SITEKIN: Journal of Science, Technology and Industry, Vol. 20, No. 2, June 2023, pp.485 - 492
ISSN 2407-0939 print/ISSN 2721-2041 online

DEVELOPMENT OF AN ERGONOMIC BANANA CHOPPING MACHINE WITH CONSIDERATION OF THE ANTHROPOMETRY OF INDONESIAN PEOPLE

Ariel Julianus Pical[1*], Yoel Fortunatus[2], Florencia Agatha Damayanti[3], Ravael Dimas Eka Narendra[4], Johan Patrick Tentua[5], Desrina Yusi Irawati[6]
[123456]Universitas Katolik Darma Cendika, Indonesia
arieljl02@gmail.com

ABSTRACT

Micro-and medium-sized enterprises are the axis of the economy, especially in Indonesia, and have an essential role in supporting the running of the national economy. With the rapid development of technology. Innovation is the primary key to improving a business so that it can compete even on an international scale. This study aims to design a banana chip chopper machine that considers ergonomic values, considering that there are still many banana chip chopper machines sold on the market without considering ergonomic values in the product. They are like the height of the machine, which is different from the average height of the Indonesian people. The chopping process is still manual, and it is challenging to create consistent quality pieces of chips because the slicing is still manual and must adjust to the size of the machine. It does not match the average height of Indonesians, where which can result in injury to the hands and muscles of the hands. Then the study results will show an ergonomic banana-chopping machine with a height and size that match the anthropometric data of Indonesian people.

Keywords : *Banana chopper machines, chips, ergonomics, anthropometry*

Introduction

MSMEs (Micro-small and medium-sized enterprises) are one of the strengths and axis of Indonesia's development; this is reflected in the economic crisis of 1998, where MSMEs were able to survive compared to other sectors [1]–[3]. Human resources in MSMEs are very reliable in completing several processes of production activities, which indirectly requires MSMEs' pioneers to create security, comfort, and health for their workforce. This resulted in the need for the application of ergonomics to production equipment. The application of ergonomics is expected to be able to provide an effective, comfortable, safe, and healthy work system, which can indirectly improve the quality of production and make MSMEs even more competitive [4]–[7]. The main object of this research is the banana chopper machine, which is often used by MSMEs to make banana chip products. MSMEs can also shorten their production time so that they can produce a lot of banana chips without having to waste a lot of resources [8]–[10].

The stages in the process of making banana chips consist of peeling, soaking, slicing, and packaging. This research focuses on machine-based banana slicing processes that still use human power. The chopping process is one of the key processes in determining product quality. In this process, workers are required to be able to chop quickly and produce a uniform thickness of slices. Here the problem is that the tool used is still traditional, namely traditional chopping. This certainly has many risks for workers.

Fig. 1. An image of an old banana chopper

Based on the results of the observations that have been made, it was found that the problems that occur in Figure 1 are related to manual and machine chopping, which still does not match the anthropometric size of Indonesians. carried out with the same movements and repeatedly with poor working posture, which in turn often results in musculoskeletal disorders, namely functional disorders of the muscles, joints, and spine that occur due to various variations of repetitive movements. In addition, bad work postures such as bending, sitting crosswise, squatting, kneeling, and other non-natural postures result in workers getting tired quickly, and the impact will reduce productivity. product quality, while workers are also required to be trained and thorough in chopping bananas so they don't break and are consistent because the chopper machine still uses manual choppers [11], [12].

This research is based on previous studies that aims to improve ergonomic posture in cassava chopping machines based on anthropometric data to reduce complaints. The results of the study with anthropometric data calculations show that business actors need to apply ergonomic principles to the machines they use. The conducted research by making a cassava cutter. According to the findings of his research, the cassava chopper machine that he created can produce efficiency in the transmission system from 1400 rpm to 180 rpm motor rotation. But the design has not paid attention to the concept of ergonomics [13]–[19].

Therefore, this research focuses on designing a banana chip chopper system that considers ergonomic aspects in the form of anthropometry of worker postures to reduce workload, and can improve the quality of the banana chips themselves. Ergonomics is derived from the Greek terms ergon (work) and nomos (rules), hence ergonomics generally refers to job-related rules. Numerous definitions of ergonomics have been provided by specialists in their respective professions, such as: Ergonomics is a "science" or multidisciplinary approach that tries to improve the human-work system in order to achieve tools, procedures, and a safe, healthy, comfortable, and productive work environment. Ergonomics is the study, art, and use of technology to harmonize or balance the facilities utilized for activity and rest with human capacities and limits, both physically and cognitively, in order to improve the overall quality of life [13], [20].

