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Design of an Ergonomic Dumpling Skin Cutting Tool Using an Anthropometric Approach: A Case Study at Rizky Jaya SMEs

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ABSTRACT

The dumpling skin production process at UMKM Rizky Jaya currently faces significant operational challenges, specifically a production bottleneck at the manual cutting station. While noodle production has been automated, dumpling skin cutting relies on manual labor using conventional knives, requiring 7 minutes per 8.5 kg batch. This inefficiency results in physical fatigue for the 26 workers, inconsistent product dimensions, and significant lost sales during peak demand periods where orders reach up to 498 kg/day. This research focuses on the ergonomic design of a dumpling skin cutting tool based on anthropometric measurements to enhance productivity and worker comfort. Data collection involved measuring specific physical dimensions of five operators to ensure the tool's geometric compatibility with the human body. The primary variables analyzed include shoulder height (average 143.4 cm), standing waist height (average 99.8 cm), and functional forward arm reach (average 77.0 cm). Statistical processing, including data adequacy and uniformity tests, was conducted to establish the 5th percentile as a design limit. The proposed design features a 70 cm high compact frame with a 50x70 cm cutting area, integrating a 5V laser line for visual precision and a neodymium magnet socket system for rapid blade replacement. By aligning the tool dimensions with the 5th percentile reach of 71.18 cm, the design ensures that all operators can function within a normal reach area, thereby minimizing the risk of Low Back Pain and shoulder fatigue. Implementation is projected to reduce cycle times from 7 minutes to under 4 minutes, effectively eliminating the current bottleneck.

1. Introduction

The Production processes serve as the most vital element in the economic chain, closely linked to distribution and consumption. The success of an industry, particularly Small and Medium Enterprises (SMEs), depends heavily on operational efficiency across all production lines. However, SMEs often face technological constraints that hinder the fulfillment of market targets. This issue is evidently experienced by UMKM Rizky Jaya, a dumpling skin producer in Gresik, where a significant imbalance exists between the capacity of the flattening machine and the cutting process, which is still performed manually [1].

The operational sustainability of SMEs is highly influenced by the ability of production systems to adapt to market demand fluctuations while maintaining efficiency and product quality. In many traditional food-processing SMEs, production activities are still dominated by manual work systems that rely heavily on operator skills and physical endurance. Although manual systems are relatively inexpensive to implement, they often create operational inefficiencies due to inconsistent processing times, limited production capacity, and high dependency on worker performance. As production demand increases, these limitations can directly affect the ability of SMEs to compete in increasingly dynamic markets.

In the food-processing SME sector, production bottlenecks frequently occur due to the continued reliance on manual operations in critical workstations. Manual production systems not only reduce operational efficiency, but also increase worker fatigue, product inconsistency, and the risk of musculoskeletal disorders caused by repetitive movements and awkward postures. Previous studies have shown that ergonomic intervention through anthropometric-based product design can significantly improve productivity, operator comfort, and work safety in small-scale manufacturing environments [2], [3].

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Nevertheless, many SMEs still lack the implementation of ergonomic tools that are specifically adapted to operator body dimensions and operational requirements.

From an ergonomics perspective, the mismatch between work facilities and operator body dimensions can force workers to adopt awkward postures and excessive repetitive movements during operational activities. Over time, these conditions may increase physical fatigue, reduce work performance, and contribute to work-related musculoskeletal disorders (MSDs). Therefore, the implementation of anthropometric principles in product and workstation design becomes important to ensure compatibility between the worker and the work system. Ergonomic tool design not only improves operator safety and comfort, but also supports higher productivity and operational consistency in manufacturing activities.

Based on historical demand data over a one-year period (April 2025 – March 2026), there are sharp fluctuations in demand, especially during holidays and long vacations. This data is summarized in Table 1 and Table 2 in below.

Table 1
Unused Production April 2025 – September 2025

Years-Month	Total Demand (kg)	Average Demand (kg/day)	Peak Daily Demand (kg)
25-Apr	9,150 kg	305 kg	485 kg
25-May	4,805 kg	155 kg	320 kg
25-Jun	8,850 kg	295 kg	492 kg
25-Jul	4,185 kg	135 kg	280 kg
25-Aug	4,650 kg	150 kg	310 kg
25-Sep	5,250 kg	175 kg	340 kg

Table 2
Unused Production October 2025 - March 2026

Years-Month	Total Demand (kg)	Average Demand (kg/day)	Peak Daily Demand (kg)
25-Oct	4,340 kg	140 kg	275 kg
25-Nov	6,300 kg	210 kg	420 kg
25-Dec	8,680 kg	280 kg	495 kg
26-Jan	4,650 kg	150 kg	350 kg
26-Feb	8,960 kg	320 kg	490 kg
26-Mar	9,610 kg	310 kg	498 kg

During peak months, such as March 2026, demand surges to 498 kg/day, while the maximum production capacity only reaches approximately 400 kg/day [1]. This results in lost sales. Further analysis through the Operation Process Chart (OPC) reveals a significant bottleneck. In a single production batch (8.5 kg), the automated noodle-cutting process takes only 3 minutes, whereas manual dumpling skin cutting with a knife takes 7 minutes [1]. This 4-minute time difference per batch is the primary cause of low productivity.

