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Ergonomical Evaluation and Dynamic Performance of Pedal Operated Coconut Dehusker

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ABSTRACT

The generally coconuts are dehusker manually using either a machine or a spike. To employ these methods safely, comfortably, and conveniently for the operator, expert labour and training are needed. Pedals, instruments, and the working position should all be placed in a practical and sensible manner. By overcoming these challenges, dynamic performance, equipment that is safe and usable. In our design, the dehusking force is increased by using a closed coil spring. It has a basic design and is pedal-operated. Only manual labour is required for operation, no motor is required. This mechanism uses a spring-type actuator. Welding and pin joints were used to assemble the device's components. The anthropometric dimensions (data) of measured using the following equipments. Integrated Composite Anthropometer, Electronic push pull dynamometer, Back-Legs-Chest dynamometer, Digital hand dynamometer, Finger goniometer, Grip diameter cone etc.

Introduction

Ergonomics is the study of how people interact with machines and the variables that influence that relationship. Its goal is to enhance human-machine interaction in order to increase system performance. This can be accomplished by "designing-in" a better interface or "designing-out" elements of the working environment, the task, or the way work is organised that hinder the performance of humans and machines. The design incorporates human factors and is contemporary farming. These elements enable the operator to carry out several complicated tasks effectively, safely, and with the least amount of weariness. The general human component in ergonomics encompasses factors like riding comfort, visibility, the placement and arrangement of controls, ease of operation, design, thermal comfort, and sound (noise), among others.

Introduction of Pedal operated of coconut dehusker machine

In the tropics and subtropics, they are a staple of many people's diets. When young, coconuts are known as tender-nuts or jelly-nuts and can be harvested for their drinkable coconut water. Coconuts differ from other fruits in that they contain a substantial amount of water, often known as "juice." When fully developed, they can be processed to produce oil from the kernel, charcoal from the hard shell, and coir from the fibroushusk, or they can be utilised as seed nuts. The dehusking of coconuts is a post-harvest procedure that is essential to preparing the coconut for subsequent use. In some countries, particularly in India, the coconut also has cultural and religious importance. Farm mechanisation promotes the efficient use of machines to increase labour and land production. Additionally, it aids in cutting down on the laboriousness, expense, and duration of farming activities. In agricultural mechanisation, the operations are separated into three categories: pre-harvesting, harvesting, and post-harvesting. One of the most important and beneficial perennial plants in the world is the coconut plant (*Cocos nucifera*). The coconut fruit is composed of a hard, protective endocarp or shell underlying a thick, fibrous fruit coat known as the exocarp.

Coconut gives coconut oil, coconut powder, husk is used to manufacture ropes, its medicinal properties etc. Hence, its post harvesting is important. Many attempts have been made to make its post harvesting mechanized either manually or power operated. These attempts of mechanization have their own advantages and limitations. The study of such tools and machines is necessary for the selection of suitable mechanism to satisfy the desired need of small-scale works. One of the major challenges in the coconut oil making industry is coconut de-husking and cutting. These mostly done manually.

Coconut is one of the world’s most useful and important perennial plants. A coconut can be divided into three parts:

Exocarp – outer covering

Thick fibrous fruit coat- husk

Endocarp-inner shell

A coconut's length and diameter range from 245mm to 295mm and 145mm to 200mm, respectively. At one end of the nut, there are three recessed 'eyes' made of softer tissue. At maturity, the endocarp contains a thin, white, fleshy layer that is called "coconut meat" and is filled with coconut water. This layer is around 12.25 mm thick. Being from the south of India, and specifically from Kerala, we understand the value of coconut water, which is a natural beverage, and coconut flesh, which is a significant component of our curries. Coconut trees develop faster because of the abundance of cytokines in coconut water. It is a clear liquid that contains bioactive enzymes such acid phosphatase, catalase, dehydrogenase, diastase, peroxidase, and RNA polymerases as well as carbohydrates, vitamins, minerals, electrolytes, enzymes, amino acids, and enzymes.

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A brief history of ergonomics

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The Principles of Scientific Management

Scientific management was a reaction against the then prevalent management methods of inherited from the Indian. Factory owners supplied premises, power and raw materials, etc. and hired foremen to organized the work. These foremen acted rather like subcontractors and were left to themselves to organized the basic industrial tasks as best they could. Management was concerned only with output and had only a global notion of ‘productivity’, regarding the work itself with disdain. Incentives were provided for employees to suggest improvements and profits.

Working practises were no longer considered to be at the employee's option, dictated by tradition or technology, but rather were seen as something that could be purchased and controlled by management. For the adoption of mass assembly and production line techniques, this shift in perspective was a prerequisite. This may be the case, but an argument might be made that it also made industrial jobs more accessible to unskilled workers and mass-produced goods more reasonably priced. For management, taylorism offered various benefits:

It provided more flexibility in assigning operators to activities that could be picked up quickly.

The need for competent labour decreased. There were no skill shortages, and pay and training expenses were easier to control.

The introduction of timed work made it possible to more precisely quantify production timelines.

