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Slice Tool Model Design Dynamo Drive Tempeh to Increase Work Productivity of Tempeh Chip Craperers

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Abstract: Tempeh chips are one of the businesses in the field of small or household industries. Tempe sold by small industries is usually in the form of crackers. To process tempeh into chips, it is necessary to cut and slice it so that it can be made thin. There is a problem in slicing tempeh into thin pieces, especially in large quantities of tempeh. Manual cutting will make the work ineffective, take a long time, and the results of many pieces of tempeh are destroyed. Based on this problem, a tempeh cutting tool design research was conducted with an ergonomic approach to increase worker productivity. This research was conducted using a one-short case study method with a pre- and post-test design group that was carried out by observation of the tempeh cutting procedure. Workload as determined by the pulse of rice before and after work; complaints of fatigue and skeletal muscle pain before and after work; and work productivity as determined by a comparison between the work pulse (measured in beats per minute) and the weight of the products produced (in kilograms) while working (minutes). The results of the study concluded that: Testing the tempeh cutting's job efficiency using an ergonomic technique yielded the following results: a). Prior to utilizing the tempeh cutting machine, the average resting pulse rate of tempeh cutting artisans was 69.84 (2.31) bpm; however, their working pulse increased to 105.96 (1.46) bpm, increasing by 37.53 (2.98) bpm, or 54.48%. The average resting pulse rate of tempeh cutting craftsmen after using tempeh cutting machine is 68.43 (±1.71) bpm and the average working pulse is 97.08 (±2.00) bpm and an increase in work pulse is 27.24 (±1.64) bpm or 39.00 %; b). The average difference between musculoskeletal disorders before work and after work before using tempeh cutting machine is 28.90 (±3.31) and the average difference between skeletal muscle disorders before work and after work after using tempeh cutting machine is 16.70 (±4.30). The decrease in the mean of skeletal muscle disorders before using the tempeh cutting machine and after using the roasting machine was significant ($p < 0.05$) or 42.21%; and c). The result of calculating the work productivity of craftsmen before using the tempeh cutting machine is 94.21±3.09 and an increase after using the tempeh cutting machine is 152.69±3.37 or an increase of 62.07%.

Keywords: Tempeh Cutting, Ergonomic, Work Productivity

1. Introduction

One of the traditional Indonesian delicacies, tempe is produced by a fermentation process. Soybean is the primary ingredient in Tempe (Glycine sp.). Even though tempeh is a typical Indonesian dish, fans have traveled outside [1]. This is so that the body may benefit from the nutrients that tempeh provides. Vegetable protein, carbs, B vitamins, and fiber are among the nutrients present. Tempe's high protein content might aid with daily protein requirements. This is evident from the fact that people need 63 g of protein on average. There are 20.7 grams of protein in 100 grams of tempeh [2].

According to Fitria's research [3], only a tiny portion of the tempeh-slicing process in the home business has included semi-automatic machinery. These circumstances and settings, together with the tedious procedure of manually slicing tempeh with a knife, drive the development of effective and secure cutting technology. Various techniques have been used in research on the creation of cutting instruments for foods like

cassava, potatoes, and carrots. The invention of a multipurpose cutting tool that powers an electric motor is one example of cutting tool research being done. Sarwono [4] claims that one sort of food made from tempeh is tempeh chips. Tempeh chips have a high protein level that ranges from 23% to 25%. The procedure of producing tempeh for tempeh chips differs somewhat from that of producing tempeh for veggies. The tempeh that will be used to make tempeh chips is thinner and has a leaf base printed directly on it.