In addition to productivity issues, the current manual cutting activity also creates ergonomic problems for workers. Operators are required to perform repetitive cutting movements continuously while maintaining a bent posture and excessive shoulder movement during the cutting process. These working conditions potentially increase physical fatigue and the risk of work-related musculoskeletal disorders (MSDs), especially lower back pain and shoulder muscle strain [3], [7]. Therefore, improving the cutting workstation is not only important from the productivity perspective, but also from the occupational health and ergonomics perspective.

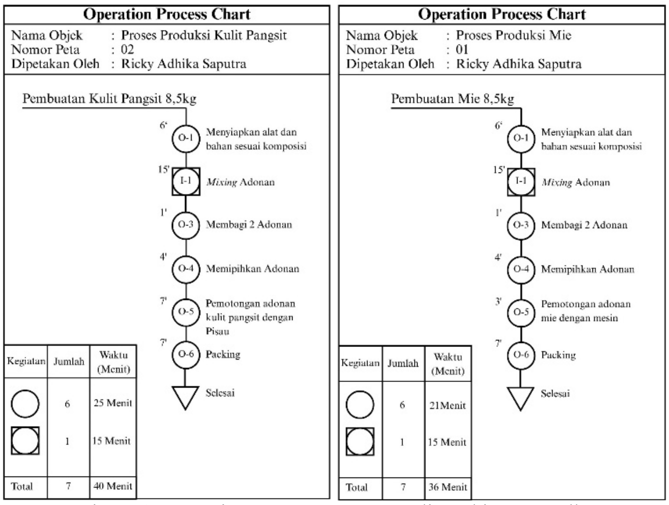

Figure 1 Operation Process Map Dumpling Skin & Noodle

To resolve this issue, an ergonomic cutting tool design is required. The use of an anthropometric approach is crucial as it focuses on the study of human body measurements to ensure alignment between tool dimensions and the operator's physical capacity [2]. This aims to create comfortable working conditions and minimize the risk of muscle injury due to unnatural working postures [3]. In the development process, a rational design method can be applied to translate user needs into structured technical specifications [4]. By integrating features such as an adjuster, laser line, and return spring mechanism, this tool is expected to reduce worker physical fatigue while significantly increasing production cycle time efficiency.

Several previous studies have discussed the application of ergonomics and anthropometric approaches in tool design for SMEs, such as the design of sand smoothing tools [5], styrofoam cutting tools [4], and ergonomic dimsum skin printing tools [2]. However, research specifically focusing on dumpling skin cutting tools integrated with anthropometric dimensions, precision support systems, and adaptive mechanical features remains limited. Therefore, this study offers novelty through the development of an ergonomic dumpling skin cutting tool equipped with a laser-line guide system, adjustable cutting mechanism, return spring system, and magnetic blade socket, all designed based on operator anthropometric measurements.

The novelty of this research does not solely rely on combining mechanical features but on integrating anthropometric-based ergonomic principles with adaptive cutting mechanisms into a unified design framework for SME production environments. Unlike previous studies that mainly focused on general ergonomic tool improvements, this study systematically translates operator body dimensions into functional engineering specifications that simultaneously address ergonomic risks, accessibility requirements, and production efficiency.

The contributions of this study can be summarized as follows:

1. Theoretical contribution: extending the application of anthropometric ergonomics in SME production tool design.

2. Methodological contribution: integrating anthropometric measurements with adaptive mechanical features in ergonomic design.
3. Practical contribution: providing an ergonomic cutting solution for reducing operational bottlenecks in food-processing SMEs.

The theoretical contribution of this study lies in extending the application of anthropometric ergonomic principles within SME production systems by demonstrating how operator body dimensions can be systematically transformed into engineering design parameters. This approach supports the relationship between ergonomic theory and practical workstation design implementation. This study aims to design and develop an ergonomic dumpling skin cutting tool using an anthropometric approach to reduce production bottlenecks, improve operator comfort, minimize physical fatigue, and increase production productivity at UMKM Rizky Jaya.

2. Research methods

The research method used is a case study based on the phenomena that occurred in the field, namely UMKM Rizky Jaya, including field observations, anthropometric data collection, ergonomic design analysis, and prototype testing [2]. The research began by observing the production constraints and conducting direct observations in the field at UMKM Rizky Jaya, Gresik. This study aims to design an ergonomic dumpling skin cutting tool using an anthropometric approach to increase operator comfort and production productivity [2], 5].

The anthropometric parameters considered are standing shoulder height, standing waist height, and forward arm reach, which are analyzed using statistical measures such as mean, standard deviation, and percentile[5] , [6]. These measurements are essential to ensure the tool's dimensions align with the physical capacity of the operators to reduce physical fatigue [6], 9]. The following Figure 2 displays the flowchart in this study, illustrating thesystematic stages from data collection to the final evaluation of the prototype [2].