If everyone worked at the same pace, the result was always a finished product.

Human relations and occupational psychology

Occupational psychology developed in the 1920s and 1930s. The essence of Taylorism had been to regard the worker as an isolated individual whose output was determined by physical factors such as fatigue or poor job design and by economic incentives. A job would be redesigned to make it as simple as possible to learn and to perform. A production standard and rate of pay would be set and a bonus scheme introduced as an incentive for workers to produce more than the standard. It was assumed that ‘rational economic men’ would maximise their productivity to maximise the bonus. The social context in which work took place was ignored. Despite its advantages, Taylorism also presented management with a dilemma. Continually increasing productivity had to be met with continual increases in pay. To avoid this, new techniques were employed. New and higher production standards were introduced whenever sustained increases in output were achieved, bonuses only being paid when the new standard was exceeded. Not surprisingly, workers reacted by restricting their output to prevent the standard being raised and placed social pressure on ‘rate-busters’. (Source: r.s. bredger book)

Working in a standing position be a problem

A person's body is affected by how their workspace is organised and the tasks they carry out while standing. The design of the workstation, the tools, and the positioning of the keys, buttons, and displays that they must use or see typically place restrictions on the body positions that the worker can adopt while standing. As a result, the worker's options for body positions are limited, and the positions themselves are more inflexible. These restrictions provide the worker less mobility and less chance to switch between different muscle groups.

Health problems result from being restricted from freely selecting different bodily positions.

These conditions commonly occur where the job is designed without considering the characteristics of the human body.

Health hazards

Significant muscular effort is required to maintain an upright posture. Standing significantly lowers the blood flow to the overworked muscles. Pain in the muscles of the legs, back, and neck (which are utilised to maintain an upright position) as well as exhaustion are symptoms of insufficient blood flow.

Along with muscle pain, the worker often has additional discomforts. Standing for extended periods of time without moving about causes blood to pool in the legs and feet. Standing for extended periods of time without moving might cause vein inflammation. Over time, this inflammation could develop into painful, persistent varicose veins. The joints in the spine, hips, knees, and feet can also lock or become temporarily immobile as a result of prolonged standing.

Recommendations for improving workplace design

The worker has the option to select from a number of well-balanced working positions in a well-designed workplace and to switch between these positions often. Adjustable workstations and benches are ideal. It is crucial to have the working height adjustable so that the workstation can accommodate each employee's unique body type and job-specific needs. A worker's capacity to perform tasks in balanced body positions is ensured by adjustability. Platforms to lift the shorter worker or pedestals on top of workstations for the tall worker should be taken into consideration if the workstation cannot be changed. Another crucial element is how the workspace is organised. There should be sufficient space to move about and adjust one's posture.

Work practices reduce the effects of working in a standing position

Working in a balanced position without placing undue strain on the body is feasible when a job and environment are both well-designed. Work practises can make a job safer or more dangerous, even though the worker's actual performance of the activity depends on them (including how they stand, move, or lift). A person can work safely if they receive the proper knowledge and training. The worker must be made aware of any health risks present at work. It is indeed required by law. The employee must be aware of the bodily motions and positions that cause discomfort as well as the fact that short-term mild discomfort might eventually develop into a chronic injury. Workplace adjustments should be covered in worker education and training as well layouts to the individual's needs.

Materials and Methods

Material selection

The material ware the construction of the machine selected based on availability, mechanical properties and economic constructions. The material was sourced locally from the open market. Two major materials used in the fabrication are mild steel rods and plate.

Closed Coil Spring

The helical spring is another name for the coil spring. That mechanical tool is usually employed to absorb shock, to store energy for later release, or to sustain a force between contacting surfaces. The wire used to create the helical springs is coiled into a helix as seen in the illustration. The wire's cross-section is often circular, though it can also be square or rectangular.

Helical springs are simple to make, dependable, and have a constant spring rate, meaning that the force placed on the spring immediately affects how far it deflects. Compression helical springs and tension helical springs are the two varieties that are available. The load acts along the axes of these springs. In helical sprigs, the wire is subjected to torsional shear stress.

Additionally, there are two types of helical springs: closely-coiled and open-coiled. The helix angle of closely-coiled springs is very small, typically less than 10°, meaning that the plane containing each turn is almost at right angles to the axis of the helix. The wire in open-coiled helical springs is so tightly wound that there is a space between two successive turns, or the helix angle, is high.

Spring Materials

Spring materials should have high yield strength and low modulus of elasticity so that they don't permanently deform under the applied loads.

Springs are built of materials that can be formed (rolled or drawn) to a high strength while maintaining a sufficient amount of ductility, or alloys that can be heat treated to a high strength and ductility prior to or after forming.

Springs are produced using both hot and cold working techniques. The intended characteristics, spring index, and material size all influence the method choice. The spring's winding creates residual bending tensions, which are relieved by heat treatment. Plain carbon steels, alloy steels, as well as non-ferrous materials including phosphor bronzes, spring brass, beryllium copper, and various nickel alloys, are used to make springs.

