaps. The selected different age subjects should be physically fit and engaged in physical work, not having any illness, handicap or chronic problem.

2.4 Determination of variables

- Independent Variable
  a. Different age =20-23,24-27, 28 -31and 32-35 years
  b. Time = 5,10,15,20 min
- Dependent Variable

1. Heart rate (b/min)
2. Oxygen consumption (l/min)
3. Energy expenditure rate (kJ/min)
4. Body part discomfort score

2.4.1 Oxygen consumption rate (OCR)

The HR and OCR were taken as the physiological parameters. The HR and OCR were taken for computational work. The OCR of subject on their measured heart rate was estimated based on general equation as given by Singh *et al*. (2008) [16].

$$OCR = 0114 \times HR - 0.68$$

Where:

- Oxygen consumption rate (OCR) in l/min

Heart rate (HR) in b/min

- The oxygen consumption rate (l/min) was converted in kJ (1 $L0_2$-20.93 kJ).

2.4.2 Energy expenditure rate (EER)

The EER was computed by using the following equation given by Nag *et al*. (1980) [15].

$$EER = 20.86 \times OCR \text{ (kJ/min)}$$

2.4.3 Measurement of body part discomfort score (BPDS)

Corlett and Bishop (1976) [14] technique was used to measure localized discomfort on body party, in this method, the body of subject is divided into 27 regions. Each body region was numbered differently to avoid a subject marking on body region only. The rating was assigned to these categories in an arithmetic order as explained below Table: 2 the number of categories of pain experienced by different subjects might vary.

Table 2: Calculation procedure for body part discomfort score

SI. No.	Category	No. of parts	Rating	Score
1	I	6	5*5/27	5.56
2	II	5	4*5/27	3.70
3	III	5	3*5/27	2.77
4	IV	4	2*5/27	1.48
5	V	2	1*5/27	0.37
		Total		13.88

2.5 Statistical analysis of data

The statistical analysis of data was done using MS excel and SAS software. Means and standard deviations were computed for all the measured variables. The experiments were planned in one way classification. Age subjects and working field were found significant at 5% level. In all statistical analysis, the significance threshold was set as 5% level of probably for subjects, modes and different age conditions.

3. Result and Discussion

In this chapter, ergonomic evaluation of drumstick cutter operated by selected operators of different age groups at working field were carried out in the field of agricultural engineering farms. The result was discussed on anthropometric data of selected operators, effect of age group on heart rate, oxygen consumption, energy expenditure and BPDS of workers at different weight sample.

