Design of a Soybean Washing Machine to Increase Productivity in the Tempe Production Process

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ABSTRACT

This study aims to design an ergonomic soybean washing machine to improve the efficiency and productivity of the tempeh production process at UD. XYZ. The main problem faced by the company is the low capacity of soybean washing which is still done manually, causing delays in the production flow and becoming a bottleneck in the production system. The study was conducted with an ergonomic approach through anthropometric measurements of operators as a basis for designing the machine to suit user needs and provide work comfort. The anthropometric data obtained were then tested using adequacy tests and data uniformity tests to ensure the validity and feasibility of the data. The machine design is based on the 95th percentile so that it can be used by most operators. In addition, the study also used the POSPAC method to analyze productivity levels before and after the implementation of the soybean washing machine. The research results show that the anthropometric data meets the requirements of adequacy and uniformity, making it suitable for use as a design reference. The designed machine can increase soybean washing capacity from 25 kg to 50 kg in a single process, significantly improving production efficiency and smoothness. Productivity analysis shows an increase in most productivity indicators, although capital productivity decreased due to the initial investment in machine procurement. Furthermore, production capacity has increased to meet and even exceed market demand. Thus, the ergonomic design of the soybean washing machine has proven effective in improving the performance and productivity of the tempeh production system at UD. XYZ.

Keywords: *Anthropometry, ergonomics, soybean washing machine, productivity, POSPAC*

Introduction

The increasingly competitive development of the industry requires companies to continuously improve operational performance to maintain the sustainability of their businesses. Companies are not only required to survive but also to thrive through various improvement strategies across all operational aspects. These efforts are undertaken to increase efficiency, productivity, and competitiveness amidst constantly changing industry dynamics .

Productivity is a key indicator in assessing the success of a production system. Productivity levels reflect a company's ability to utilize resources effectively and efficiently to produce optimal output. Therefore, measuring and improving productivity is a crucial step in evaluating production system performance and serves as a basis for continuous improvement [1].

One of the growing small-scale industries in Indonesia is the tempeh processing industry . Tempeh, a fermented soybean product, has high nutritional value and is relatively affordable, making it widely consumed. However, most tempeh industries still use manual production methods with simple equipment, which limits production capacity and process efficiency [2].

UD. XYZ is a tempeh production company located in Sidoarjo Regency with a daily production capacity of approximately 1 ton of soybeans. The production system employed is make-to-stock to meet routine demand and make-to-order for additional orders. However, based on observations, the existing production capacity is insufficient to meet market demand.

The main problem identified was the soybean washing process, which is still performed manually with a limited capacity of approximately 25 kg per cycle and a processing time of approximately 20 minutes. This process must be repeated repeatedly to meet production needs, resulting in high processing times and potentially creating a bottleneck in the production system. Furthermore, the washing and hull separation processes are still carried out separately, increasing work time and operator burden.

Several previous studies have designed soybean washing machines to improve the efficiency of the tempeh production process . Research conducted by [3] showed that the use of soybean washing machines can increase washing capacity and speed up the process time compared to manual methods. Another study conducted by [4] also discussed an ergonomically designed soybean washing machine to increase work productivity in the soybean washing process. However, these studies generally still focus on the washing function alone and have not integrated the skin separation process into one system. Therefore, innovation is needed in the form of designing a soybean washing machine integrated with a skin separation system to increase overall efficiency and productivity.

Although previous studies have demonstrated that soybean washing machines can improve washing efficiency and productivity, these studies primarily focused on the washing function as a standalone process. The soybean hull separation stage remains a separate operation, requiring additional handling time and increasing operator workload. Consequently, the production process still experiences inefficiencies due to fragmented operations. This study addresses this research gap by designing an ergonomic soybean washing machine integrated with a soybean hull separation system in a single unit. The integration is expected to reduce process bottlenecks, minimize manual handling, and improve overall production productivity in the tempe manufacturing process.