Terminology of Helical Springs

Solid Length

Length of the spring when it is compressed so that the coils touch each other.

Solid Length, $L_s = n.d$

where n = numbers of coils and d = wire diameter

Compressed Length

Length of the spring, when it is subjected to maximum compressive force.

Even under the worst load, minimum clearance is maintained between the two adjacent coils so that they don't clash with each other. It is called clash allowance and is generally taken as 15% of the maximum deflection.

Working and Principle

Coconut is the primary crop grown in the Kokan region, and dehusking coconuts is a crucial step in preparing them for future use. Dehusking a coconut entails taking the husk off of it. Traditional dehusking is a laborious and time-consuming operation. A new design dehusking machine is introduced and manufactured to get around this restriction, improve automation, and ensure safety for the operator. An altered closed coil spring that is attached to the pedal is employed in place of the typically used manual coconut dehusker. Then, it is manually operated without the use of motors or trained staff.

The spring that is attached to the pedal transmits the most force to the husker to husk the coconut when the load is applied to the pedal. This coconut dehusker's parts include a manual husker, a closed coil spring, and a foot pedal. The coconut that needs to be husked is placed on top of the pedal-operated, knife-edged coconut dehusker. The pedal, which is attached to the coconut dehusker, is then loaded. Then, with that force, the lever that is attached to the pedal is pulled. With such force, the knife-edge coconut dehusker is opened. The force produced by the spring causes the knife edge to shut after the coconut has been husked.

Sphericity of Coconut

For the determination of sphericity of coconut 5 coconuts were selected randomly. Sphericity of coconut is determined by following formula.

Test- 1

length(l) = 18 cm

breadth(b) = 14 cm

thickness(t) = 12 cm

Maximum length(l_{max}) = 18cm

$$Sphericity(S) = \sqrt[3]{lbt}/l$$

$= (18\times14\times12)^{1/3}/18$

$= 14.46/18$

Sphericity(S) = 0.803

Test- 2

length(l) = 20 cm

breadth(b) = 17 cm

thickness(t) = 13 cm

Maximum length(l_{max}) = 20 cm

$$Sphericity(S) = \sqrt[3]{lbt}/l$$

$= (20\times17\times13)^{1/3}/20$

$= 16.41/20$

Sphericity(S) = 0.820

Results and Discussion

The results obtained from the studies conducted for ergonomic evaluation of the pedal operated coconut dehusker is presented.

Selection of subjects

Four male and four female subjects, medically fit and in the age group of twenty five to thirty five years, were selected from the farm workers of the college. All the subjects had more than five years of experience in operation of the manual coconut dehusker.

Analysis of anthropometric data and strength parameters

Anthropometric data of selected four male and four female subjects were collected and tabulated. The measured data of men and women are given in table 4.2 respectively. The stature and weight of the male subjects ranged from 167 cm to 172 cm and 61 kg to 70 kg, while stature and weight of female subjects ranged from 142 cm to 153 cm and 50 to 55 kg respectively.

Calibration of subjects

All the selected subjects (both male and female) were calibrated in laboratory. Sanders and McCormick (1993) suggested the calibration of each person to determine the relationship between heart rate and oxygen consumption.

Basal Metabolic Rate

The basal metabolic rate of the subject was measured by the following procedure. Sample calculations of both male and female subjects is shown below.

Computation of BMR (for female)

Average age of female (years) = 30

Average weight of female (kg) = 48

Average height of female (cm) = 144.8

Room temperature (T_2), K = 303

Room pressure (P_2), bars = 0.99 Oxygen consumption for a period of 6 min (V_2), cc = 900

Standard temperature (T_1), K = 273

Standard pressure (P_1), bars = 1.032

Oxygen consumed under standard

Temperature and pressure,

$$L = \frac{P_2 V_2}{T_2} \times \frac{T_2}{P_1}$$

$$= \frac{0.99 \times 0.900}{303} \times \frac{273}{1.032}$$

= **0.7778**

Energy produced in 6 min, kcal = 0.7778 × 4.832

= 3.758 kCal

Energy per day, kcal = 3.758 x 60 x 24 /6

Basal Metabolic Rate, kcal /day = 901.92

Basal metabolic rate of male subjects ranged from 1100 kcalday^{-1} to 2300 kcal/day. For female subjects it ranged from 900 kcalday^{-1} to 2000 kcalday^{-1}

Calibration chart

The selected subjects were subjected to calibration tests, to determine a relation between their heart rate and oxygen consumption. Calibration charts were prepared for the selected four male and four female subjects. The calibration charts were plotted with heart rate as the ordinate and the oxygen consumption as abscissa, to obtain a linear relationship, as first reported by Narashingrao (1997) through their studies on the same. This linear relationship obtained is also in consonance with the result reported by Sam (2014) for all the subjects.

Step-I Testing The Pedal Operated Coconut Dehusker

After testing the pedal operated coconut dehusker result were final conclusion were drown are as follows:

Based on the overall objectives of the project, a pedal operated coconut dehusker, had been successfully developed and constructed using locally available materials.