3.1 Fabricate manually operated drumstick cutter

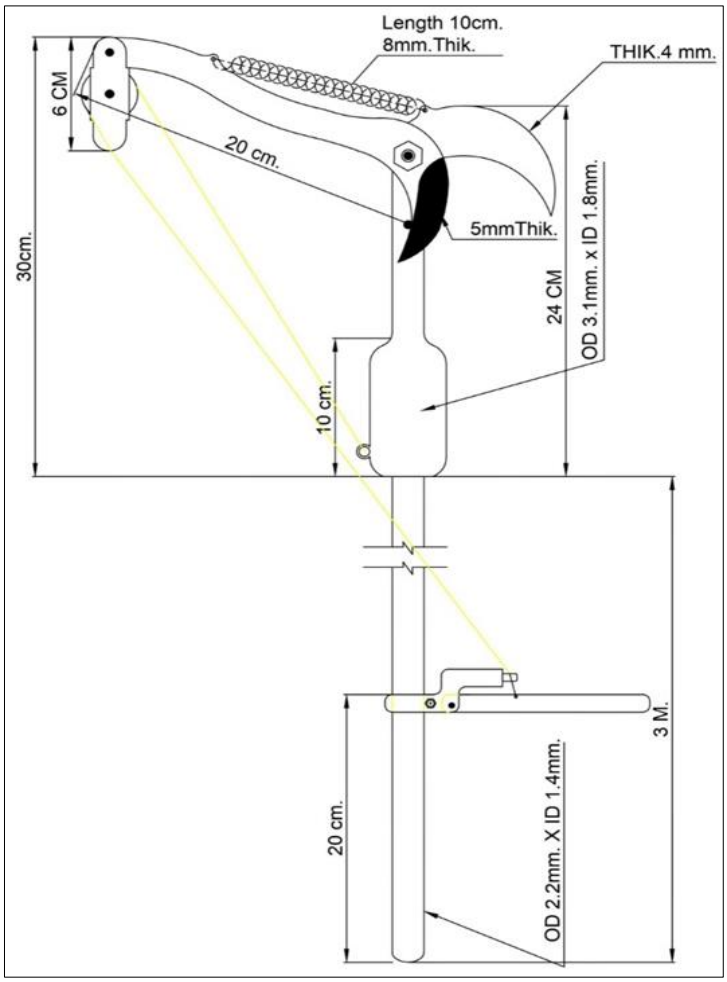

Fig 1: Manually operated drumstick cutter

Table 3: comparative result manually operated drumstick cutter

Sr. No.	Particulars	Manually operated cutter
1	No. of ponds cut in 1 hr.	800
2	Total time required	1500 min
3	Damage to pond	No
4	Laboure required	1
5	Cost of operation	Rs.1000
6	Ease of operation	Difficult

Table 4: Actual field capacity of manually operated drumstick cutter

Sr. No.	Area (ha)	No. of tree	No. of ponds	Productive time (min)	Non- productive time(min)	Actual field capacity (ha/hr)
1	0.06095	95	4000	140	45	0.01978
2	0.06095	95	4200	158	62	0.01665
3	0.06095	95	4800	245	70	0.011609
4	0.06095	95	5000	165	56	0.015910
mean	0.06095	95	4500	177	58	0.015588

Table 5: Condition of implement and operator for manually operated drumstick cutter

Sr. No.	Particulars	Performance test
1	Source of power	Human mussel
2	Weight of implement	3.2 kg
3	Max height of implement	3.2 m
5	Clearance Scissor	65 mm 150 mm
6	Skill of operator	Not necessary

3.2 Anthropometric data of selected age subjects

Anthropometric data of selected subjects were measured using measuring tape in complete resting condition. Fore subjects were selected from agricultural engineering farms of different age groups. It is presented in Table: 6

Table 6: Anthropometric data of selected age subjects

Sr. No.	Particular Dimension	Anthropometric data			
		20-23yr	24-27yr	28-31yr	32-35yr
1	Stature(cm)	168	167	170	168
2	Arm length(cm)	73	74	74	75
3	Arm span(cm)	167	179	177	179
4	Standing eye height(cm)	157	155	158	157
5	Sitting height(cm)	85	82	85	83
6	Sitting eye height(cm)	75	72	75	74
7	Popliteal height(cm)	42	43	43	44
8	Knee height(cm)	51	52	50	49
9	Pelvic height(cm)	90	93	89	91
10	Elbow height(cm)	112	108	109	110
11	Shoulder height(cm)	136	142	142	141
12	Weight(kg)	65	62	77	70

The Table: 6 of anthropometric data was show that the body part dimension (stature, arm length, standing eye height, knee height and elbow height) is given. The stature dimension is average 168.25cm, arm length dimension average 74cm, standing eye height dimension average 156.75cm, knee height dimension average 50.5cm, elbow height dimension average 109,75cm. Body mass index were found average 35.58.

Similar results were reported (Lee, 2004; Ram *et al*., 2008) where anthropometric data of seven and four age groups agricultural workers respectively were determined using an anthropometric and other measuring device.

3.3 Effect of different age on heart rate of workers during working on manually operated at working field

The results of heart rate of different age groups are presented in fig: 2 and Table: 7during working on drumstick cutter. When age of subjects was increased, then heart rate increase during working on drumstick cutter at working field.