Anthropometry is the scientific study of the human body's dimensions [21]–[23]. These dimensions are broken down into statistical groups and percentile measurements. If one hundred people were lined up from smallest to largest, they would be classified as belonging to the 1st to 100th percentiles. This data on human dimensions is extremely useful for product design, as it enables the determination of product compatibility with the humans who will be using it. The use of anthropometric data seeks to adapt all tools to human abilities, as opposed to adapting humans to tools. A design that is highly compatible with the people who will use it is crucial for reducing the occurrence of hazards resulting from work errors caused by design flaws (design-induced errors). Here are the average anthropometric characteristics of Indonesians [24]–[28].

Table 1. Indonesian anthropometric data

Dimension	Description	50th (cm)
D1	Body height	152.58
D2	Eye height	142.22
D3	Shoulder height	126.79
D4	Elbow height	95.65
D5	hip height	87.3
D6	Bone height	66.51
D7	Fingertip height	60.39
D8	Height in a sitting position	78.1
D9	Eye level in a sitting position	67.89
D10	Shoulder height in a sitting position	54.89
D11	Thick elbows in a sitting position	24.65
D12	Thigh thickness	14.7
D13	knee length	49.9
D14	Popliteal length	39.88
D15	Knee High	48.12
D16	Popliteal height	40.07
D17	Shoulder width	38.75
D18	Top shoulder width	31.32
D19	Hip width	32.32
D20	Thick chest	19.22
D21	Thick belly	20.58
D22	Upper arm length	32.04
D23	Forearm length	40.53
D24	Fore arm length	

D25	Shoulder length, forward grip	66.18
D26	Head length	56.72
D27	Head Width	17.91
D28	Hand length	16.05
D29	Hand width	17.05
D30	leg length	9.43
D31	Leg Width	22.73
D32	Extend the arms to the sides.	9.14
D33	Elbow length	152.71
D34	Hand grip height in a standing position	79.88
D35	High grip in a sitting position	185.76
D36	Forward long hand grip	113.42
		64.51

Research Methods

The first phase of this research entails the observation of small and medium-sized enterprises (SMEs) operating in the banana chip business and the review of relevant literature about machine design, specifically the ergonomically designed banana chopper machine. Following this, data was collected on the engine frame. The following step involves incorporating anthropometric measurements into the design of the new machine. The findings of data processing serve as the basis for 3D models with sketch-ups and anthropometric tables that implement the ergonomics concept.

Results and Discussions

Data processing

Following the collection of anthropometric data, the size of the old banana chopper machine is modified to accommodate the anthropometry of Indonesians in order to create an ergonomic machine, i.e., a machine that is comfortable and safe to use, making work easier and increasing productivity (Hadi & Dahlan, 2017).

Table 1. Old Machine size

Parts on the machine	Machine size (cm)
Machine Width	33
Machine Length	40
Machine Height	45
Dynamo Length	10
Protective length	30
The length of the raw material place	9

The information above shows that the size of banana-chopping equipment currently available does not, in terms of machine width, length, and height, correspond to the average Indonesian's standard anthropometric measurements. As a result, ergonomics' core tenets—healthy, secure tools, procedures, and workspaces that are efficient and comfortable—have not been implemented.

Fig. 2. Old banana chopper machine

Implementation of ergonomics in machine design

Table 3- Machine antropometry

Parts of machine	Dimensions sign	50th	Machine size (cm)
Machine width			33 cm
Machine Length	Elbow span length (D32)	79.88 cm	40 cm
Machine height	Body Height (D1)	152.58 cm	145 cm
Dynamo length			10 cm
Raw material guard width			30 cm
Width entry of raw material			9 cm
Machine height from the bottom to the place of raw materials	Elbow height (D4)	95.65 cm	91 cm
Handle width	Hand width (D29)	9.43 cm	9 cm
Machine height to banana slice container	Hip height (D5)	87.3 cm	87 cm

It is clear from the data in the table above that the size of the banana chopper machine was altered and added to in accordance with anthropometric data or the typical posture of Indonesians in order to provide ergonomic guidelines for using the machine.

A. Machine width

The width of the machine, measured from the length of the dynamo to the protector, is 33 cm.