The machine is simple in operation, less bulky with good ergonomic considerations for its comfortable use in a standing posture by either male or female operator.

This is justified by the portability and low height of as well as the low energy requirement.

The machine overall performance is favourable with more dehusking capacity, more dehusking efficiency and less coconut damage.

The machine developed required a low cost.

A very reduced human effort was required for dehusking coconuts

The pedal operated coconut dehusker has a better output capacity, reasonable dehusking efficiency.

This pedal operated coconut dehusker can be used for household use and consumption.

Pedal operated coconut dehuskercan be used for dehusking both wet and dry coconuts.

Table.1 Analysis of anthropometric data and strength of female parameter

Sr. No	Parameters		Female(1-5)				
			1st	2nd	3rd	4th	**5th**
1	Stature (cm)		144.5	138.5	150	150	**141**
2	Weight (kg)		45.8	46.5	50	50	**48**
3	Acromion height (cm)		71.5	75	90	91	**86**
4	Grip diameter (cm)		7	6	8	7.5	**8.2**
5	Hand length (cm)		54	57	68	60	**59**
6	Palm length (cm)		15	13.5	18	17.5	**15.2**
7	Palm width (cm)		8.9	8	9	9.5	**8**
8	Fore arm hand length (cm)		37	33	36	38	**37.1**
9	Grip strength (kg_f)	Right	9	12	16	13	**9**
		Left	7.8	10	11.5	11.2	**8.7**
10	Hand pull(both)(kg_f)		14	15	18	16.2	**15**
11	Leg push- (kg_f)	Right	38	43	45.8	42	**40**
		Left	30	40	41	40.9	**32**
12	**Muscle strength (kg_f)**		**52**	**68**	**70.1**	**70**	**53**

Fig.1 Human Factor

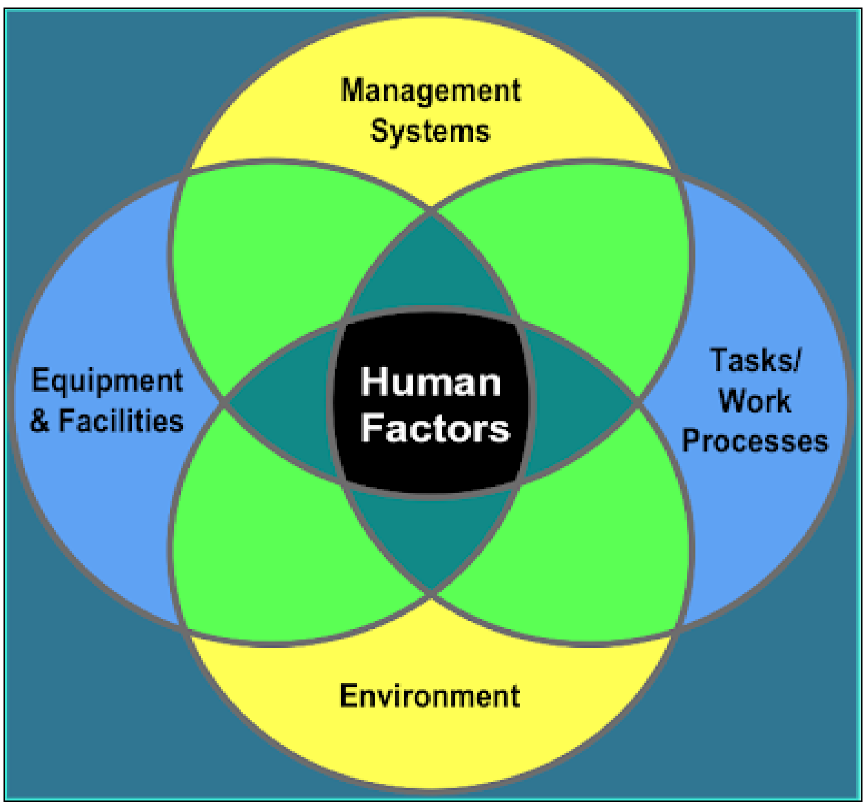
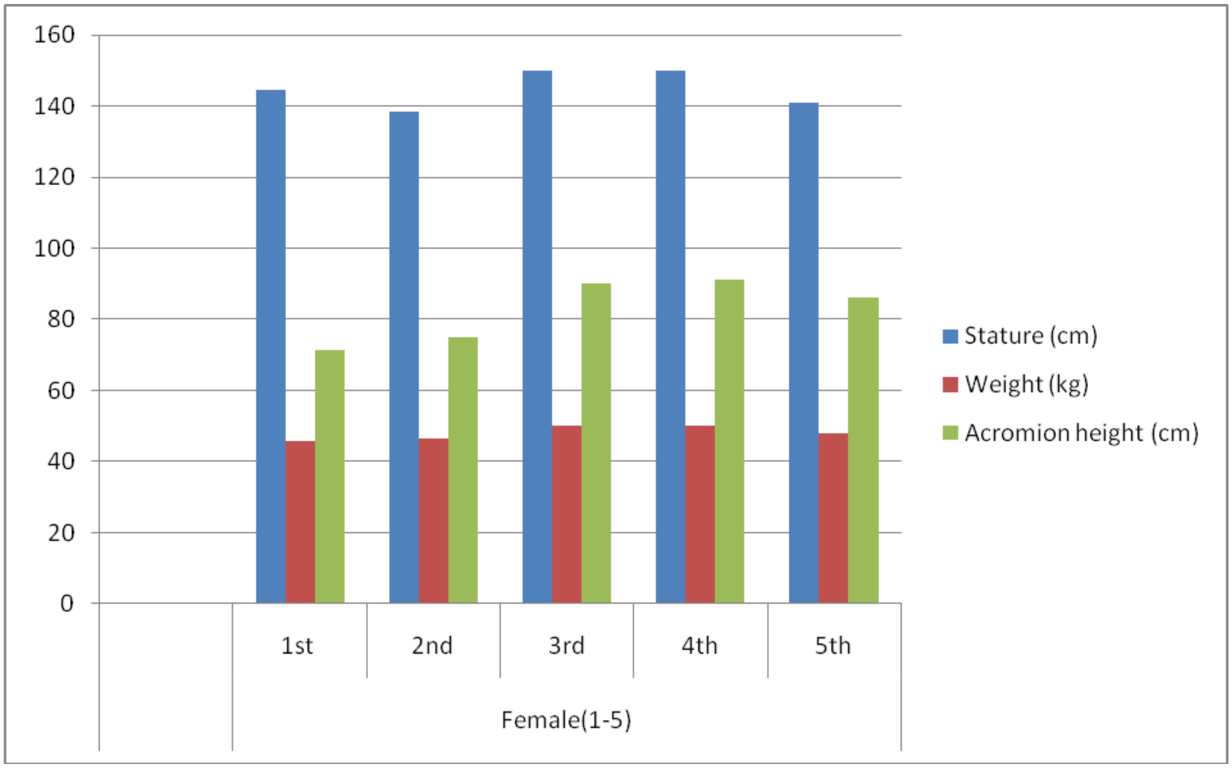