Table 7: Measure heart rate of working during on manually operated drumstick cutter at field

Age (years)	Stable heart rate (b/min)	Working heart rate on manually operated Drumstick cutter (b/min)
20-23	71	98
24-27	73	108
28-31	76	112
32-35	79	120

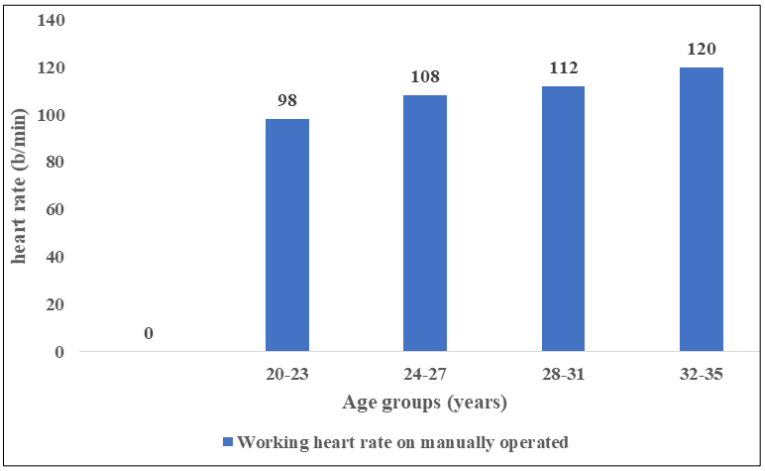

Fig 2: Heart rate of different age groups (20-35 yrs)

Heart rate of different age groups (20-23 years) varied from 98 to 120 bpm during operating on manually operated drumstick cutter at working field. Lowest heart rate was found 98 bpm for age groups (20-23 years) and highest heart rate was 120 bpm for the age groups (32-35 years) at working field.

3.4 Effect of different age groups on oxygen consumption rate of workers during working on manually operated and motor operated drumstick cutter at working field

The results of OCR of different age groups are presented in fig: 3 and Table: 8 during working on manually operated Cutter. When age of subjects was increased, there was increase OCR during working on manually operated drumstick cutter at working field.

Table 8: Measured OCR of working on manually operated drumstick cutter

Age (years)	Working OCR on manually operated cutter (l/min)
20-23	0.450
24-27	0.565
28-31	0.630
32-35	0.670

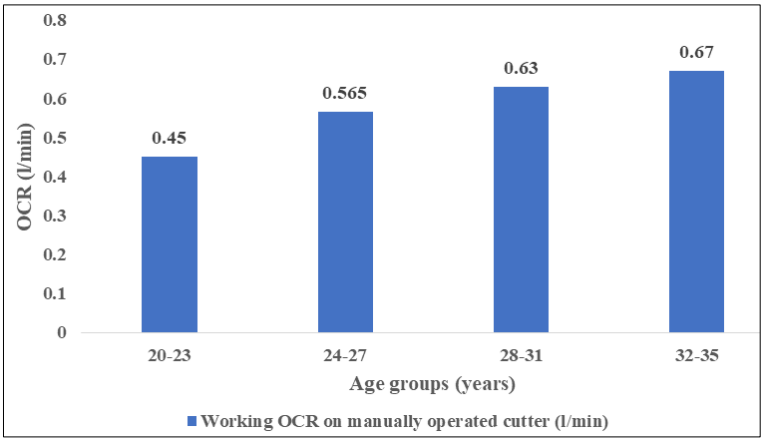

Fig 3: OCR of different age groups (20-35 years)

OCR of different age groups (20-35 years) varied from 0.450 l/min to 0.670 l/min during operating of manually operated drumstick cutter at working field. Lowest OCR was found 0.423 l/min for the age groups (20-23 years) at working field and highest OCR was 0.670 l/min for age groups (32-35 years) at working field area.

3.5 Effect of different age groups on energy expenditure rate of workers during working on manually operated drumstick cutter at working field

The results of EER of different age groups are presented in fig: 4 and Table: 9. during working on manually operated drumstick cutter. When age of subjects was increased, there was increase EER during working on manually operated drumstick cutter at working field.