2.1 Problem Identification

A comprehensive field study conducted at the Rizky Jaya MSME production facility in Gresik specifically addressed operational constraints in the dumpling skin production line. Observations and evaluations focused on the cutting location, where the dough portioning process still relies heavily on manual labor using conventional knives. This work system forces operators to perform highly repetitive movements and maintain unnatural (awkward) postures for extended periods. This condition triggers significant time inefficiencies, with manual cutting requiring up to 7 minutes to complete a single 8.5 kg batch of dough [1]. This directly creates a production bottleneck when compared to an automated noodle cutting line that only requires 3 minutes for the same dough capacity [1]. Furthermore, this repetitive physical workload, disproportionate to the operator's baseline capacity, causes significant physical fatigue [2]. This persistently maintained poor working posture directly increases the risk of musculoskeletal disorders in workers, particularly triggering lower back pain and chronic fatigue in the shoulder muscles [7].

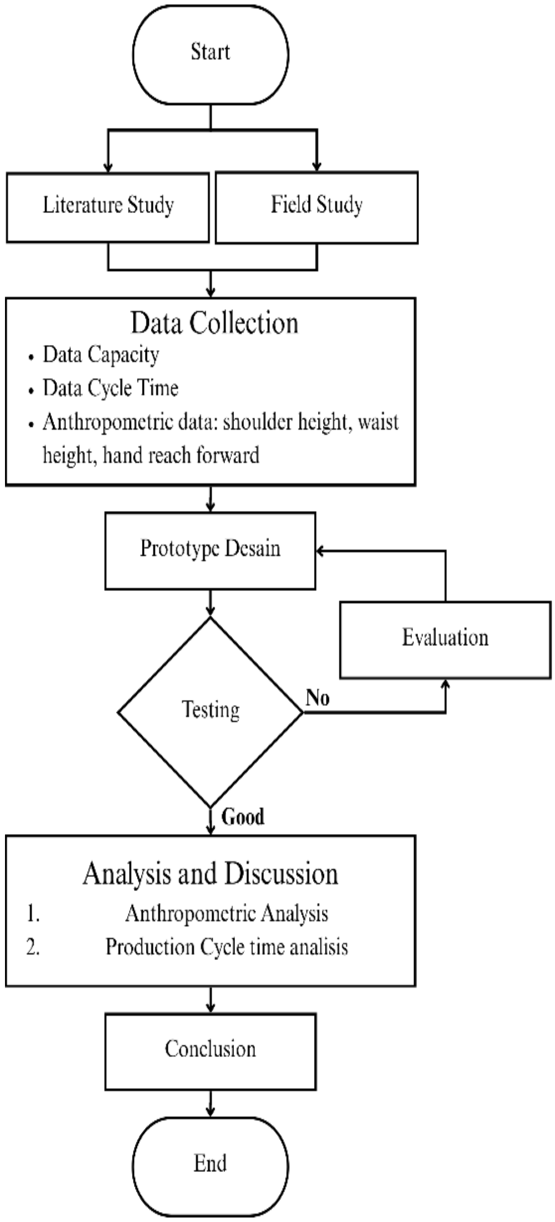

Figure 2 Research Stages

2.2 Data Collection

To ensure the dumpling skin cutting tool design aligns with the physical capacity of its users, primary data collection in this study focused exclusively on anthropometric dimension measurements. This approach is crucial for creating an ergonomic workstation and minimizing the risk of physical fatigue in workers [4], [7]. Data was collected directly from five operators who interact daily at the Rizky Jaya MSME manual cutting station. The specific physical body dimensions measured included three main variables: standing shoulder height, standing waist height, and arm reach.

These three variables were selected based on their direct relationship with operator posture and operational interaction with the proposed tool. Standing shoulder height was selected to determine the lever height and avoid excessive shoulder elevation during repetitive movements. Standing waist height was used to determine workstation height and maintain upright posture during operation. Forward hand reach was selected to determine the operational reach area and prevent excessive stretching during repetitive cutting activities, ensuring the designed tool can be operated comfortably, safely, and efficiently without straining the operator's muscles [6], [8].

2.3 Basic Concepts and Calculations of Anthropometrics

T Anthropometrics is a branch of ergonomics that focuses on measuring the physical dimensions of the human body, including linear dimensions, volume, reach, speed, and characteristics of functional body movements [9]. Anthropometric studies are applied to ensure that designed work facilities or assistive devices are aligned (fit) with the physical capacities of their users [2], [8]. The collected anthropometric data is transformed into functional design parameters, enabling the equipment to be operated easily, safely, and comfortably by the operator [6], [10]. The distribution of anthropometric data is applied to the design through percentile calculations to accommodate the wide variety of user body sizes. Details of the standard percentile multipliers used can be seen in Table 3..