The creation of a design solution for the dynamo-driven tempeh slicer is an attempt to solve this issue. It aims to increase the productivity of the tempeh slicer, which will increase production more quickly, and to simplify the tempeh slicing process. This will help increase production capacity in the manufacture of processed foods, especially fried tempeh, and will enable us to solve the issues that currently exist in the slicing process, such as crushed or uneven size. A tool is required for slicing tempeh in micro, small, and medium-sized businesses (MSMEs) that handle fried meals, including tempeh. This tempe slicing machine uses an electric motor as the main driver. The electric motor is turned on by pressing the on button. After the electric motor is connected, the rotation of the electric motor will rotate the pulley and the transmission belt (V-Belt) which will move the pulley on the reducer which causes the engine shaft to rotate. The tempeh will be sliced by a knife (cutter) with the thickness of the cut can be adjusted according to the desires of the producer so that the results of slicing with thin results and are not broken. The tempeh will be placed in the hopper and will move forward with the assistance of a pendulum as part of the mechanism.

The design of this tempeh slicer also needs to be done with an ergonomic approach. Using this tempeh slicing machine will make tempeh craftsmen work more effectively and more productively with better tempeh slicing results. Management and production systems in small and medium industries must pay attention to ergonomic factors so that workers can work healthier and more productively so that companies can get better profits [5, 6]. Using an ergonomics approach will provide solutions to worker problems and production systems so as to get higher productivity [7, 8].

2. Method

2.1. Research Design

This study is a one-short case study with a pre- and post-test design group that was carried out by observation of the tempeh cutting procedure [9]. Following is a description of the chart:

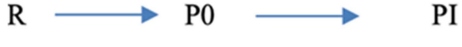

Figure 1. *Research Design.*

Information:
R = Random sample.
P0= the result of the pre-test experimental unit.
PI = the result of the post-test experimental unit.

2.2. Research Variable

The following factors will be assessed in this study: (1) workload as determined by the pulse of rice before and after work; (2) complaints of fatigue and skeletal muscle pain before and after work; and (3) work productivity as determined by a comparison between the work pulse (measured in beats per minute) and the weight of the products produced (in kilograms) while working (minutes). Before employing a tempeh cutting machine, the comparison is made using the information from the beginning condition and the final state as measured by variables numbers (1) through (3).

2.3. Data Analysis

The volume of cutting results, duration of labor, fatigue complaints, and job productivity were taken into consideration while calculating the data from the test results using the dynamo-driven tempeh slicer. The data was then evaluated quantitatively descriptive to draw conclusions.

3. Results and Discussion

3.1. Product

The Design Concept of the Electric Motor Driven Tempe Slicer Tool is as below:

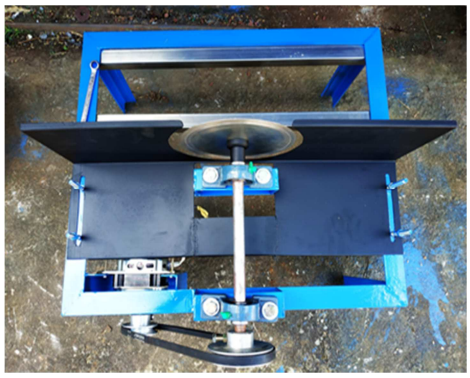

Figure 2. *Tempeh Cutter Design.*

3.2. Tempe Cutter Working Principle

Mechanical Temper Slicer With 0.5 Horsepower This mechanical tempe slicer is a tool created to carry out the mechanical way of slicing tempeh, where the user uses the instrument to cut the tempeh. This tool's production intends to develop and test the design of a mechanical tempeh slicer with a driving force of 0.5 HP, to be more effective and produce more tempeh slices in the same amount of time than cutting by hand. Whereas the mechanical tempe slicer also results in lower labor expenses. The proposed operation of this tempeh slicing device involves using the rotation of an electric motor to move the pully with the aid of a v-belt in order to rotate the cutting blade, which rotates to slice the tempeh in order to slice it to a specific thickness. This tool has a 0.5 hp electric motor that spins at 1420 rpm. By coupling the pulley on the 7-inch gadget to the pulley on the 2.5-inch motor with a V-belt, the electric motor

will drive the device. The used V-belt measures 58.44 inches in length. The tool rotates at 507 rpm, which is projected to conduct slicing well and efficiently based on a comparison of the two pulleys. When designing a tool, one must take into account the instrument's size and the material that was utilized to make it. The tool's measurements serve to specify its length, breadth, and height. It might make the process of constructing the tool easier to know the size and mass of the tool. The quality and durability of a tool are significantly influenced by the choice of material used in its construction.