Based on these problems, this study aims to design an integrated soybean washing machine that is able to increase process capacity, reduce production time, and support increased productivity in the tempeh industry , especially at UD. XYZ. From a practical perspective, the proposed machine is expected to provide direct benefits for UD. XYZ and other small and medium-sized tempe enterprises by reducing bottlenecks in the soybean washing stage, increasing production capacity, decreasing operator workload, and improving production efficiency. The findings may also serve as a reference for ergonomic machine development in similar food-processing industries.

Research methods

The following is the research flow carried out in designing the tool, which is presented in the form of a flowchart in Figure 2.

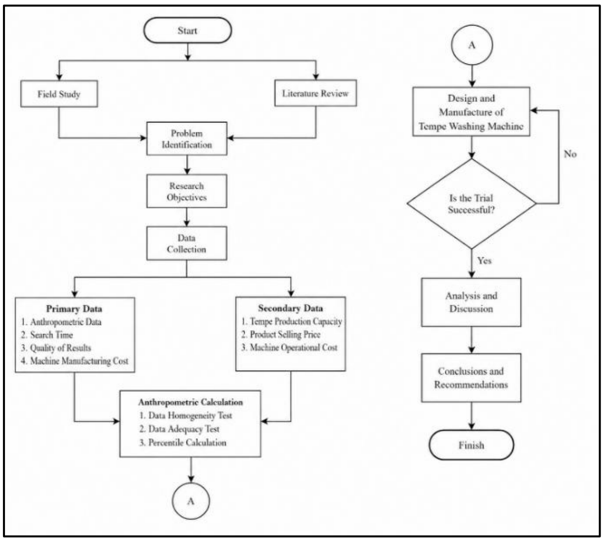

Figure 1 Research Flowchart

Results and Discussion

a. *Anthropometric* Data and Calculations

Anthropometry is a branch of ergonomics that studies the size, dimensions, and physical characteristics of the human body. Anthropometric studies encompass not only linear body measurements but also other aspects such as body area, strength, speed, and body movement. Information about human body measurements is crucial for designing equipment, work facilities, and work environments to suit the user's abilities and characteristics [5]. Anthropometric data is crucial for determining tools and how to use them. When working, the compatibility between a worker's body size and the tools used can affect work ability, productivity, body position during work, and also fatigue levels [6].

1) *Anthropometric* Data

Anthropometric data were obtained through direct measurements of three workers in the soybean washing process at UD. XYZ. The anthropometric measurements involved all three soybean washing operators employed at UD. XYZ. Since the company only has three operators assigned to this workstation, the entire target population was included in the study (total sampling), ensuring that the anthropometric data accurately represented all machine users. These measurements are used as a basis for designing machines to suit user characteristics. The dimensions measured include standing shoulder height (SSH) and hand reach (HRT), which are presented in Table 1.

Table 1. *Anthropometric* Data

No.	Worker	Standing Shoulder Height (SSH)	Hand Reach
1.	Dika	142	75
2.	Randy	143	73

3.	Agus	139	72

2) Data Sufficiency Test

Data adequacy testing is carried out to determine whether the amount of data collected is sufficient to represent actual conditions in the field. This test aims to ensure that the data used in the research can provide accurate results. In addition, a confidence level of 95% with a value of k = 2 is also determined, which describes the level of confidence in the accuracy of the *Anthropometric data* obtained. If the number of observation data meets the condition ($'\leq$ N), then the data is declared sufficient. Conversely, if the calculation results show (N' $\geq$ N), then the number of existing data is insufficient, so it is necessary to increase the number of observations [7].

calculation of the data adequacy test was carried out using the following formula :

$$N' = \left[\frac{k/_{s}\sqrt{n.\sum x^2-(\sum x^2)}}{\sum x}\right]^2$$

Calculation:

1. Standing Shoulder Height

Table 2. Calculation of Standing Shoulder Data

No.	**Worker**	**Standing Shoulder Height (x)**	**Σx ²**
1.	Dika	142	20,164
2.	Randy	143	20,449
3.	Agus	139	19,321
	Total	**424**	**59,934**
	(Σx) ²	**179,776**	

$$N' = \left[\frac{k/_{s}\sqrt{n.\sum x^2-(\sum x^2)}}{\sum x}\right]^2$$

$$N' = \left[\frac{2/_{0,05}\sqrt{3x(59934)-(424)^2}}{424}\right]^2$$

$$N' = \left[\frac{40\sqrt{179802-179776}}{424}\right]^2$$

$$N' = \left[\frac{40\sqrt{26}}{424}\right]^2$$

$$N' = \left[\frac{40x5,099}{424}\right]^2$$

$$N' = [0,481]^2$$

$$N' = 0.231$$

0.231 < 3, N' < N (Sufficient Data)

Based on the data adequacy test, the N′ value was 0.231. This value is smaller than the number of observations conducted (N = 3). Therefore, it can be concluded that the collected Standing Shoulder Height data is sufficient and no additional data is needed.

2. Hand Reach

Table 3. Hand Reach Data Calculation

No.	**Worker**	**Hand Reach**	**x ²**
1.	Dika	75	5,625
2.	Randy	73	5,329
3.	Agus	72	5,184
	Total	**220**	**16,138**
	(Σx) ²	**48,400**	

$$N' = \left[\frac{k/_{s}\sqrt{n.\sum x^2-(\sum x^2)}}{\sum x}\right]^2$$

$$N' = \left[\frac{2/_{0,05}\sqrt{3x(16138)-(220)^2}}{220}\right]^2$$

$$N' = \left[\frac{40\sqrt{48414-48400}}{220}\right]^2$$

$$N' = \left[\frac{40\sqrt{14}}{220}\right]^2$$

$$N' = \left[\frac{40x3,742}{220}\right]^2$$

$$N' = [0,680]^2$$

$$N' = 0.462$$

0.462 < 3, N' < N (Sufficient Data)

Based on the results of the data sufficiency test, the N′ value was 0.462. This value is smaller than the number of observations conducted (N = 3). Therefore, it can be concluded that the collected Standing Shoulder Height data is sufficient and no additional data is needed.

3) Data Uniformity Test

Data uniformity tests are carried out to determine whether the *anthropometric data* obtained is within control limits. Data is considered uniform if all data fall between the upper control limit (UCL) and lower control limit (LCL). In this study , a k value of 2 with a 95% confidence level was used because this value is a commonly used standard and is considered to accurately represent the data conditions. The formula used is as [7]–[13]:

$$BKA = x + k.\ \sigma$$
$$BKB = x - k.\ \sigma$$

Calculation:

1. Standing Shoulder Height

a. Average (*Mean)*

$$x = \frac{(142+143+139)}{3} = 141{,}333$$

Based on the calculation results, the average standing shoulder height value was 141.33 cm .

b. Standard Deviation

$$\sigma = \sqrt{\frac{\sum(xi-\bar{x})^2}{(n-1)}}$$
$$\sigma = \sqrt{\frac{(142-141{,}33)^2+(143-141{,}33)^2+(139-141{,}33)^2}{(3-1)}}$$
$$\sigma = \sqrt{\frac{0{,}44+2{,}78+5{,}44}{2}}$$
$$\sigma = \sqrt{\frac{8{,}67}{2}}$$
$$\sigma = 2.08$$

The standard deviation value obtained for 3 standing shoulder heights was 2.08 cm .

c. BKA

$BKA = x + k.\ \sigma$
BKA = 141.33 + (2 x 2.08)
BKA = 145.50

Based on the calculations, the upper control limit (BKA) value was obtained as 145.50 cm .

d. BKB

$BKB = x - k.\ \sigma$
BKB = 141.33 - (2 x 2.08)
BKB = 137.17

Based on the calculations, the lower control limit (BKB) value was obtained as 137.17 cm .