Table 3
Percentile Value

Persentil (th)	Perhitungan (Calculation)
1-st	$\bar{x} - 2.325\sigma_x$
2.5-th	$\bar{x} - 1.960\sigma_x$
5-th	$\bar{x} - 1.645\sigma_x$
10-th	$\bar{x} - 1.280\sigma_x$
50-th	$\bar{x}$
90-th	$\bar{x} + 1.280\sigma_x$
95-th	$\bar{x} + 1.645\sigma_x$
97.5-th	$\bar{x} + 1.960\sigma_x$
99-th	$\bar{x} + 2.325\sigma_x$

Methodologically, the steps for processing anthropometric data and calculating percentiles are carried out through the following systematic stages:

a. Data Identification: Identifying and collecting anthropometric data from relevant operator body parts that will interact directly with the planned tool design.
b. Statistical Analysis: Performing basic statistical analysis on the collected data by calculating the average (mean) and standard deviation, as well as conducting data adequacy and homogeneity tests to ensure sample validity. The equation used is:

Average:

$$\bar{X} = \frac{\sum X}{N} \tag{1}$$

Standard Deviation (SD):

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{N - 1}} \tag{2}$$

Data Sufficiency Test (N'):

$$N' = \left[\frac{\frac{k}{s}\sqrt{N\sum x^2 - (\sum x)^2}}{\sum x}\right]^2 \tag{3}$$

Data Uniformity Test (Upper and Lower Control Limits):

$$BKA = \bar{x} + k \cdot \tag{4}$$

$$BKB = \bar{x} - k \cdot \tag{5}$$

c. Design Dimensioning: Ensuring that the design dimensions of the device accommodate individuals with extreme body sizes. Once the target population percentile (e.g., the 5th percentile) is calculated based on tested data, that size is established as the final reference for functional limits in the product specification engineering.

2.4 Product Design

Equality Conceptually, product design is a set of procedures, techniques, and instruments comprehensively implemented by designers in transforming ideas into a physical prototype or technical solution [8]. In the product development literature, there are two main approaches commonly used in executing the product design process [10], [11]:

a. Creative Method: This approach is specifically aimed at stimulating the designer's creativity [10]. Its goal is to break down mental barriers to operational innovation, thereby encouraging the emergence of radical ideas and expanding the spectrum of alternative mechanical solutions that can potentially be implemented.
b. Rational Method: In contrast to the more free-form creative method, the rational method applies a procedural and systematic approach based on the analysis of factual data (such as user complaints and anthropometric data) [11]. Although both methods target the birth of innovation, the rational method prioritizes a structured workflow from the identification of initial parameters to the formulation of final technical specifications [11].

Design and Evaluation Activities Every engineering process must be strictly guided by a comprehensive description of product characteristics [14]. This specification description includes not only the selection of physical dimensions, but also the determination of material types, electrical components, working mechanisms, and other structural elements [8], [10]. A crucial stage in the design activity is the evaluation process (design evaluation). The main objective of the evaluation is to test and assess the feasibility of the design proposal (prototype) before the final approval decision is issued towards the mass manufacturing stage. In the early phase of prototyping, designers are generally faced with complex functional problems and parameters that have not been precisely defined. This condition requires designers to navigate two fundamental engineering challenges: first, dissecting and understanding the root causes of operational problems holistically (such as production bottleneck issues); and second, formulating appropriate technological solutions that are effective, economical, and ergonomic.

3. Results and Discussion

3.1 Anthropometric Data

Anthropometric data was collected to ensure that the dumpling skin cutting tool's geometric design matched the operator's physical characteristics, thus creating ergonomic and safe working conditions. Measurements were conducted directly on five workers working at the manual cutting station of the Rizky Jaya MSME. Data collection focused on the three functional body dimensions most relevant to the operational interaction of the tool. A summary of the physical dimension measurements of the five respondents is presented in Table 4 below:

Table 4
Anthropometric Data

No	Attribute	Respondent					Average
		1	2	3	4	5	
1	Shoulder Height	143	140	149	145	140	143.4
2	Waist Height	101	96	100	103	99	99.8
3	Forward Hand Reach	75	74	77	83	76	77

Based on Table 4 above, the collected data has specific technical uses in determining the design specifications of the tool, namely:

a. Shoulder Height (Average 143.4 cm): This dimension is used as a reference parameter to determine the maximum position point of the pressure lever. Adjustment of this height limit is crucial so that the operator does not need to lift the shoulder excessively (shoulder elevation) when pressing the lever, thus effectively preventing premature fatigue in the trapezius muscle.
b. Waist Height (Average 99.8 cm): This dimension is applied as a basis for determining the elevation of the base or cutting table. Alignment of the height of the tool frame with the worker's waist height is projected to ensure that the back posture remains upright during the operational process, in order to minimize the risk of lower back injury (Low Back Pain) due to repetitive bending positions.
c. Forward Hand Reach (Average 77.0 cm): This reach dimension is used to calibrate the placement distance of the adjuster system (blade slider) along with the cutting area limit on the work table. By making this dimension a design limitation, all the tool's drive mechanisms are ensured to remain within the normal reach area, so that workers can operate without having to stretch their arms or bend their bodies extremely.