B. Machine length

The machine's length is determined by anthropometric data for elbow span length (D32), which is taken at the 50th percentile because 50% of the population is 50 years of age or older, and the machine is designed to adhere to this reference so that workers are comfortable operating this tool. From the results of these measurements, the size set is 40 cm for the length of the machine, so that it is neither longer nor shorter than the worker's elbow span.

C. Machine height

The height of the table on the banana chopper machine is calculated using height measurement data (D1) using the 50th percentile. This percentile of intended use for a large average worker can be compared to comfortable, so workers with a smaller average size can still use it. If you use the 95th percentile and then the worker with that small body, using the 50th percentile on such a large worker will be uncomfortable. (Taryat & Nurwathi, 2021). From the percentile calculation that was carried out, namely the 50th percentile, it was determined that the height of the machine from top to bottom was 145 cm and was not higher or lower than the average anthropometric data for Indonesian people's height.

D. Machine height to raw material entry point

The height of the machine to the entry point for raw materials here uses elbow height data (D4), which is 95.65 cm, so to adjust the worker's posture so that when entering raw materials to avoid a bent posture or not strapping the machine, the height of the machine from the bottom to the entry point for raw materials is 91 cm.

Fig. 3. Machine Height Overview

E. Handle width

The width of the handle here uses the reference for the width of the hand (D29), which is 9.43 cm from the percentile calculation of the anthropometric data set for the size of the lever handle, which is 9 cm

.

Fig. 4. Overview of machine handles

F. Machine height from bottom to banana slices

The height of the machine from the bottom to the banana slice container here uses hip height data (D5), which is 87.3 cm, so adjust the worker's posture so that when picking up the banana slices, avoid a hunched or unsteady body posture. So the height of the machine from the bottom to the banana slice container is 87 cm.

Fig. 5. Machine height measured from the bottom to accommodate banana slices

Machine Components

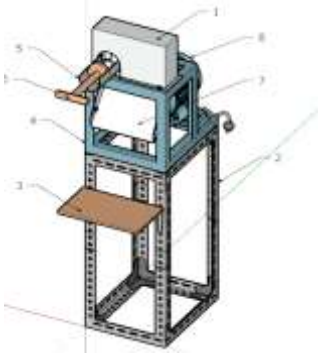

Fig.6. Machine Components

Description of machine components:

1. Raw material cover

Fig. 7. Raw material cover

The machine guard is rectangular in shape with a width of 30 cm. Machine protectors from bananas are also made with acrylic-based ingredients so that workers or MSMEs can easily wash them and control the cleanliness of the machine guards.

2. Machine legs

Fig. 8. Machine foot

The legs of the machine are made based on Indonesian anthropometry so that they are comfortable while doing work and avoid bad posture. The legs of the machine have a height of 100 cm.

3. Place the container for the banana slices

Fig. 9. Place the container for the banana slices

The banana slice container holder is used to place the container over the banana slices. So the workers only need to put the container under the machine, and the results of the disposal of the banana slices have been allocated directly to the container. The position of this holder also refers to the anthropometry of the waist height of Indonesians, with a height of 87 cm when measured from the bottom to the seat.

4. Machine frame

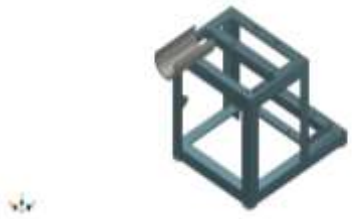

Fig. 10. Machine frame

The machine frame is square in shape with a size of 30x40x45 because the height of the machine itself is not yet ergonomic, so machine legs are added.

5. Handle & place of entry of raw materials

The machine handle aims to push the raw material into the banana slice knife through the raw material path that has been provided. The handle itself also refers to the anthropometry of the width of the Indonesian people's hands, so if it is measured, it is 9 cm wide. And the height of the machine from the bottom to where the handle itself is ergonomic with reference to anthropometric data is the elbow height of Indonesians, with a height of 91 cm.

6. Machine knife

Fig. 11. Machine knife

This machine knife has four blades with a diameter of 30 cm. These three blades are made to speed up cutting, so the time needed to cut is faster.

7. Line out banana slices

The chopped bananas will go in here and right into the pan. The place where the bananas come out is made so that the sliced bananas do not get messy.