Based on the results, the results of the standing shoulder height data uniformity test can be presented in Table 3. following:

Table 3. Uniformity Test Data for Standing Shoulder Height Data

No.	Types of Measurement	Worker	Standing Shoulder Height (cm)	Mean (cm)	BKA (cm)	BKB (cm)
1	Standing Shoulder Height	Dika	142.00	141.33	145.50	137.17
		Randy	143.00			
		Agus	139.00			

The following is a test graph for the uniformity of standing shoulder height data:

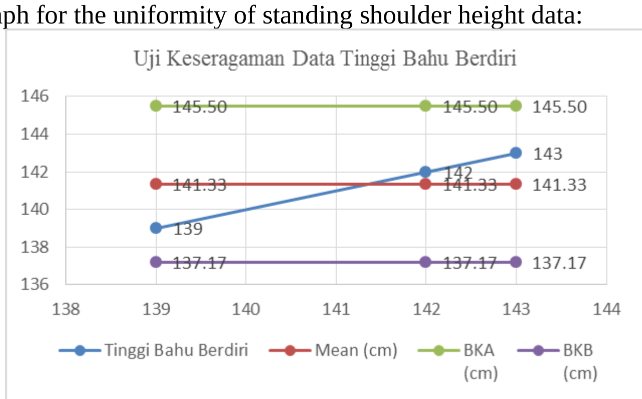

Figure 1. Uniformity Test Graph of Standing Shoulder Height *Anthropometric Data*

From the standing shoulder height uniformity test graph, it can be seen that all measurement results are still within the safe limits, namely between the upper control limit (BKA) of 145.50 cm and the lower control limit (BKB) of 137.17 cm. The average value is 141.33 cm, and no data goes outside these limits. so it can be concluded that the data is uniform.

2. Hand Reach

a. Average (*Mean)*

x $= \frac{(75+73+72)}{3} = 73{,}33$

Based on the calculation results, the average hand reach value was 73.33cm.

b. Standard Deviation

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

$$\sigma = \sqrt{\frac{(75-73{,}33)^2+(73-73{,}33)^2+(72-73{,}33)^2}{(3-1)}}$$

$$\sigma = \sqrt{\frac{2{,}78+0{,}11+1{,}78}{2}}$$

$$\sigma = \sqrt{\frac{4{,}67}{2}}$$

σ = 1.53

The standard deviation value obtained for 3 hand reaches was 1.53 cm .

c. BKA

BKA = $x + k.\ \sigma$

BKA = 73.33 + (2 x 1.53)

BKA = 76.39

Based on the calculations, the upper control limit (BKA) value was obtained as 76.39 cm .

d. BKB

BKB = $x - k.\ \sigma$

BKB = 73.33 - (2 x 1.53)

BKB = 70.28

Based on the calculations, the lower control limit (BKB) value was obtained as 70.28 cm .

Based on the results, the results of the Hand Reach data uniformity test can be presented in Table 4.3 below:

Table 4. Hand Reach Calculation Results Data

No.	Types of Measurement	Worker	Hand Reach	Mean (cm)	BKA (cm)	BKB (cm)
1	Hand Reach	Dika Randy Agus	75.00 73.00 72.00	73.33	76.39	70.28

The following is a graph of the uniformity test of hand reach data.

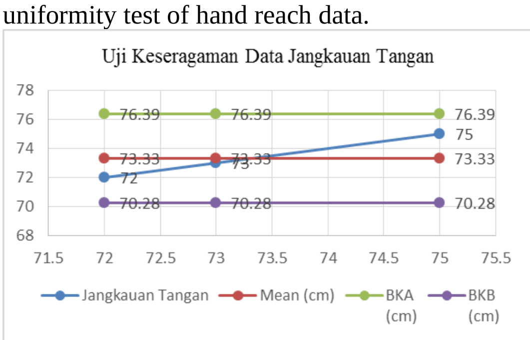

Figure 2. Graph of Hand Reach *Anthropometric* Data

From the standing shoulder height uniformity test graph, it can be seen that all measurement results are still within the safe limits, namely between the upper control limit (BKA) of 76.39 cm and the lower control limit (BKB) of 70.28 cm. The average value is 73.33 cm, and no data goes outside these limits. so it can be concluded that the data is uniform.

4) Percentile Calculation

A percentile is a value that indicates the position of a size within a data set. This value indicates that a certain percentage of the population has a size equal to or smaller than that percentile value. In *anthropometric analysis* , percentile calculations are used to determine the appropriate size in product design so that it can be used by the majority of users. Percentile size calculations can be done using the formula in Table 5 below [7].