3.2 Anthropometric Data Testing

The statistical data testing phase was conducted systematically to validate the appropriateness of the collected samples. This evaluation had two purposes: first, to ensure that the sample size was sufficient to represent the entire worker population (data adequacy test); and second, to verify that the data distribution was uniform, with no extreme values or outliers deviating from reasonable control limits (data uniformity test). As the initial step in this series of statistical evaluations, the testing focused specifically on the first anthropometric variable, namely the Shoulder Height dimension.

1) Shoulder Height

a. Shoulder Height Data Adequacy Test : The data adequacy test uses a 95% confidence level and an index (k) of 2, so the accuracy level value (S) is 0.05. The calculation of the N' value is as follows:

$$N' = \left[\frac{\frac{2}{0,05}\sqrt{5(102875) - (717)^2}}{717}\right]^2 = 0,89 \quad (6)$$

From the calculation above, it can be concluded that the value of $N' < N$ $(0.89 < 5)$, which means that the shoulder height sample data used is adequate and sufficient to represent the population.

b. Shoulder Height Data Uniformity Test : A data uniformity test is performed to determine whether any data falls outside the control limits. The Upper Control Limit (UCL) and Lower Control Limit (LCL) are calculated using a mean value $(\bar{x})$ of 143.4 and a standard deviation (σ) of 3.78:

$$BKA = \bar{x} + k \cdot \sigma = 143,4 + (2 \times 3,78) = 150,96 \quad (7)$$

$$BKB = \bar{x} - k \cdot \sigma = 143,4 - (2 \times 3,78) = 135,84 \quad (8)$$

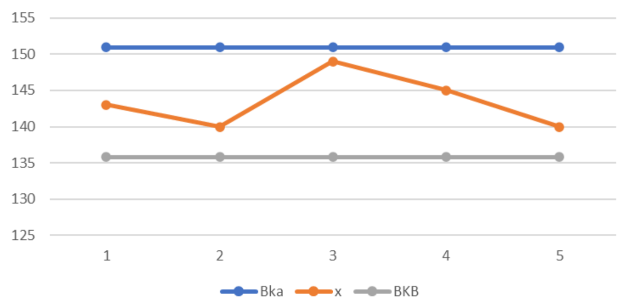

Figure 3 Control Limits Shoulder Height

Figure 3 shows a graph of the results of the uniformity test for shoulder height data, which is indicated by the absence of data outside the BKA (150.96) and BKB (135.84) limits.

2) Waist Height

a. Waist Height Data Adequacy Test
The data adequacy test uses a 95% confidence level and an index (k) of 2, so the accuracy level value (S) is 0.05. The calculation of the N' value is as follows:

$$N' = \left[\frac{\frac{2}{0,05}\sqrt{5(49827) - (499)^2}}{499}\right]^2 = 0,86 \quad (9)$$

From the calculation above, it can be concluded that the value of $N' < N$ (0.86 $<$ 5) which means that the waist height sample data collected is sufficient to represent the existing population.

b. Waist Height Data Uniformity Test
Data uniformity tests were performed to verify that the data were within reasonable control limits. The calculation of the Upper Control Limit (UCL) and Lower Control Limit (LCL) used a mean value ($\bar{x}$) of 99.8 cm and a standard deviation (σ) of 2.59:

$$BKA = \bar{x} + k \cdot \sigma = 99{,}8 + (2 \times 2{,}59) = 104{,}98 \quad (10)$$

$$BKB = \bar{x} - k \cdot \sigma = 99{,}8 - (2 \times 2{,}59) = 94{,}62 \quad (11)$$

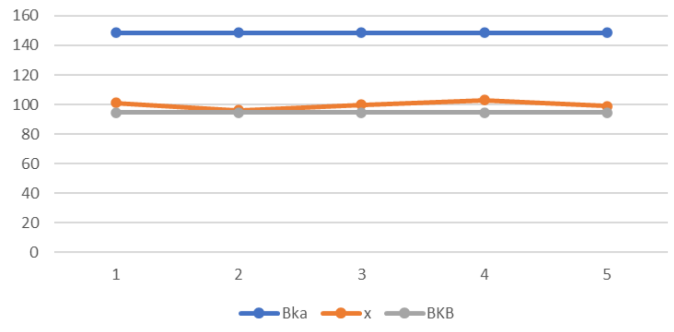

Figure 4 Control Limits Waist Height

Figure 4 shows a graph of the results of the uniformity test for waist height data, which is indicated by all observation data not being outside the BKA (104.98) and BKB (94.62) limits.