3.3 Tempeh Cutting Machine Effective Capacity

The 0.5 horsepower is the power of the electric motor used by the mechanical tempe slicer. Inserting tempeh into the material intake tube (hopper) for slicing is how it is done. By slicing tempeh three times, using a 1 kg amount of tempeh for each repeat, the tool's actual capacity was discovered. The weight of the raw material being sliced is divided by the amount of time needed to slice it, and the result is the tool's effective capacity. Table 1 below displays the outcomes of the tool's effective capacity calculation.

Table 1. *Mechanical tempe slicer working capacity data.*

Test	Mo (gram)	Mt (gram)	t (sec)	capacity (kg/hour)
1	1000	740.30	7.44	370.15
2	1000	784.25	7.87	373.45
3	1000	755	7.60	359.52
Average	1000	759.85	7.63	367.70

Table 1 displays the findings of study that involved replicating 1 kg of tempeh three times by slicing it. According to the findings of the slicing, it takes an average of 7.63 seconds to slice 1 kilogram of tempeh, meaning the tool's actual capacity is 367.70 kg per hour.

The test results for this tempeh slicer revealed a 24.015% percentage of material damage. The first iteration yielded the greatest percentage, which was 25.97%. The tempeh that was sliced and fell by bouncing owing to the rotation of the blade disc such that it contacted the cover wall and was damaged was the factor that had an impact on the percentage of material damage.

According to the information gathered from the research, the tool's BEP value would be reached after it has sliced 1,763.355 kg of tempeh every year. According to Waldiyono (2008), the process of calculating the amount of output to make sure that the business activities utilized are self-financing and may then expand themselves is typically connected to the break-even point analysis (self-growing). The starting profit is taken to be zero in this study. The benefit of determining the break-even point is to identify the minimal production threshold that must be met and sold in order for the managed firm to remain viable. In this situation, the income is only enough to pay for operating expenses, with no surplus.

The criteria used to determine whether or not a tool should be developed is called net present value (NPV). This NPV may be utilized as an option in financial analysis when deciding to invest cash in expanding a company's toolkit. It is clear from the experiment and the data from the study that the NPV at a 7.5% interest rate is Rp. 1,642,089,764.1.

3.4. The result of Ergonomics Test Using Tempeh Cutting Machine

3.4.1. Objective Complaint

Musculoskeletal issues and tiredness complaints rise as a result of the craftsman's hunched-over work position. A work posture that bends repeatedly for an extended period of time is not physiological. Muscle problems develop as a result of strain on the muscles from ongoing workloads without rest [10, 11].

The average difference between musculoskeletal issues before work and after work before treatment was 28.90 and after treatment was 16.70, according to measurements made using a Nordic body map questionnaire for 10 artisans who were measured before and after labor. Significant (p 0.05), or 42.21%, reduction in the mean difference between musculoskeletal illnesses existed before and after therapy.

Table 2. *Measurement Results of Musculoskeletal Disorder.*

Descriptions	Everage difference musculoskeletal disorder		t	p
	Mean	Standard Deviation		
Manual tempeh cutting	28,90	3,31	6,578	0,00
Machine tempeh cutting	16,70	4,30		

3.4.2. Work Load

The average working pulse is 105.96 (1.46) bpm, which represents an increase of 37.53 (2.98) bpm or 54.48% over the craftsmen's average resting pulse rate of 69.84 (2.31) bpm (before utilizing the roasting equipment). After utilizing a tempeh cutting machine, craftsmen's average resting pulse rates were 68.43 (1.71 bpm) and 97.08 (2.00 bpm) respectively. The increase in work pulse was 27.24 (1.64 bpm) or 39.00%.