Table 5. Percentile Formula

Percentile	Formula
1st	X̄ - 2.325S
2.5th	X̄ - 1.96S

5th	$\bar{X}$ - 1.645S
10th	$\bar{X}$ - 1.28S
50th	$\bar{X}$
90th	$\bar{X}$ + 1.28S
95th	$\bar{X}$ + 1.645S
97.5th	$\bar{X}$ + 1.96S
99th	$\bar{X}$ + 2.325S

Calculation:

1. Standing Shoulder Height

It is known that:

- $\bar{X}$ = 141.33
- S = 2.08

Results :

Table 6. Calculation of Standing Shoulder Height Percentile

Percentile	Average	P	Standard Deviation	Results
P1	141.33	2,325	2.08	136.49
P2.5	141.33	1.96	2.08	137.25
P5	141.33	1,645	2.08	137.91
P10	141.33	1.28	2.08	138.67
P50	141.33	141.33	-	141.33
P90	141.33	1.28	2.08	143.99
P95	141.33	1,645	2.08	144.75
P97.5	141.33	1.96	2.08	145.41
P99	141.33	2,325	2.08	146.17

2. Hand Reach

It is known that:

- $\bar{X}$ = 73.33
- S = 1.53

Results :

Table 7. Hand Reach Percentile Calculation

Percentile	Average	P	Standard Deviation	Results
P1	73.33	2,325	1.53	69.77
P2.5	73.33	1.96	1.53	70.33
P5	73.33	1,645	1.53	70.81
P10	73.33	1.28	1.53	71.37
P50	73.33	73.33	-	73.33
P90	73.33	1.28	1.53	75.29
P95	73.33	1,645	1.53	75.85
P97.5	73.33	1.96	1.53	76.33
P99	73.33	2,325	1.53	76.89

5) Determining the Design Size of the Tool

The design of this tool uses a soybean skin peeling machine that works automatically by utilizing a friction mechanism on a rotating cylinder. Boiled and soaked soybeans are fed through a hopper to a peeling unit, where friction between the cylinder, the hopper walls, and the soybeans removes the husks. Next, they are automatically separated based on their density differences , with the husks exiting through a drain, while the soybeans proceed to the washing stage. This system reduces manual processing, saves time, and increases production efficiency[10], [14]–[18].

The machine's dimensions were designed taking into account operator anthropometric data and the average Indonesian population for a more universal design. Measurements revealed that the average standing shoulder height for operators is 141.33 cm, while population data indicates a range of 161.7–164.2 cm. Therefore, the 95th percentile (P95) of 144.75 cm was used as the machine's dimension reference, ensuring the tool's usability for most users.

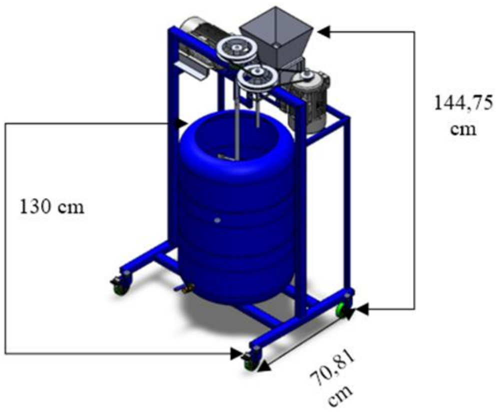

Figure 3. Soybean Washing Machine Design

Figure 4. Soybean Washing Machine

b. Productivity

Productivity is a comparison between output and input used, and is a performance indicator in the effective and efficient use of resources [7]

1) Productivity Calculation Using the POSPAC Method

POSPAC method is a method used to partially measure productivity levels. This method is often used as a reference in assessing and improving productivity in the industrial sector. The POSPAC model has six main components that form the basis for measuring productivity: production, organization, product, sales, capital, and labor. By applying this method, companies can obtain productivity index values for each of these components, thereby determining the company's performance level in terms of production, organization, sales, product, labor, and capital [19]. The following is the calculation of the Productivity Level [20].