3) Forward Hand Reach

a. Forward Hand Reach Data Adequacy Test
The data adequacy test uses a 95% confidence level and an index (k) of 2, so the accuracy level value (S) is 0.05. The calculation of the N' value is as follows:

$$N' = \left[\frac{\frac{2}{0{,}05}\sqrt{5(29695) - (385)^2}}{385}\right]^2 = 2{,}70 \quad (12)$$

From the calculation above, it can be concluded that the value of $N' < N$ (2.70 $<$ 5), which means that the forward hand reach sample data collected is sufficient to represent the existing population.

b. Forward Hand Reach Data Uniformity Test
Data uniformity tests were performed to verify that the data were within reasonable control limits. The calculation of the Upper Control Limit (UCL) and Lower Control Limit (LCL) used a mean value ($\bar{x}$) of 77.0 cm and a standard deviation (σ) of 3.54:

$$BKA = \bar{x} + k \cdot \sigma = 77{,}0 + (2 \times 3{,}54) = 84{,}08 \quad (13)$$

$$BKB = \bar{x} - k \cdot \sigma = 77{,}0 - (2 \times 3{,}54) = 69{,}92 \quad (14)$$

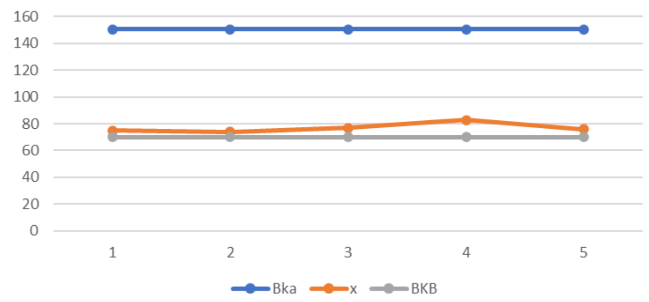

Figure 5 Control Limits Forward Hand Reach

Figure 5 shows a graph of the results of the uniformity test for the forward hand reach data, which is shown by all the observation data not being outside the BKA (84.08) and BKB (69.92) limits.

3.3 Percentile Calculation

After all anthropometric data collected through field observations were proven valid—by being declared to have met the statistical adequacy and uniformity tests—the next crucial stage in this product's engineering was determining the percentile values. In ergonomic studies, percentiles are quantitative measurement tools that group the distribution of the physical dimensions of the worker population, which will later be translated into geometric parameters in the tool specifications. In the design of this dumpling skin cutting tool prototype, functional parameters were determined using the 5th percentile limit reference (P5). The selection of this percentile point was not done randomly, but rather strictly based on the ergonomic principle of design for extreme individuals (designing for individuals with extreme sizes). Specifically, this design targets the smallest physical dimension limit of the operator population. The fundamental logic behind selecting P5 emphasizes aspects of ensuring accessibility and reach limits [14]. The philosophy is: if the layout, height, and depth of the work aids are designed in such a way that they can be reached and operated safely and comfortably by operators with the smallest physical body dimensions (represented by the 5th percentile), then it can be ensured that operators with larger physical dimensions (such as the 50th or 95th percentile) will also be able to operate them freely. This approach will proactively prevent awkward postures, such as excessive muscle stretching or the obligation to stand on tiptoes while working. Mathematically, the determination of the 5th percentile limit is calculated by extracting the sample mean value ($\bar{x}$).

which is then subtracted by the product of the standard deviation (σ_x) and the standard normal distribution multiplier for the 5% percentile, which is 1.645. Therefore, the statistical formulation used is: $P_5 = \bar{x} - 1.645\sigma_x$Based on the theoretical basis and formulation, a detailed description of the descriptive and functional calculations for each body dimension (Shoulder Height, Waist Height, and Forward Hand Reach) is described as follows:

a. Shoulder Height
This data is used as the upper limit of the maximum lever reach reference, to ensure the operator does not have to lift the shoulder too high (shoulder elevation), which can trigger trapezius muscle fatigue.

$Mean(\bar{x})$: 143.4cm
$Standard\ Deviation\ (\sigma)$: 3.78 cm
$Calculationof\ P_5$:

$$P_5 = 143{,}4 - (1{,}645 \times 3{,}78)$$

$$P_5 = 143{,}4 - 6{,}22$$

$$P_5 = 137{,}18 \text{ cm} \tag{15}$$

b. Waist Height
This data is used as a reference for the height of the main frame or the position of the cutting base to ensure that the operator's back remains in an upright posture while working.
$Mean(\bar{x})$: 99,8 cm
$Standard\ Deviation\ (\sigma)$: 2,59 cm
$Calculationof\ P_5$:

$$P_5 = 99{,}8 - (1{,}645 \times 2{,}59)$$

$$P_5 = 99{,}8 - 4{,}26$$

$$P_5 = 95{,}54 \text{ cm} \tag{16}$$

c. Forward Hand Reach
This data is used to determine the maximum width of the cutting area and the placement of the adjuster system, so that the furthest point of the tool remains within normal reach and prevents the operator from bending excessively.
$Mean(\bar{x})$: 77,0 cm
$Standard\ Deviation\ (\sigma)$: 3,54 cm
$Calculationof\ P_5$:

$$P_5 = 77{,}0 - (1{,}645 \times 3{,}54)$$

$$P_5 = 77{,}0 - 5{,}82$$

$$P_5 = 71{,}18 \text{ cm} \tag{17}$$

Table 5
Anthropometric Percentile Calculation Results

No	Anthropometric Attribute	P5 Result (cm)
1	Shoulder Height	137.18
2	Waist Height	95.54
3	Forward Hand Reach	71.18

Based on the calculation results in Table 6, these percentile values are directly implemented as structural limitations in the design engineering of the proposed dumpling skin cutting tool.

