Increasing the Productivity of French Fries Business Actors with Ergonomic Potato Cutters

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Abstract. Potatoes are one type of horticultural plant that is consumed for its tubers. The high carbohydrate content makes potatoes known as a food ingredient that can substitute other carbohydrate foods from rice, corn, and wheat. Increasing productivity in the potato industry can be achieved through innovation and improvement in the production process. One crucial aspect of the production of French fries is the potato-cutting process, which can affect the efficiency and quality of the final product. This study aims to increase the productivity of French fries entrepreneurs through the design and implementation of efficient potato-cutting tools. The research method used involves literature studies, direct observation of the French fries production process, and conceptual design of a new potato-cutting tool. The cutting tool design considers speed, accuracy, and safety in the potato-cutting process. In addition, ergonomic aspects are also considered to increase operator comfort during the use of the tool. The results obtained in this study show that the productivity of French fries entrepreneurs increases by using the tool made. The increase in work productivity reaches 150% and the workload of potato-cutting operators can be minimized by using this potato-cutting tool.

Keywords: Ergonomics, Potato-Cutting Tool Design, Work Productivity

1 Introduction

Potatoes are one type of horticultural plant that is consumed for its tubers. The high carbohydrate content makes potatoes known as a food ingredient that can substitute other carbohydrate foods from rice, corn, and wheat. Potato plant production tends to increase from year to year, in addition to the population and the increasing standard of living of the community. The community uses the results of potato farming for household and industrial needs. The increasing potato production is a business opportunity for the community and if the potatoes are not processed, the farmers' production cannot be absorbed. To absorb the results of potato farmers, potato processing businesses have begun to develop into various foods. Currently, the processing of various foods made from potatoes is still constrained by the process of cutting potatoes into the desired shapes. The obstacles faced by potato business actors are the relatively long cutting process time, frequent work accidents and workers often complain of pain after carrying out the process of cutting potatoes in large quantities. Increasing productivity in the potato industry can be achieved through innovation and

A. A. N. G. Sapteka et al. (eds.), *Proceedings of the International Conference on Sustainable Green Tourism Applied Science - Engineering Applied Science 2024 (ICoSTAS-EAS 2024)*, Advances in Engineering Research 249,
https://doi.org/10.2991/978-94-6463-587-4_53

improvement in the production process. One crucial aspect of the production of French fries is the potato-cutting process, which can affect the efficiency and quality of the final product. This study aims to improve the productivity of potato business actors through the design and implementation of efficient and ergonomic potato-cutting tools. This study is expected to contribute to the development of technology in the potato industry and provide practical solutions to improve the productivity of small and medium business actors in this sector. The existence of efficient potato-cutting tools is expected to open up new opportunities for business development and increase competitiveness in an increasingly competitive market.

2 State of The Art

2.1 Design and Construction

Angil et al. conducted a study on the design and performance test of a potato cutter in the form of French fries. The design of the potato cutter was carried out by comparing the cutting blades between the cutter blade, tobacco blade, and Maspion blade. The resulting cutting tool was then tested against the best blade from the comparison of the three blades. The treatment used in testing the cutting blade was a variation of the cutting angle, namely 24° (tobacco blade), 27° (Maspion blade), and 28° (cutter blade). The Maspion blade gave the best results compared to the tobacco blade and cutter blade. The Maspion blade was tested with speed treatments: 20 rpm, 30 rpm, and 40 rpm. Each angle and speed variation was repeated 3 times. The test data results compare the average cutting results with speed variations in sequence: Full Cut (TP) 240 g, 233.3 g, and 243.3 g, Edge Cut (TT) 81.7 g, 78.3 g, and 75 g, Full Cut Damage (RTP) 86.8 g, 95 g, and 95 g, Edge Cut Damage (RTT) 36.7 g, 38.3 g, and 31.7 g, time 48.67 seconds, 24 seconds, 26.33 seconds. Based on data analysis, the variation of cutting speed does not significantly affect the cutting results of TP, TT, RTT, or RTP, except for having a very significant effect on time. This tool has an average effective capacity of 47.48 kg/hour, an average yield damage of 40.3%, and an average efficiency of 57.02% (Reka et al., 2015).