1. Production Productivity Level

$$\text{Production Productivity} = \frac{\text{Sales Revenue}}{\text{Cost of Goods Sold}}$$

2. Organizational Productivity Level

$$\text{Organizational Productivity} = \frac{\text{Value Added}}{\textit{General Administrative Expenses}}$$

3. Sales Productivity Level

$$\text{Sales Productivity} = \frac{\text{Gross Profit}}{\text{Selling Expenses}}$$

4. Product Productivity Level

$$\text{Product Productivity} = \frac{\text{Gross Profit}}{\text{Direct Product Costs}}$$

5. *Labor Productivity Level*

$$\text{Labor Productivity} = \frac{\text{Gross Profit}}{\text{Total Labor Costs}}$$

6. Capital Productivity Level

$$\text{Capital Productivity} = \frac{\text{Sales Revenue}}{\text{Total Capital}}$$

a) Production Productivity

The first calculation performed is production productivity. Production productivity is used to measure the efficiency of the production process by comparing the output (sales) value with the production costs incurred.

This calculation aims to determine the efficiency of the production process before and after the use of the soybean washing machine for one month, namely from April 16, 2026, to May 16, 2026. Based on the calculation results, the production productivity values for each period are as follows:

Table 8. Production Productivity Level

Month	Sales Results (Rp)	Production Cost (Rp)	Production Productivity Level	Production IP	Production PIP
Before Machine					
August 2025	320,558,000	290,697,000	1.10	100.00	0.00
September 2025	302,450,000	275,778,000	1.10	99.46	-0.54
October 2025	284,829,000	264,893,000	1.08	97.51	-2.49
November 2025	300,596,000	275,232,000	1.09	99.04	-0.96
December 2025	309,891,000	283,185,000	1.09	99.24	-0.76
January 2026	389,005,500	353,206,000	1.10	99.88	-0.12
February 2026	266,917,000	240,509,000	1.11	100.64	0.64
March 2026	317,117,000	283,571,000	1.12	101.41	1.41
After Machine					
April 16–May 16, 2026	400,986,000	358,370,000	1.12	101.47	1.47

Based on the calculation results, the production productivity value before the use of the machine still fluctuated. The highest productivity value occurred in March at 1.41 , while the lowest occurred in October at -2.49. This indicates that the production process before the use of the machine was unstable and its efficiency was still fluctuating. After the use of the machine in the period April 16–May 16, 2026, the productivity value increased to 1.41 . This value is the highest compared to previous months. This means that the use of the machine can make the production process more efficient.

b) Organizational Productivity

After calculating production productivity, the next step is calculating organizational productivity. Organizational productivity is used to determine the efficiency of organizational management by comparing added value to administrative and general costs. The following is the formula used. Based on the calculation results, the organizational productivity value for each period is as follows:

Table 9. Organizational Productivity Level

Month	Value Added (Rp)	General and Administrative Expenses	Organizational Productivity Level	Organization IP	PIP Organization
Before Machine					
August 2025	50,540,754	3,185,000	15,868	100.00	0.00
September 2025	47,349,075	3,240,000	14,614	92.09	-7.91
October 2025	40,612,890	3,295,000	12,326	77.67	-22.33
November 2025	46,041,291	3,330,000	13,826	87.13	-12.87
December 2025	47,384,613	3,410,000	13,896	87.57	-12.43
January 2026	56,486,288	3,575,000	15,800	99.57	-0.43
February 2026	47,080,851	3,520,000	13,375	84.29	-15.71
March 2026	54,225,571	3,610,000	15,021	94.66	-5.34
After Machine					
April 16–May 16, 2026	63,306,312	3,450,000	18,350	115.64	15.64

Based on the calculation results, before the machine was used, all sales productivity values were negative, indicating a decline in productivity. After the machine was used from April 16 to May 16, 2026, the sales productivity value increased to 15.64 . This value is the highest compared to previous months. This indicates that the use of the machine can increase sales productivity.

c) Sales Productivity

Sales productivity is used to measure a company's ability to generate gross profit from sales activities. This calculation is done by comparing gross profit with the sales costs incurred. Based on the calculation results, the sales productivity value for each period is obtained as follows.