Fig.2 Human factor impact and benefits

Fig.3 Spring

Fig.4 Pedal Operated Coconut Dehusker

Fig.5 Grip diameter (cm)



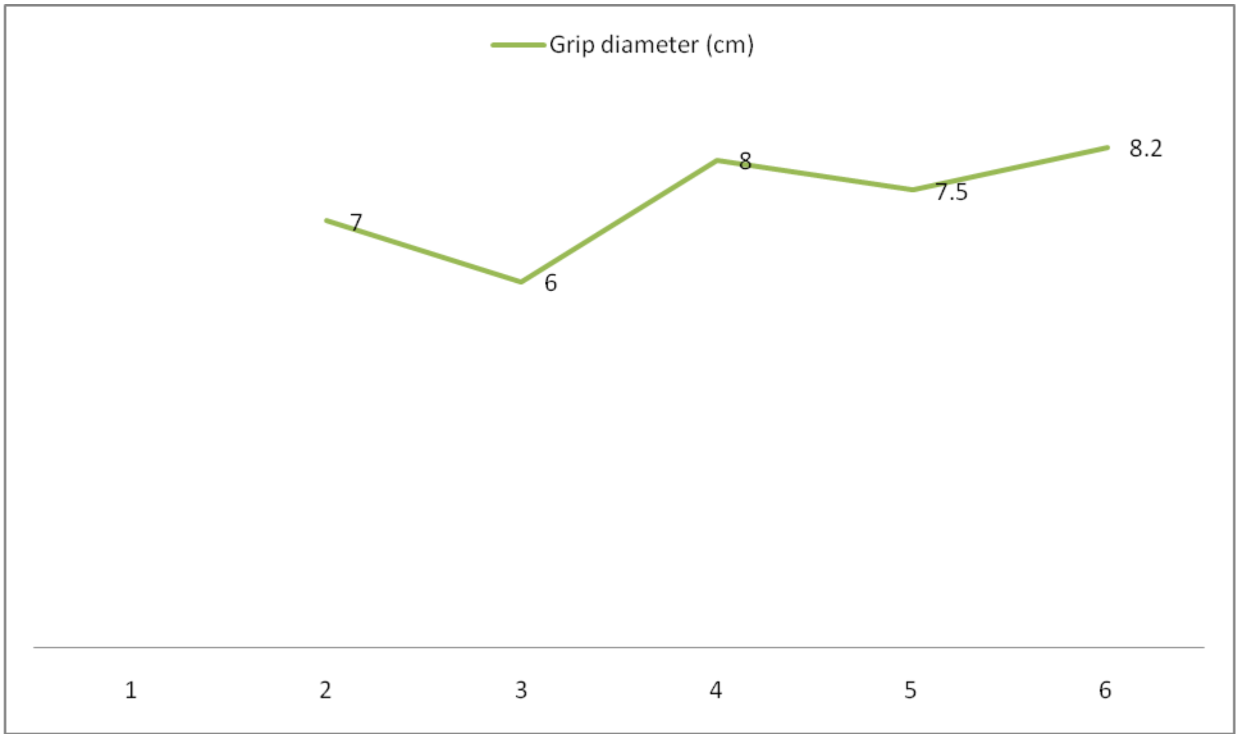


Fig.6 Relation between hand, palm length and width

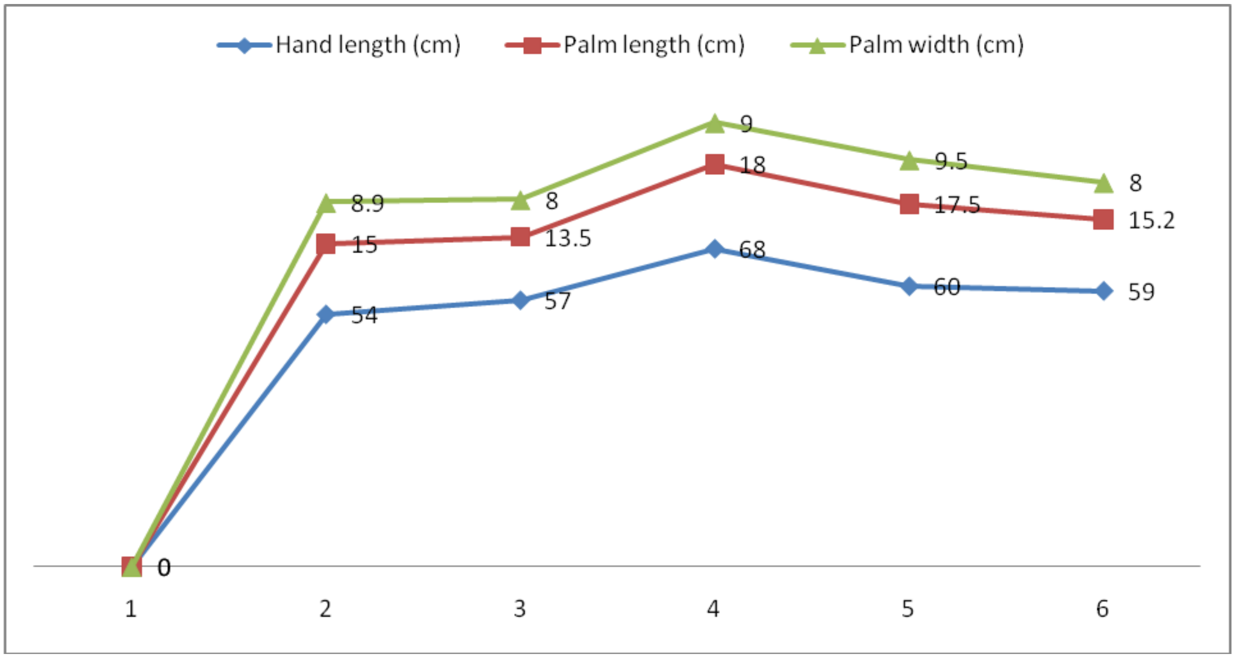


Fig.7 Arm hand (L) and grip strength (R&L)