Novri et al. conducted a design and construction of a potato cutting tool in the form of a stick based on an Atmega 328 microcontroller. In this study, the VL53L0X sensor was used as a potato detector, pneumatics to push the potatoes toward the blade which was driven by a compressor by regulating the air pressure using a solenoid valve and ATMega 328 as the control center in the overall working system of the tool. The design of this automatic potato-cutting tool is an electrical and mechanical circuit that works based on a program controlled by an Arduino Uno microcontroller. Based on the results of testing and calculations, within 1 minute it produces 2.14 kg of potato sticks (Alfino & Aswardi, 2020).

Syafik and Hamid conducted a study on portable automatic potato-cutting machines with crank-slider and flexible cutter mechanisms. The results obtained based on the 1 kg potato research trial showed that the effective capacity of the automatic potato-cutting tool prototype to cut potatoes into blocks was 265.29 kg/hour or 4.4 kg/minute with a cutting speed of 23.33 rpm. Based on the results of the research trial conducted, it showed that the cutting efficiency of the Automatic Potato Cutting Tool Prototype to cut potatoes into blocks was 74.76%. The value of the tool efficiency is determined by the effective capacity of the tool, the greater the cutting capacity, the greater the efficiency will be (Syafiq & Abdillah, 2013).

2.2 Workload

Workload measurement needs to be done to determine the severity of a workload received by workers, this is useful for determining the classification of workload and determining working hours that are adjusted to the ability or capacity of workers. The heavier the workload received by workers, the shorter the working time of a person to work without significant fatigue and interference or vice versa (Tarwaka & Bakri, 2004; Purbasari & Purnomo, 2019). Workload measurement can be done with a physiological approach to measure physical workload and a psychological approach to measure mental workload. The physiological approach is an approach in the field of Ergonomics that focuses on measuring the energy consumed, metabolic needs, body function performance, and its components in designing work (Iridiastadi & Yassierli, 2019; Sitohang et al., 2010; Purba & Jabbar Rambe, 2014).

3 Methodology

3.1 Design

Results should be clear and concise. The results should summarize (scientific) findings rather than provide data in great detail. The results of data analyses can be presented in tables, graphs, figures, or any combination of the three. The authors are advised to use proper variation in presenting tables, graphs, or verbal descriptions. All displayed tables and graphs should be referred to in the text. What answer was found to the research question; what did the study find? Was the tested hypothesis true This potato cutter is designed with a capacity of 3 Kg, with a potato container diameter of Ø 252 mm x 400 mm and this tool stops automatically or does not work when the potatoes in the tube are finished, this tool has a width of 252 mm, a length of 815 mm, and a height of 830 mm. The detailed design of this potato cutter is presented in Figure 1.

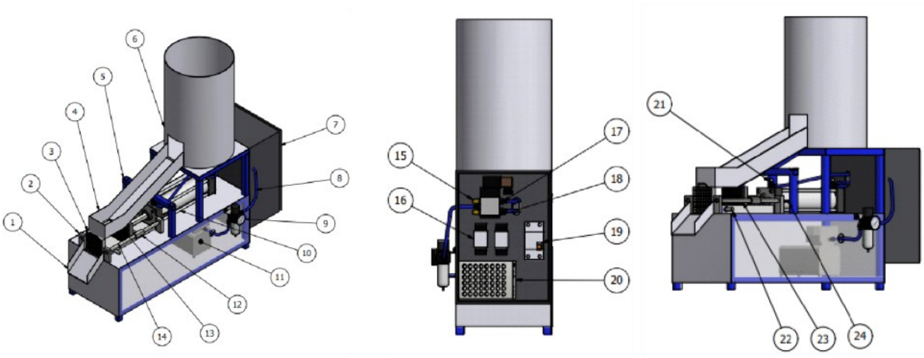

Figure 1. Pneumatic-based potato-cutting tool

Information:

1. Potato drop guide plate
2. Knife rail bracket
3. Cutting knife
4. Potato drop guide plate to cutter
5. Frame
6. Potato collection tube
7. Panel
8. Pneumatic hose
9. Airlock
10. Pneumatic cylinder
11. Compressor
12. Knife holder to rail
13. Pusher
14. As rail
15. Silencer fitting
16. Relay
17. Fitting
18. Pneumatic hose
19. RCCB
20. SMPS
21. Air volume regulator to pneumatic cylinder
22. Capacitive Proximity Sensor
23. Cutter holder or influence
24. Pneumatic Magnetic Reed Sensor

3.2 Determination of Data Sources

The data source is obtained from the test results by measuring the completion time of potato cutting with a capacity of 3 kg of potatoes compared to the manual method currently being carried out. In addition to time, product quality is also measured by direct observation with 3 categories: good, medium, and bad. Operator health complaint data is measured by conducting a workload test for 2 hours.

