Design of ergonomic grated coconut squeezer

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Abstract. The use of machines with manual technology is still a mainstay for small industries, especially home industries. One of them is the activity of squeezing grated coconut that still uses hands repeatedly. Users experience musculoskeletal complaints in the hands, body, and neck. The design of grated coconut squeezer has the aim to create a squeezer that provides comfort and does not cause musculoskeletal complaints. This design uses anthropometric theory to produce the product size according to the user. The anthropometric data used in the form of pulse size and standard Nordic Questionnaire (SNQ) filling questionnaire were carried out directly. Data processing was carried out by the sufficiency test, and data uniformity, percentile calculation, fatigue analysis, and statistical tests. The result of this design is an ergonomic grated coconut squeezer. Based on the statistical test Paired Sample t-Test is known the difference in pulse rate before and after using a grated coconut squeezer that illustrates the results of the device being made.

1. Introduction
Today, technology in the industrial world is not a foreign thing. Industrial machines that can relieve human workload while saving time for the production process have become a value in the hearts of its users. However, it turns out that not only large-scale industries need machines, but also in living a lot of life, people need tools that can help them ease their work so they can get good productivity from work. Of course, all the work done is inseparable from the human factor as the operator to the power source if the machine used is a simple aircraft.

Human aspects need to be considered to be able to optimize the work of machines that use humans as a source of energy because humans are central to these activities and the main point in the process of creating the tools used. The physical and psychological workload influences work productivity. The workload is assessed based on measurements of the human pulse that will use the engine that was created. Workloads that exceed the bat factor can cause injuries to humans who use machines.

Squeezing grated coconut is very common in households and even small household industries. Squeezing of grated coconut for a certain amount can be done manually so that it causes some fatigue and less efficient time for humans who do it.

Based on research conducted by [8], assessment of musculoskeletal complaints based on the Standard Nordic Questioner (SNQ) showed that the average user experienced pain in the right wrist (70%), upper arm and right forearm (63%), stiffness in the lower neck (50%). This complaint indicates that further improvements must be made.

The grated coconut squeezer that is made can overcome fatigue and time efficiency for the user because this tool is designed using ergonomic principles by taking into account all aspects of the human need to improve work productivity in squeezing grated coconut for small industries and household activities.
1.1. Ergonomics in Product Design
Ergonomics is a systematic branch of knowledge to utilize information about the nature, abilities, and limitations of humans to design a working system so that people can live and work well, namely achieving the desired goals through the work effectively, safely and comfortably.

Evaluation in the design of tool designs is done for the benefit of humans so that they are accommodated in every form so that the creation of man-made objects. To get an ergonomic grated coconut squeezer design, the human body's anthropometric data corresponds to the use of the squeezer itself.

1.2. Work Fatigue
Fatigue is defined as a change from a stronger state to a weaker state. Fatigue is a condition characterized by feeling tired and decreasing alertness and influencing work productivity.

Conceptually tired state includes physiological aspects, and this concept of fatigue has its meaning and is subjective in nature which is characterized by a decrease in physical performance, feeling tired, decreased motivation, and decreased work productivity. Fatigue is divided into two types, namely [4], there are muscle fatigue and general fatigue. The causes of fatigue are due to internal factors (age, nutritional status), and external factors (workload, work complaints).

1.3. Measurement of fatigue level
1. The subjective feeling of fatigue was measured by using a Subjective Self Rating Test questionnaire from the Industrial Fatigue Research Committee (IFRC).
2. Complaints with scale are measured using the Standard Nordic Questionnaire (SNQ).
3. Measurement of cardiovascular load (Cardiovascular load =% CVL).
4. Measurement of heart rate and respiratory rate.
5. Blood pressure measurement, air circulation in the lungs, amount of oxygen used, amount of CO2 produced, body temperature, and chemical composition in urine and blood.

2. Research methodology
2.1. Location and research subjects
This study uses guidelines for measuring anthropometric data ergonomics, which are measured from the dimensions of the human body (normal range and high hand grip). Data collection was carried out at Griya Mayang Asri of Public Corporation, Jambi City as many as ten users and repeated three times for each respondent, the data of the users taken were female.

2.2. Measurement of anthropometric data
To get an ergonomic design of a grated coconut squeezer, body anthropometry data such as Figure 1 and Table 1 are needed.