Table 3. *Resting Pulse, Pulse Working and Work Pulse.*

Descriptions	Manual roasting process		Machine roasting process		t	p
	Mean	SD	Mean	SD		
Resting Pulse	69.84	2.31	68.43	11.71	-1,53	0,16
Pulse Working	105.96	1.46	97.08	2.00	10.51	0.00
Work Pulse	37.53	2.80	27.24	1.64	15.55	0.00

SD: Standard deviation

Prior to therapy, the average working pulse for the medium workload group was 105.96 (1.46) beats per minute [12]. Workers who labor continually without breaks are to blame for this burden.

3.4.3. Work Productivity

Based on the ratio of output to input at a particular time unit, the productivity of the tempeh cutting machine process is measured. The output is measured in kilos of tempeh cutting generated during working hours, while the input is the crafter's working pulse. Calculating productivity after utilizing the tempeh cutting machine yields a value of 152.69 3.37 as opposed to 94.21 3.09 previously, or an increase of 62.07%. This boost in productivity is the result of a lighter workload and an ergonomic work position that lessens tiredness and musculoskeletal problems while increasing output. According to Kimberly [12], a change in the work system is required to boost productivity in order to decrease worker weariness and enable longer workdays and higher output. The creation of an ergonomic work system, according to Torik et al. [13] can lessen worker weariness. an ergonomic approach will be effective in increasing the productivity of workers [14, 15].

Table 4. *Work Productivity of tempeh cutting machine.*

Descriptions	n	Mini-mum	Maxi-mum	Mean	Standard Deviation
Manual tempeh cutting Process	10	149	151	152.69	3.370
Machine tempeh cutting Process	10	91	102	94.21	3.091

Ergonomics researchers frequently advocate ergonomic interventions to boost production, as seen in Priambadi's [16] and Bawa Susana's studies [17]. For example, changing working conditions for gamelan artisans who scald instruments can boost output by 26.67% and 54.88%, respectively. According to Setiawan's research [18], work station design can boost productivity by 20.29%. Worker problems can be solved with a total ergonomics approach so that it can provide higher productivity [6, 19] and the company gets better profits [20, 21].

4. Conclusion

Based on the discussion that has been carried out, the following conclusions can be:

1) From the research conducted, the cost for slicing tempeh is the same every year. The cost of using the tool is Rp. 30,446/kg in the first year to the fifth year. This is due to the equation of the value of depreciation costs in each year so that the fixed costs of the equipment are the same each year.
2) Based on the data obtained from the research conducted, the BEP value obtained by this tool will reach the break-even point if it has sliced tempeh as much as 1,763,355 kg/year and it can be seen that the amount of NPV with an interest rate of 7.5% is Rp.1,642,089,764.
3) Testing the tempeh cutting's job efficiency using an ergonomic technique yielded the following results: a). Prior to utilizing the tempeh cutting machine, the average resting pulse rate of tempeh cutting artisans was 69.84 (2.31) bpm; however, their working pulse increased to 105.96 (1.46) bpm, increasing by 37.53 (2.98) bpm, or 54.48%. The average resting pulse rate of tempeh cutting craftsmen after using tempeh cutting machine is 68.43 (±1.71) bpm and the average working pulse is 97.08 (±2.00) bpm and an increase in work pulse is 27.24 (±1.64) bpm or 39.00 %; b). The average difference between musculoskeletal disorders before work and after work before using tempeh cutting machine is 28.90 (±3.31) and the average difference between skeletal muscle disorders before work and after work after using tempeh cutting machine is 16.70 (±4.30). The decrease in the mean of skeletal muscle disorders before using the tempeh cutting machine and after using the roasting machine was significant ($p < 0.05$) or 42.21%; and c). The result of calculating the work productivity of craftsmen before using the tempeh cutting machine is 94.21±3.09 and an increase after using the tempeh cutting machine is 152.69±3.37 or an increase of 62.07%.

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