3.3 Research Instruments

In this research, the tool supports the process of collecting analysis data from the design, preparation of tools, preparation of materials, to obtaining analysis data from the test results. Some of the instruments needed are: Capacitive sensors to detect falling potatoes pneumatic pistons will advance to push the potatoes to the pneumatic knife; Magnetic reed sensors to command the piston to return to the back; A stopwatch as a tool to measure how long the potatoes are cut for and how many minutes; Data collection sheets to record data obtained from the analysis results; Potato chipper tools on the type of potatoes to produce potato stick pieces.

3.4 Research Procedures

To obtain the test data of this potato-cutting tool, the procedures that need to be done are preparing the potato-cutting tool that has been designed, preparing potatoes according to data collection needs, preparing a potato-cutting operator who has often cut potatoes manually, carrying out the process of cutting 3 kg of potatoes by the operator manually and recording the processing time starting from washing the potatoes, peeling and until the potatoes are cut. In addition to the observation time, the quality of the cuts is also observed as well as complaints felt after carrying out the potato cutting process. After giving enough time to rest for approximately 1 hour, the operator carries out the same process using the designed potato-cutting tool, and the same data is also observed.

3.5 Data Analysis

In this study, the data analysis method used is a descriptive quantitative method. The measurement data obtained in the form of time and quality of potato cutting are presented in table form and then the productivity of the tool and the workload of the operator are calculated.

4 Result and Discussion

4.1 Data Analysis

From the results of the shape design, mechanism selection and carrying out engineering calculations to determine the dimensions and strength of the components, followed by making detailed drawings of the product and its components so that the tool manufacturing process can be carried out based on the working drawings, the results of the potato cutting tool design with a capacity of 3 kg are obtained as in Figure 2.

Figure 2. Design results of a potato-cutting tool

4.2 Potato-Cutting Mechanism

The working mechanism of this potato cutter is if the tool is made in the on position then the potatoes that are in the position ready to be cut will be pushed using a pneumatic piston controlled by air and sensors. When the potato falls on the proximity sensor, the piston moves forward and backward until it hits the magnet sensor, and the potatoes are cut into potato sticks. In the next position the potatoes will fall on the proximity sensor and the cutting process occurs again, and so on, until the 3 Kg of potatoes in the storage tank run out.

4.3 Test Result

From the results of the potato cutting test with two cutting methods, the first operator cuts the potatoes manually using a knife starting from the washing process until the potatoes are cut into sticks of 3 kg of potatoes and then the operator rests for 1 hour and continues cutting using the tool and then repeats 3 times.

Table 1. Potato-cutting time using manual methods, tools, and cutting quality

No	Potato capacity (Kg)	Manual cutting time (Minutes)	Cutting time with a tool (Minutes)	Cutting quality
1	3	29	21	Good
2	3	31	20	Good
3	3	30	19	Good
Average	3	30	20	Good

The results obtained showed that manual cutting took an average of 30 minutes and using a potato cutter that was made took an average of 20 minutes, with almost similar results in good condition. There was a slight difference in the quality of cutting manually and using a tool, namely cutting using a tool produced more uniform results. The operator's pulse was measured after the operator had worked for 1 hour and repeated 3 times. The measurement results obtained are presented in Table 2.

Table 2. Results of measuring the pulse rate of potato cutter operators

No	Manual cutting pulse rate (beats/min)	Cutting with tools pulse rate (beats/min)	Resting heart rate (beats/min)	
			Manual cutting	Cutting with tools
1	121.2	98.5	73.2	72.5
2	120.3	97.2	73.0	74.3
3	123.6	99.4	72.6	73.3
Average	121.7	98.4	72.9	73.4

From the results of the average pulse measurement of the operator, the pulse of the operator using the designed tool and the manual method produced almost the same pulse, so it can be concluded that the initial condition of the operator's pulse is the same. After cutting potatoes, the pulse of the potato cutter operator using the manual method was 121.7 beats/minute, while the operator using the designed tool showed a lower pulse rate of 98.4 beats/minute.