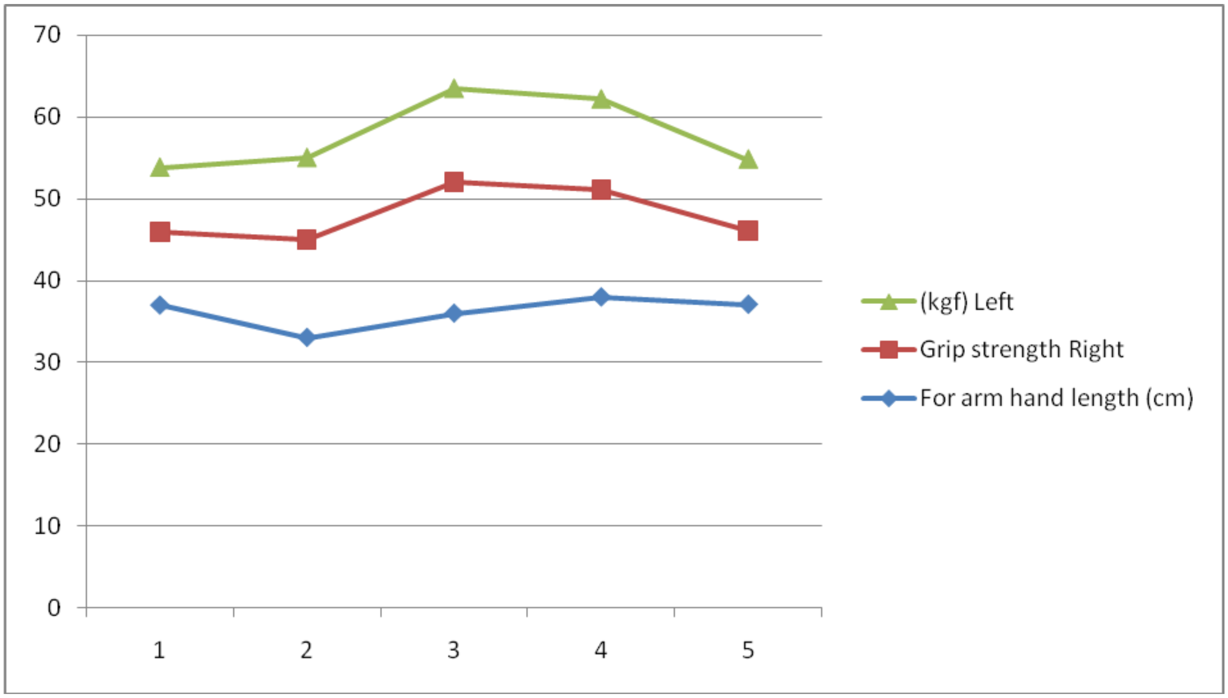


Fig.8 Relation between hand pull and leg push(R&L)