8. Dynamo

Dinamo is a familiar tool in life; this dynamo is used as a driving machine. The motor used has a middle RPM specification, namely a mid-rotational power of 1500 Rpm.

How the Machine Works

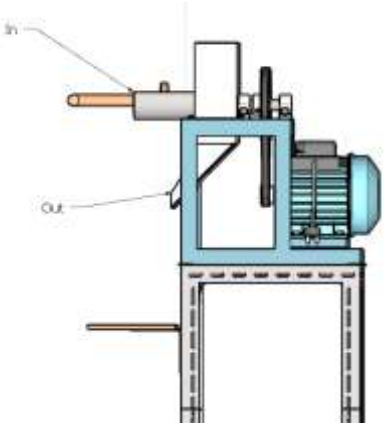

Fig. 12. How the machine works

The way this banana chopper machine works is that the knife rotates and the raw materials, or bananas, approach the knife. This knife rotation is generated by the dynamo. The blade rotation speed is affected by how fast the electric motor rotates.

Conclusion

The body dimensions used to design an ergonomic cassava machine are as follows elbow span length (D32), body height (D1), elbow height (D4), hand width (D29), and hip height (D5). The author's proposed design for the banana chopper machine has the following dimensions:

a. Data reference elbow span length. The machine has a length of 40 cm.
b. Based on height anthropometry, the total machine height is 145 cm.
c. Raw material entry point with a height of 91 cm from the bottom to the raw material entry point based on elbow height data.
d. A handle width of 9 cm based on hand width data.
e. Based on hip height data, a banana-slice container seat with a height of 87 cm.

References

[1] A. A. Fauzi and M. L. Sheng, “The digitalization of micro, small, and medium-sized enterprises (MSMEs): An institutional theory perspective,” *J. Small Bus. Manag.*, vol. 60, no. 6, pp. 1288–1313, 2022, doi: 10.1080/00472778.2020.1745536.
[2] J. Vásquez, S. Aguirre, E. Puertas, G. Bruno, P. C. Priarone, and L. Settineri, “A sustainability maturity

model for micro, small and medium-sized enterprises (MSMEs) based on a data analytics evaluation approach," *J. Clean. Prod.*, vol. 311, no. May, 2021, doi: 10.1016/j.jclepro.2021.127692.

[3] D. HANGGRAENI and T. SINAMO, "Quality of Entrepreneurship and Micro-, Small-and Medium-sized Enterprises' (MSMEs) Financial Performance in Indonesia*," *J. Asian Financ. Econ. Bus.*, vol. 8, no. 4, pp. 897–907, 2021, doi: 10.13106/jafeb.2021.vol8.no4.0897.

[4] S. Shinozaki and L. N. Rao, *ADBI Working Paper Series COVID-19 IMPACT ON MICRO, SMALL, AND MEDIUM-SIZED ENTERPRISES UNDER THE LOCKDOWN: EVIDENCE FROM A RAPID SURVEY IN THE PHILIPPINES Asian Development Bank Institute*, no. 1216. 2020. [Online]. Available: https://www.adb.org/publications/covid-19-impact-msme-under-lockdown-evidence-rapid-

[5] Y. Amornkitvikai, S. Y. Tham, C. Harvie, and W. W. Buachoom, "Barriers and Factors Affecting the E-Commerce Sustainability of Thai Micro-, Small- and Medium-Sized Enterprises (MSMEs)," *Sustain.*, vol. 14, no. 14, pp. 1–28, 2022, doi: 10.3390/su14148476.

[6] R. Rupeika-Apoga and K. Petrovska, "Barriers to Sustainable Digital Transformation in Micro-, Small-, and Medium-Sized Enterprises," *Sustain.*, vol. 14, no. 20, 2022, doi: 10.3390/su142013558.

[7] K. Z. Sahela, R. Susanti, and A. R. Adjie, "The Influence of Government Dimension on Financial Education and Empowerment of Micro-, Smalland Medium-Sized Enterprises in Indonesia," *J. Asian Financ. Econ. Bus.*, vol. 8, no. 3, pp. 637–643, 2021, doi: 10.13106/jafeb.2021.vol8.no3.0637.

[8] S. Sulaeman, "A conceptual and empirical study on the development of the Islamic donation-based crowdfunding platform model for micro small and medium-sized enterprises (MSMEs) in times of Covid-19 pandemic in Indonesia," *Asian J. Islam. Manag.*, vol. 2, no. 2, pp. 107–122, 2020, doi: 10.20885/ajim.vol2.iss2.art4.