4.4 Discussion

Productivity. The work productivity of the designed potato cutting tool is calculated by considering the standard work time to cut 3 kg of potatoes compared to the work time of the designed tool to cut 3 kg of potatoes. The work productivity of the machine can be calculated using the formula:

$$Productivity = \frac{production\ capacity\ \times standard\ time}{produciton\ capacity\ \times time\ with\ tool} \times 100\% \quad (1)$$

$$Productivity = \frac{3\ kg\ \times 30\ minutes}{3\ kg\ \times 20\ minutes} \times 100\%$$

$$Productivity = \ 150\%$$

The use of a potato cutting tool designed to increase potato-cutting productivity by 150%.

Workload measurement. Workload measurement can be done with a physiological approach to measure physical workload. The physical approach is an approach in the field of Ergonomics that focuses on measuring the energy consumed, metabolic needs, body function performance, and its components in designing work (Iridiastadi & Yassierli, 2019; Sitohang et al., 2010; Purba & Jabbar Rambe, 2014). Evaluation of the physical load experienced by a worker can be done by measuring heart rate. This approach can be done considering that the harder a person's physical work, the harder the heart works, which is indicated by an increase in heart rate (Iridiastadi & Yassierli, 2019). Heart rate can be used to estimate a person's physical condition or degree of physical fitness (Iridiastadi & Yassierli, 2019); (Purbasari & Purnomo, 2019). Heart rate measurement is an objective and easy measurement to do. Measurement can be done by measuring the pulse (Purbasari & Purnomo, 2019). One method used to measure the pulse manually is felt according to the pulse on the radial artery in the wrist and using a stopwatch using the 10-beat method (Tarwaka & Bakri, 2004; Purbasari & Purnomo, 2019). Increasing the human body's pulse rate plays an important role in increasing cardiac output from rest to maximum work (Tarwaka & Bakri, 2004); (Purbasari & Purnomo, 2019; Iridiastadi & Yassierli, 2019; Sitohang et al., 2010). The assessment of the classification of indirect workload levels can be determined from the percentage of cardiovascular load (%CVL) (Tarwaka & Bakri, 2004; Purbasari & Purnomo, 2019; Purba & Jabbar Rambe, 2014; Wahyuni et al., 2018). The %CVL value is calculated from the workload classification level based on the increase in work heart rate compared to the maximum heart rate, with the formula:

$$\%CVL = \frac{100 \times (working\ heart\ rate - resting\ heart\ rate)}{(maximum\ heart\ rate - resting\ heart\ rate)} \quad (2)$$

Based on this formulation, the workload for potato-cutting operators using the manual method is as follows:

$$\%CVL = \frac{100\ \times (98.4 - 73.4)}{(220 - 73.4)}$$

$$\%CVL = 33.17\%$$

% CVL for operators using the tools designed are:

$$\%CVL = \frac{100 \times (121.7 - 72.9)}{(220 - 72.9)}$$

$$\%CVL = 17.05\%$$

Based on the % CVL classification where for % CVL below 30 there is no fatigue, for % CVL 30 - 60 improvements need to be made, 60 - 80 work in a short time, 80 - 100 immediate action is needed and above 100 are not allowed to be active. So for operators using the manual method with CVL reaching 33%, the operator needs to improve their work attitude, while the % CVL of operators using the designed tool shows that there is no fatigue after working for 1 hour with a CVL value reaching 17.05%. So using the potato cutter designed by the manufacturer, it can reduce the workload of the operator, this is following several other researchers who state that ergonomic tools can reduce subjective complaints and the workload of workers (Santosa & Yusuf, 2017).

5 Conclusion

Based on the research conducted, several conclusions can be drawn. First, the implementation of the newly designed potato-cutting tool has successfully increased work productivity by 150%. Additionally, the quality of the potato-cutting results remains high, both when using manual methods and with the aid of the tool, consistently producing good quality cuts. Furthermore, the workload of the operator was reduced after utilizing the designed potato-cutting tool, indicating its effectiveness in improving working conditions.

Acknowledgment

Gratitude is expressed to all parties who have helped carry out this research and this research still requires a lot of innovation so that a reliable and environmentally friendly electric vehicle battery cooling system can be realized.

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