Figure 1. Anthropometric dimensions for tool design.
Table 1. Dimensions for tool design.

| No | Anthropometric Data     | Measuring Way                                                                 |
|----|-------------------------|-------------------------------------------------------------------------------|
| 1  | Normal reach            | Measuring the horizontal distance from the elbow to the tip of the middle finger when the hand is bent at 90° |
| 2  | High hand grip          | Measuring the vertical distance (height) of the hand grip in the position of the relax down |

2.3. Data analysis

2.3.1. Adequacy of data

This process is carried out to find out whether the anthropometric data obtained from the measurement of body dimensions is sufficient or not [27]. In this study, 95% confidence level and 5% degree of accuracy were used. This means that 95% of the sample taken, the deviation will not be more than 5%.

\[
N' = \frac{k}{s} \sqrt{\left( \frac{N \sum x_i^2}{N} - \left( \sum x_i \right)^2 \right)}
\]

where:
- \(N\) = Number of actual observation data
- \(N'\) = The amount of data theoretically
- \(x_i\) = Result data from measurements
- \(s\) = Degree of accuracy
- \(k\) = Level of trust

2.3.2. Uniformity of data

Data uniformity test is used to determine the distribution of data obtained, whether it is still within the control limits or there are those that are outside the control limits [27].

| Average | Standard deviation | Data uniformity |
|---------|--------------------|-----------------|
| \(\bar{x} = \frac{\sum x_i}{N}\) | \(s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N - 1}}\) | \(BKA = \bar{x} + ks\) |
| \(N = \) Number of data | \(N = \) Number of data | \(BKB = \bar{x} - ks\) |
| \(UCL(B) = \) Upper Control Limit (Bottom) |

2.3.3. Percentile calculation

Percentile values calculated from each type of data obtained are

- \(P_{95} = \bar{x} + 1.645s\) for large body size.
- \(P_{50} = \bar{x}\) for percentile values equal to average.
- \(P_{5} = \bar{x} - 1.645s\) for small body size.

2.3.4. Fatigue Analysis

In the stage of fatigue analysis, data collection was carried out using tools or instruments, namely a questionnaire for 30 respondents in Griya Mayang Asri of Public Corporation. Questionnaires were used to collect variable data regarding fatigue on users of coconut milk squeezer and pulse which affected fatigue.
In this study, pulse data was obtained by measuring the pulse rate of each respondent by feeling the heartbeat in the radial artery on the wrist using the stopwatch. After the data has been collected, the paired t-test statistical test, regression analysis, and the validity and reliability of the questionnaire were tested using SPSS software.

3. Results and discussion
3.1. Anthropometric data measurement
Anthropometric data from the dimensions of the normal range and the height of the hand grip used presented in Table 2.

Table 2. Anthropometric measurement data

| Data               | Measurement results (1 – 30) | Adequacy of data | Uniformity of data |
|--------------------|-----------------------------|------------------|--------------------|
| Normal reach       | 43 43 44 41.5 42.5 41.5 46 45.5 45.7 43.1 43.2 43 39.8 39.5 39.4 | Enough           | Uniformity         |
| High hand grip     | 41.6 40.5 40.9 41.8 42 42 42.5 42.3 42.7 44.5 44 43.8 44.3 44.2 44.2 | Enough           | Uniformity         |

3.2. Data analysis
For the data adequacy test and uniformity test can be seen in the following table:

Table 3. Results of data adequacy test and data uniformity test

| Anthropometric dimensions | Adequacy of data | Uniformity of data |
|---------------------------|------------------|--------------------|
|                           | N               | σ                 | BKA      | BKB      | Info.    |
| Normal reach              | 30 2.54 42.73   | 1.73              | 46.2     | 39.27    | Uniformity |
| High hand grip            | 30 2.25 8.31    | 0.32              | 8.94     | 7.68     | Uniformity |

3.3. The ergonomic design of grated coconut squeezer
Ergonomic dimensions used in the design of grated coconut squeezer are the normal range and high hand grip with the following values:

Table 4. Ergonomic dimensions

| No. | Part of the tool | Anthropometric data | Percentile | Design dimensions (cm) |
|-----|------------------|---------------------|------------|------------------------|
| 1   | Distance of use  | Normal reach        | 50%        | 43                     |
| 2   | High handle teapot | High hand grip   | 95%        | 9                      |