3.4 Dumpling skin cutter design

a. Basic Concept and Ergonomics of the Main Frame

The proposed design of this dumpling skin cutting tool represents the physical embodiment of a technical response to worker complaints, rigorously designed based on 5th percentile (P5) anthropometric calculations. This approach was implemented to create a work facility that is not only hygienic and precise, but also prioritizes ergonomic principles. For the basic construction, the main frame of the tool is constructed using 3x3 cm hollow steel, designed to have a total operational height of 70 cm. These dimensions have been calibrated to be below the operator's safe waist height limit of 95.54 cm. This elevation is crucial to ensure that the worker's posture remains naturally upright during the cutting process, effectively avoiding and eliminating the risk of low back pain due to a hunched posture.

b. Work Platform Specifications and Reach Area.

Turning to the cutting table, the work platform is designed using 1-2 cm thick wooden planks with a surface area of 50x70 cm. The length and width of this anvil directly accommodate the operator's maximum forward hand reach, which is 71.18 cm. By basing the dimensions on this limit, the entire cutting point and tool movement mechanism are guaranteed to remain within the normal reach area [12]. This frees workers from having to lean forward excessively or strain their shoulder muscles while operating the tool. Integration of Precision Features and Mechanical Drive System.

To improve material efficiency and minimize cutting errors that result in waste, as well as to reduce worker cognitive load, this design integrates an adjuster system equipped with a 5-volt laser line module. This laser module projects a highly accurate visual cutting line guide directly onto the dough. Mechanically, the press drive system utilizes a lever longer than 50 cm. This long lever was chosen to maximize the arm's leverage, resulting in significantly less pressure. This lever system is fully supported by a 10 cm return spring mechanism, which plays a vital role in dampening cutting pressure and automatically returning the lever to its starting point without requiring additional operator effort.

c. Blade Innovation and Ease of Maintenance.

At the core of the cutting operation, the blade component is manufactured from food-grade stainless steel to ensure food safety. The blade is connected to the tension lever system through an innovative socket system powered by a strong neodymium magnet. This magnetic socket system offers high flexibility with a plug-and-play mechanism. This allows for very fast, practical, and easy blade installation and removal at any time, especially for daily cleaning and maintenance purposes. Overall, the precise integration of anthropometric human body dimension mapping with various adaptive mechanical features effectively eliminates bottlenecks at the cutting station. Ultimately, this innovation not only boosts productivity but also significantly reduces worker fatigue.