Table 9: EER during working on manually operated drumstick cutter

Age group (years)	Working EER on manually operated cutter (kJ/min.)
20-23	10
24-27	13
28-31	15
32-35	17

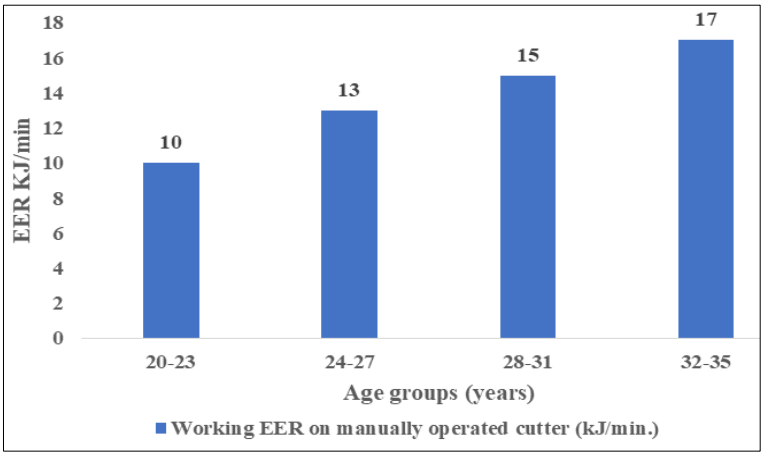

Fig 4: EER of different age groups (20-35 yrs)

EER of different age operators (20-35 years) varied from 10-17 kJ/min during operating of manually operated drumstick cutter at working field. Lower EER found 8 kJ/min and highest EER was 17kJ/min for age groups (32-35 years) at working field.

3.6 Effect of different age groups on body part discomfort score of workers during working on manually operated drumstick cutter at working field

The results of BPDS of different age groups are presented in fig: 5 and table: 10 during working on manually operated drumstick cutter. When age of subjects was increased, there was increase BPDS during working on manually operated drumstick cutter at working field.

Table 10: Measure BPDS of working during on manually operated drumstick cutter at working field

Age groups (year)	Working BPDS on manually cutter
20-23	22.12
24-27	31.82
25-31	40.25
32-35	49.43

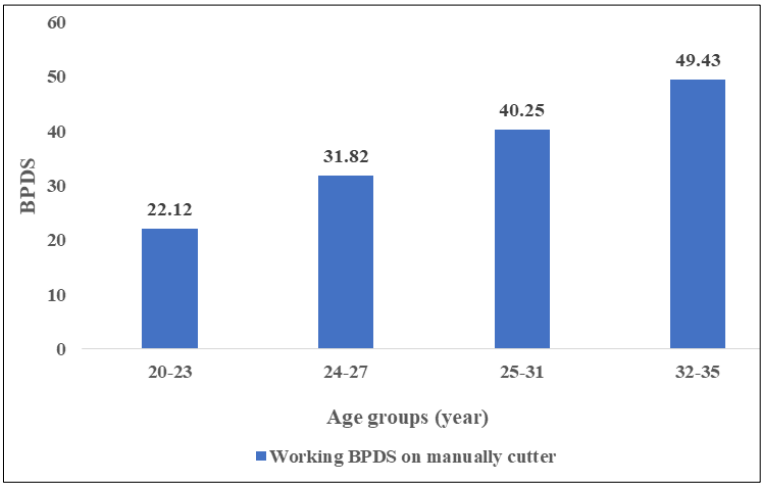

Fig 5: BPDS of different age groups (20-35 years)

BPDS of different age operators (20-35 years) varied from 22.12 to 49.43 during operating of manually operated drumstick cutter at working field. Lowes BPDS found 20.13 for age groups (20-23 years) and highest BPDS was 49.43 for age groups (32-35 years) at working field.

4. Conclusion

The study was conducted by determining anthropometric data selected subject, selection material for cutter (manually operated), determination or variables (heart rate, oxygen consumption, energy expenditure, and body part discomfort score) and statistical analysis of data. The experiment were conducted at working field on drumstick cutter.

Following conclusion were drawn from the study:

1. The modified such as manually operator drumstick cutter, main frame, lever, operational safety, and easiness in fabrication were taken into account for modification and made simple so that local artesian can fabricate and operate machine easily.
2. Anthropometric data of age (years) subject for male workers *viz*. stature, arm length, arm span, standing eye height, sitting eye height, popliteal height, knee height, pelvic height, elbow height and shoulder height were found out using anthropometer.
3. With increasing age groups of subjects, heart rate, oxygen consumption rate, energy expenditure rate and body part discomfort score increased on manually operated drumstick cutter during working on field.

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