3.4. Product Design
The dimensions of grated coconut squeezer based on the results of measurements and calculations are as follows:
1. Storage Tube (inside)
   a. Grated coconut shelters with a capacity of 0.5 kg, density $3.52 \times 10^{-4}$ kg / cm³, and a diameter of 11 cm, obtained a height of 15 cm.
   b. Screw pole holder with a height of 5 cm. The total height of the tube canister is 20 cm.
2. Teapot Tube
   To accommodate coconut milk up to 1200 cm³, a teapot tube with a diameter of 18 cm, must have a coconut milk reservoir as high as 5 cm, so that for the entire height of the teapot tube is 25 cm.
3. Operating: Screw threaded lever clockwise
4. Composite components on grated coconut squeezer:
   a. Teapot tube
   b. Container tube
   c. Pressing tube
   d. Threaded bolt
   e. Nut
   f. Flange
   g. Lockdown

After testing, this tool can produce more coconut milk than squeezing coconut milk by hand, which is an increase in coconut milk productivity by 14.29%.

3.5. Fatigue Analysis
The level of fatigue of respondents before and after using the grated coconut squeezer can be seen in Figure 3, 4, 5 and 6.

![Figure 2. Sketch of the tool](image)

![Figure 3. Graph of the respondent's pulse rate before squeezing grated coconut](image)

![Figure 4. Graph of respondents' pulse rate after squeezing grated coconut](image)
Based on the graph above, the respondents' fatigue when squeezing grated coconut manually was higher than by squeezing grated coconut which is using an ergonomic grated coconut squeezer.

In testing the validity and reliability of the SSRT questionnaire, 9 out of 30 questions were valid. While the SNQ questionnaire 4 of 27 questions were declared valid with an average of 89.06 beats per minute using the hand, while 85.93 pulses per minute squeezed grated coconut using a grated coconut squeezer.

While based on questionnaire data collection using SSRT and SNQ, the following results are obtained in Table 5 and 6.

**Table 5.** Results of t-paired pulse rate analysis before and after squeezing grated coconut using hands

|         | Paired Differences |                  |                  | t     | df  | Sig. (2-tailed) |
|---------|--------------------|-------------------|-------------------|-------|-----|-----------------|
|         | Mean               | Std. Deviation    | Std. Error Mean   | 95% Confidence Interval of the Difference |     |     |                 |
| Pair 1  | sblm - ssdh        | -20.7             | 2.32156           | .42386 | -21.5669 -19.8331 | -48.837 | 29 | .000             |

**Table 6.** Results of t-paired pulse rate analysis before and after squeezing grated coconut using grated coconut squeezer

|         | Paired Differences |                  |                  | t     | df  | Sig. (2-tailed) |
|---------|--------------------|-------------------|-------------------|-------|-----|-----------------|
|         | Mean               | Std. Deviation    | Std. Error Mean   | 95% Confidence Interval of the Difference |     |     |                 |
| Pair 1  | sblm - ssdh        | -15.90            | 2.95191           | .53894 | -17.00226 -14.79774 | -29.502 | 29 | .000             |

From tables 1 and 2 above it can be seen that by using the number of respondents as much as 30 and the significance (error level) used is 5%, then the t-table value can be seen through the Pearson t product moment table with DF (Degree of Freedom) = 30 -1 = 29, namely t-table = 2.045, while the t-count value is -29.502. This states that there are differences in pulse rate before and after using a grated coconut squeezer.
Table 7. Analysis of simple linear regression in respondents' pulse rate

| Model | Unstandardized Coefficients | Standardized Coefficients | T   | Sig. |
|-------|-------------------------------|---------------------------|-----|-----|
|       | B                              | Std. Error                | Beta|      |
| (Constant) | 84.493                       | 5.619                      | 15.038 | 0   |
| 1     | Fatigue                       | .045                       | .175 | .049 | .257 | .799 |

The simple linear regression analysis above has shown that there is a positive correlation between fatigue and pulse that will occur in the respondent. The more tired the respondent feels, and then this will lead to an increase in the respondent's pulse.

4. Conclusion
1. Grated coconut squeezer that is ergonomically made using anthropometric theory, it is in accordance with the dimensions of the human body to provide a sense of comfort for its users.
2. There is a difference in pulse rate before and after using a grated coconut squeezer.
3. There is an influence between pulse and work exhaustion.
4. Grated coconut squeezer made is understood as an ergonomic tool.

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