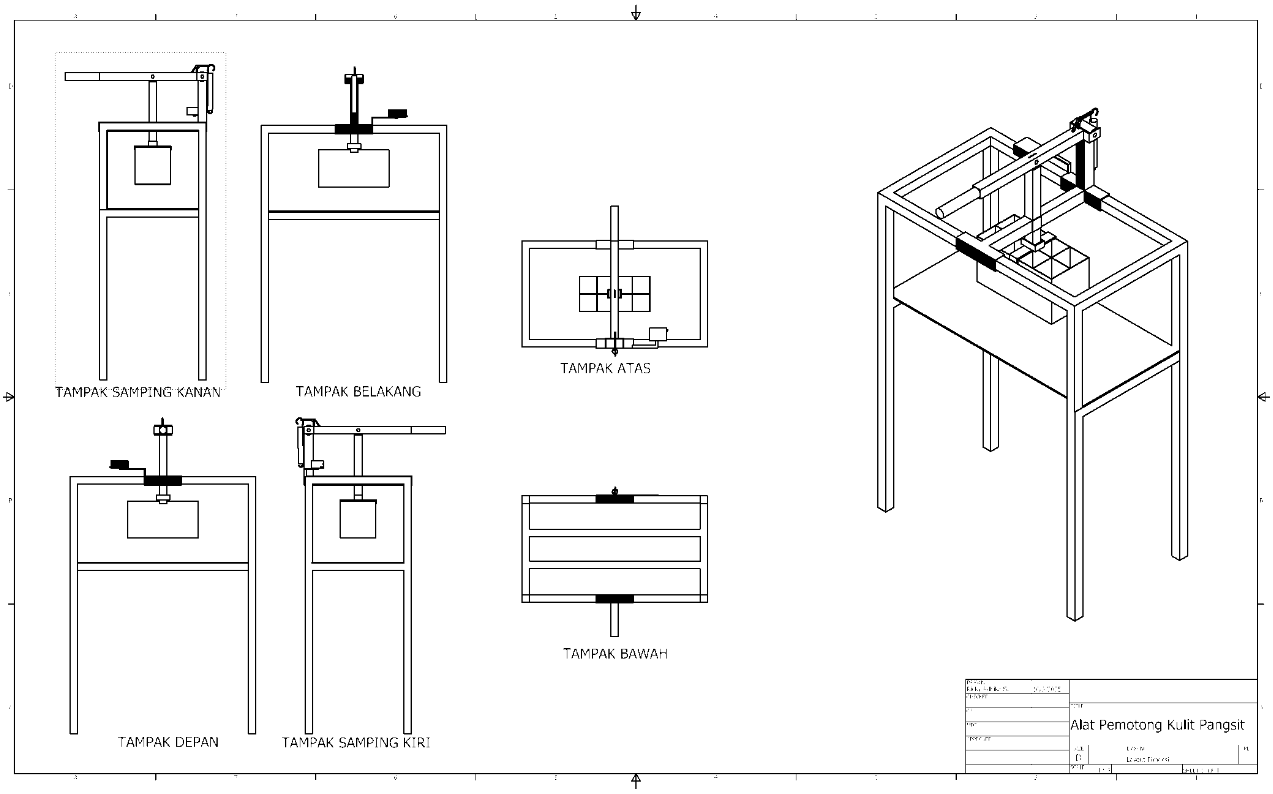

Figure 6 Dumpling Skin Cutter Design

3.5 *Prototype Validation and Performance Testing*

To evaluate the practical feasibility of the proposed tool, prototype testing was conducted through limited operational trials involving five operators. Performance indicators included production cycle time, user comfort observations, and operational functionality. The results indicate that the average production cycle time decreased from 7 minutes per 8.5 kg batch using manual cutting methods to approximately 4 minutes per batch using the proposed prototype, representing approximately 42.8% improvement in process efficiency. User observations also indicated reduced repetitive shoulder movement and reduced bending posture during operation. Although subjective comfort measurements and physiological fatigue indicators were not quantitatively measured, operators reported improved ease of operation and reduced physical workload.

Table 6.
Prototype Validation Results

Indicator	Manual	Prototype	Improvement
Cycle time (minutes/batch)	7	4	42.8%
Posture condition	Bent posture	Neutral posture	Improved
Cutting consistency	Moderate	High	Improved

The prototype evaluation results indicate that the proposed ergonomic design contributes to operational improvements in both efficiency and usability aspects. The reduction of production cycle time suggests that the integration of anthropometric design principles and adaptive mechanical components can improve workstation effectiveness [13]. Compared with previous studies focusing mainly on ergonomic redesign, the present study incorporates additional adaptive features that support both operational precision and user accessibility. Ergonomically, applying the 5th percentile principle ensures that operators with smaller anthropometric dimensions remain capable of operating the tool safely and comfortably.

4. **Conclusion**

This research has succeeded in formulating the design of an ergonomic dumpling skin cutting tool prototype to provide a solution to the bottleneck problem at the manual cutting station of Rizky Jaya MSME. The design of this tool is entirely based on a rational approach that emphasizes the suitability between the structural dimensions of the machine and the physical characteristics of workers through the utilization of anthropometric data.

Based on the results of data processing and statistical testing from five operators, the physical design of the tool is determined using the 5th percentile reference (P5) as a safe functional limit. The main frame of the tool is designed with a

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height of 70 cm, which is ideally below the waist height percentile limit (95.54 cm), so as to maintain the worker's posture upright and prevent the risk of Low Back Pain. The cutting platform area is designed to be 50x70 cm, which fully accommodates the forward hand reach limit (71.18 cm) so that the operational area remains within the normal reach zone. In addition, the elevation limit of the pressure lever is adjusted in such a way by considering the 5th percentile shoulder height (137.18 cm) to minimize fatigue in the trapezius muscle.

This study is limited by the relatively small sample size consisting of five operators, representing the entire active workforce at the manual cutting station of Rizky Jaya SMEs. Therefore, the findings should be interpreted as a local ergonomic optimization within a case-study context rather than a generalized anthropometric representation. Future studies should involve larger and more diverse samples to improve generalizability. As an added value in terms of precision and time efficiency, this tool integrates various adaptive technical features, such as an adjuster system equipped with a 5 Volt laser line as an accurate visual cutting guide, as well as a return spring mechanism that reduces the load on the lever. The use of food-grade stainless steel blades combined with a neodymium magnet-based socket system also provides practicality in terms of maintenance (plug-and-play). Through preliminary prototype evaluation, the proposed ergonomic tool demonstrates potential to reduce cutting cycle time from 7 minutes to approximately 4 minutes per batch. The proposed design may contribute to reducing production bottlenecks and improving operational efficiency. Further studies involving quantitative fatigue measurements and larger-scale operational testing are required to validate these findings.

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