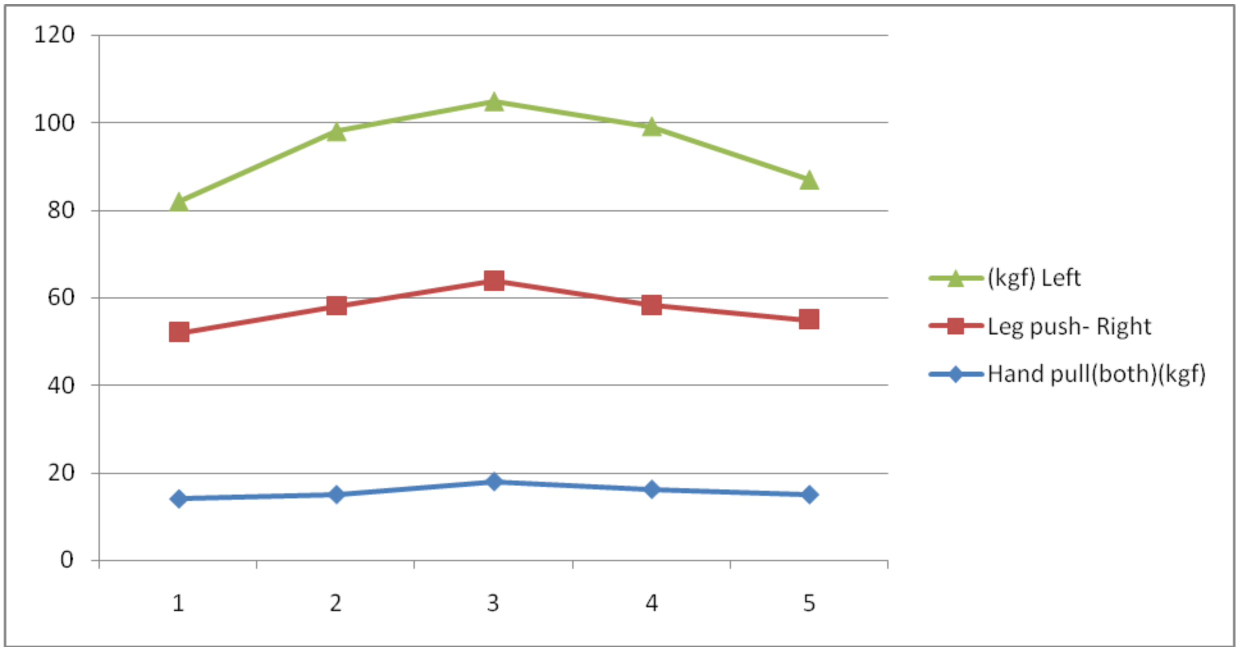


Fig.9 Relation between muscle strength with hand

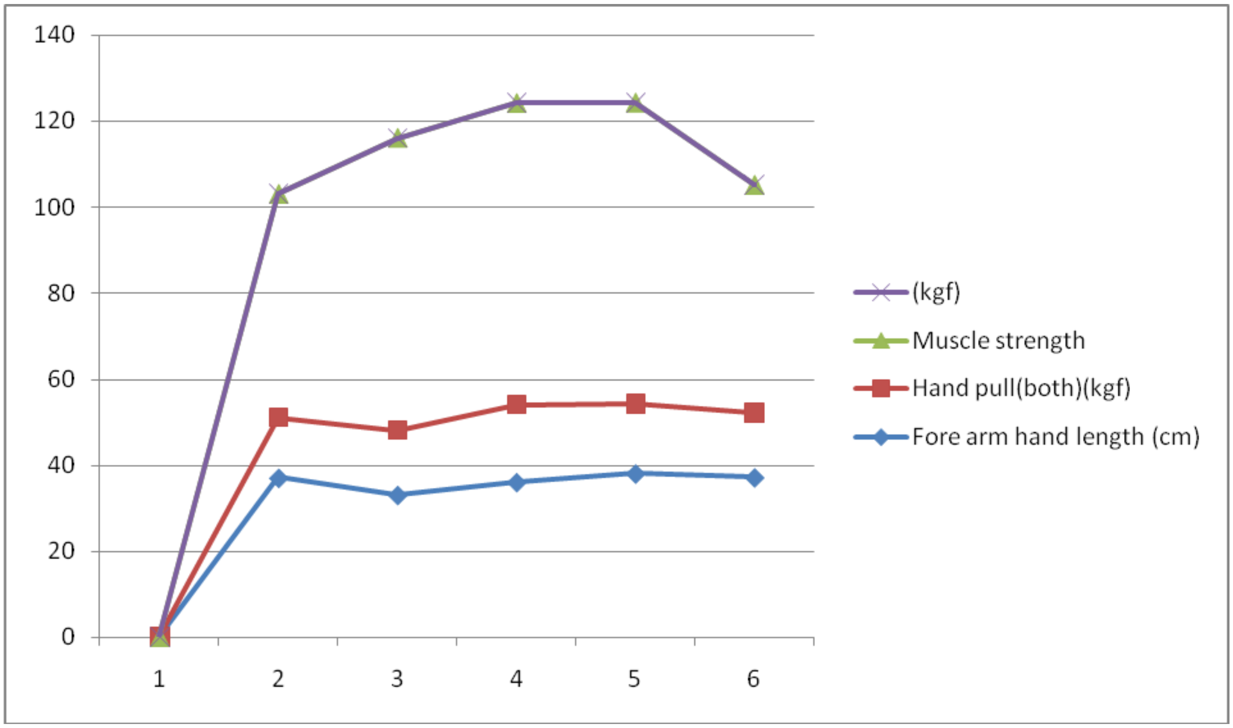


Fig.10 Analysis of anthropometric data & strength male parameter

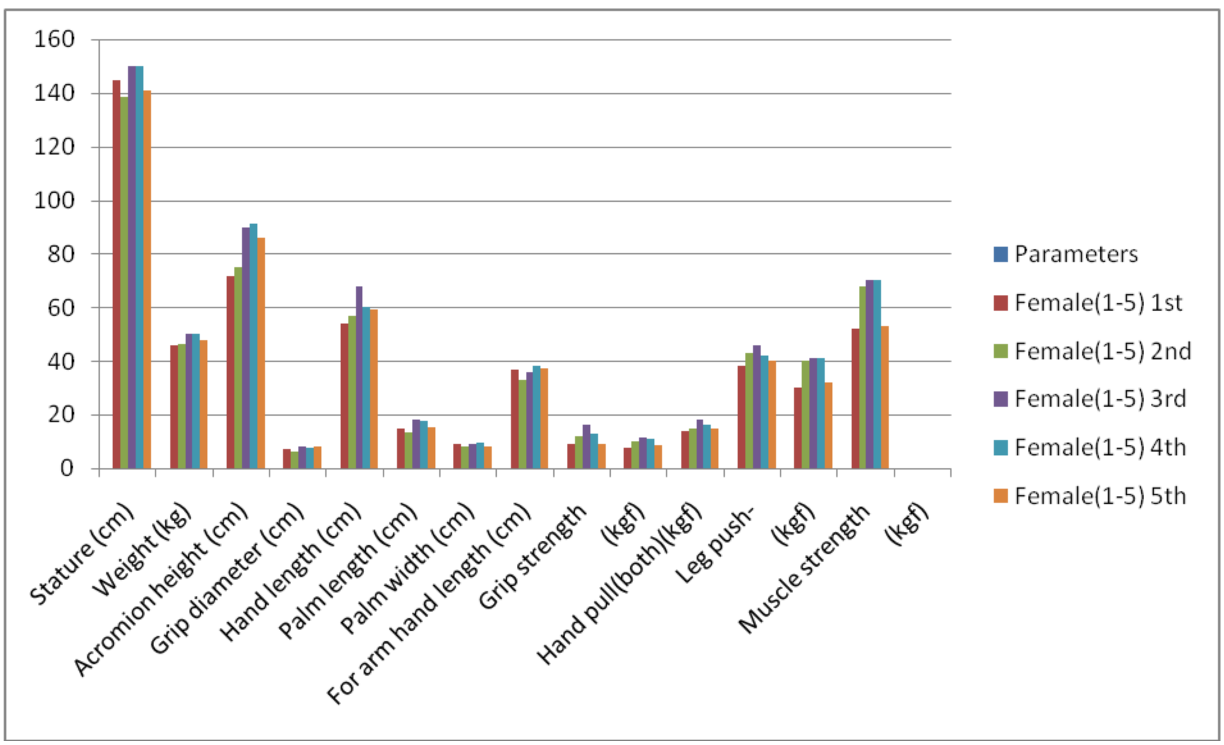


Plate.1 Before Dehusking

Plate.2 After Dehusking

By implication, machine performance efficiency does not give a true reflection of how effective a system work until the machine capacity is determined.

The section of this chapter of the study fulfill objective in which the related to “ergonomical evaluation & dynamic performance of pedal operated coconut dehusker” and to validated the ergonomically design.

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