Table 10. Sales Productivity Level

Month	Gross Profit (Rp)	Cost of Sales (Rp)	Sales Productivity Level	Sales IP	Sales PIP
Before Machine					
August 2025	29,861,000	1,650,000	18,098	100.00	0.00
September 2025	26,672,000	1,620,000	16,464	90.97	-9.03
October 2025	19,936,000	1,721,000	11,584	64.01	-35.99
November 2025	25,364,000	1,760,000	14,411	79.63	-20.37
December 2025	26,706,000	1,850,000	14,436	79.77	-20.23
January 2026	35,799,500	2,050,000	17,463	96.49	-3.51
February 2026	26,408,000	1,920,000	13,754	76.00	-24.00
March 2026	33,546,000	2,100,000	15,974	88.27	-11.73
After Machine					
April 16-May 16, 2026	42,616,000	2,100,000	20,293	112.13	12.13

Based on the calculation results, before the machine was used, all sales productivity values were negative, indicating a decline in productivity. After the machine was used from April 16 to May 16, 2026, the sales productivity value increased to 12.13 . This value is the highest compared to previous months. This indicates that the use of the machine can increase sales productivity.

d) Labor Productivity

Next, labor productivity calculations are carried out to determine the level of efficiency of labor use in generating profits. The following is the formula used. Based on the calculation results, the labor productivity value for each period is as follows:

Table 11. Labor Productivity Level

Month	Gross Profit (Rp)	Labor Cost (Rp)	Labor Productivity Level	Workforce IP	PIP for Workers
Before Machine					
August 2025	29,861,000	20,650,000	1,446	100.00	0.00
September 2025	26,672,000	20,650,000	1,292	89.32	-10.68
October 2025	19,936,000	20,650,000	0.965	66.76	-33.24
November 2025	25,364,000	20,650,000	1,228	84.94	-15.06
December 2025	26,706,000	20,650,000	1,293	89.43	-10.57
January 2026	35,799,500	20,650,000	1,734	119.89	19.89
February 2026	26,408,000	20,650,000	1,279	88.44	-11.56
March 2026	33,546,000	20,650,000	1,625	112.34	12.34
After Machine					
April 16-May 16, 2026	42,616,000	20,650,000	2,064	142.71	42.71

Based on the calculation results, before the use of the machine, the highest labor productivity value occurred in January at 19.89 , while the lowest occurred in October at -33.24. After the use of the machine in the period April 16–May 16, 2026, the labor productivity value increased to 42.71 . This value is the highest compared to previous months. This means that the use of machines can increase labor productivity.

e) Capital Productivity

Capital productivity is used to measure a company's ability to utilize its capital to generate sales. This calculation is performed by comparing sales revenue to total capital employed. Based on the calculation, the capital productivity value for each period is as follows:

Table 12. Capital Productivity Level

Month	Total Sales (Rp)	Total Capital (Rp)	Capital Productivity Level	Capital IP	PIP Capital
Before Machine					
August 2025	320,558,000	295,532,000	1,085	100.00	0.00
September 2025	302,450,000	280,638,000	1,078	99.36	-0.64
October 2025	284,829,000	269,909,000	1,055	97.29	-2.71
November 2025	300,596,000	280,322,000	1,072	98.86	-1.14
December 2025	309,891,000	288,445,000	1,074	99.05	-0.95
January 2026	389,005,500	358,831,000	1,084	99.95	-0.05

February 2026	266,917,000	245,949,000	1,085	100.05	0.05
March 2026	317,117,000	289,281,000	1,096	101.06	1.06
After Machine					
April 16-May 16, 2026	400,986,000	371,920,000	1,078	99.40	-0.60

Based on the calculation results, before the machine was used, the highest capital productivity value occurred in March at 1.06 , while the lowest occurred in December at -0.95. After the machine was used in the period April 16–May 16, 2026, the productivity value decreased by -0.60 . This was due to the additional costs in that month in the form of a machine priced at 8 million.

f) Product Productivity

Next, product productivity is calculated. This calculation aims to determine the efficiency of direct product costs in generating gross profit. Based on the calculation results, the product productivity value for each period is obtained as follows.