[9] N. T. P. Sari and A. Kusumawati, "Literature Review : The Efforts To Strengthening of Micro, Small and Medium-Sized Enterprises (MSME) in Indonesia," *Asian J. Manag. Entrep. Soc. Sci.*, vol. 2, no. 01 SE-Articles, pp. 98–115, 2022, [Online]. Available: https://ajmesc.com/index.php/ajmesc/article/view/52

[10] C. Harvie, "Trade Logistics in Landlocked and Resource Cursed Asian Countries," *Trade Logist. Landlocked Resour. Cursed Asian Ctries.*, pp. 155–174, 2019, doi: 10.1007/978-981-13-6814-1.

[11] L. Benos, D. Tsaopoulos, and D. Bochtis, "A review on ergonomics in agriculture. part II: Mechanized operations," *Appl. Sci.*, vol. 10, no. 10, 2020, doi: 10.3390/app10103484.

[12] B. D. Lowe, P. G. Dempsey, and E. M. Jones, "Ergonomics assessment methods used by ergonomics professionals," *Appl. Ergon.*, vol. 81, no. June, p. 102882, 2019, doi: 10.1016/j.apergo.2019.102882.

[13] T. A. M. De Macêdo *et al.*, "Ergonomics and telework: A systematic review," *Work*, vol. 66, no. 4, pp. 777–788, 2020, doi: 10.3233/WOR-203224.

[14] M. S. Bakhtiar Choudhary, A. B. Choudary, S. Jamal, R. Kumar, and S. Jamal, "The Impact of Ergonomics on Children Studying Online During COVID-19 Lockdown," *J. Adv. Sport. Phys. Educ.*, vol. 3, no. 8, pp. 117–120, 2020, doi: 10.36348/jaspe.2020.v03i08.001.

[15] E. Stefana, F. Marciano, D. Rossi, P. Cocca, and G. Tomasoni, "Wearable devices for ergonomics: A systematic literature review," *Sensors (Switzerland)*, vol. 21, no. 3, pp. 1–24, 2021, doi: 10.3390/s21030777.

[16] A. Reiman, J. Kaivo-oja, E. Parviainen, E. P. Takala, and T. Lauraeus, "Human factors and ergonomics in manufacturing in the industry 4.0 context – A scoping review," *Technol. Soc.*, vol. 65, no. March, 2021, doi: 10.1016/j.techsoc.2021.101572.

[17] L. Gualtieri, E. Rauch, and R. Vidoni, "Emerging research fields in safety and ergonomics in industrial collaborative robotics: A systematic literature review," *Robot. Comput. Integr. Manuf.*, vol. 67, no. May 2020, p. 101998, 2021, doi: 10.1016/j.rcim.2020.101998.

[18] F. Caputo, A. Greco, M. Fera, and R. Macchiaroli, "Digital twins to enhance the integration of ergonomics in the workplace design," *Int. J. Ind. Ergon.*, vol. 71, no. February, pp. 20–31, 2019, doi: 10.1016/j.ergon.2019.02.001.

[19] B. A. Kadir, O. Broberg, and C. S. da Conceição, "Current research and future perspectives on human factors and ergonomics in Industry 4.0," *Comput. Ind. Eng.*, vol. 137, p. 106004, 2019, doi: 10.1016/j.cie.2019.106004.

[20] M. Soltaninejad, A. Babaei-Pouya, M. Poursadeqiyan, and M. F. Arefi, "Ergonomics factors influencing school education during the COVID-19 pandemic: A literature review," *Work*, vol. 68, no. 1, pp. 69–75, 2021, doi: 10.3233/WOR-203355.

[21] M. S. Parvez, A. Rahman, and N. Tasnim, "Ergonomic mismatch between students anthropometry and university classroom furniture," *Theor. Issues Ergon. Sci.*, vol. 20, no. 5, pp. 603–631, 2019, doi: 10.1080/1463922X.2019.1617909.

[22] W. L. Wang, S. Liang, F. L. Zhu, J. Q. Liu, X. M. Chen, and G. Y. Cai, "Association of the malnutrition-inflammation score with anthropometry and body composition measurements in patients with chronic kidney disease," *Ann. Palliat. Med.*, vol. 8, no. 5, pp. 596–603, 2019, doi: 10.21037/apm.2019.10.12.