Table 13. Product Productivity Level

Month	Gross Profit (Rp)	Direct Product Cost (Rp)	Product Productivity Level	Product IP	PIP Product
Before Machine					
August 2025	29,861,000	269,547,000	0.111	100.00	0.00
September 2025	26,672,000	254,628,000	0.105	94.55	-5.45
October 2025	19,936,000	243,743,000	0.082	73.83	-26.17
November 2025	25,364,000	254,082,000	0.100	90.11	-9.89
December 2025	26,706,000	262,035,000	0.102	92.00	-8.00
January 2026	35,799,500	332,056,000	0.108	97.32	-2.68
February 2026	26,408,000	219,359,000	0.120	108.67	8.67
March 2026	33,546,000	262,421,000	0.128	114.15	14.15
After Machine					
April 16-May 16, 2026	42,616,000	337,000,000	0.126	115.39	15.39

Based on the calculation results, before the use of the machine, the highest product productivity value occurred in March at 14.15 , while the lowest occurred in September at -26.17. After the use of the machine in the period April 16–May 16, 2026, the product productivity value increased to 15.39 . This value is the highest compared to previous months. This means that the use of machines can increase product productivity.

2) Production Capacity to Meet Demand

Apart from increasing productivity, one of the problems faced by companies is the inability to meet market demand. Therefore, an analysis of production capacity was conducted before and after the use of the soybean washing machine. The data is presented in the following table.

Table 14. Production and Demand Data Levels

No	Month	Production	Request
Before Machine			
1	August 2025	29,754	39,123
2	September 2025	27,075	36,759
3	October 2025	26,890	35,031
4	November 2025	27,291	33,564
5	December 2025	28,613	36,183
6	January 2026	36,788	45,598
7	February 2026	22,851	31,249
8	March 2026	29,571	35,108
After Machine			
9	April 16-May 16, 2026.	40,312	36,842

Based on production and demand data, it is known that before the use of soybean washing machines, production volume was not able to meet market demand. This can be seen throughout the period from August 2025 to March 2026, where production volume was consistently lower than demand.

After the use of the machine in the period April 16–May 16, 2026, there was an increase in the production amount, namely 40,312 kg, while demand was 36,842 kg. This shows that production is not only able to meet demand, but also exceeds the existing demand.

This increase shows that the use of soybean washing machines is able to increase production capacity, so that the problem of production shortages that occurred previously can be overcome.

3) Soybean Washing Process Time

This study also observed the soybean washing process time. This observation aimed to compare the time required before and after using the soybean washing machine (Wignjosoebroto, 2003) . Observations were conducted 10 times for each condition, before and after machine use. The results of the soybean washing process observations are presented in the following table.

Table 15. Soybean Washing Process Time Data

No	Before Using the Machine		After Machine Use	
	Weight (kg)	Time (minutes)	Weight (kg)	Time (minutes)
1	25	20.24	50	24.35
2	25	21.15	50	25.2
3	25	22.4	50	26.1
4	25	23.25	50	26.19
5	25	21.1	50	25.1
6	25	22.2	50	26.3
7	25	20.25	50	24.2
8	25	24.3	50	23.43
9	25	23.05	50	25
10	25	21.4	50	22.71
	Average	**21.93**	**Average**	**24.86**

Based on observations, before using the machine, washing 25 kg of soybeans took an average of 21.93 minutes . After using the machine, the washing capacity increased to 50 kg, with an average time of around 24.86 minutes . This indicates that the use of the machine can increase the efficiency of the soybean washing process.

Conclusion

Based on the results of the research that has been conducted, it can be concluded that the operator's *Anthropometric data* including standing shoulder height and hand reach have met the adequacy and uniformity tests, so it is suitable to be used as a basis in designing a soybean washing machine, with design dimensions using the 95th percentile, namely 144.75 cm for standing shoulder height and 75.85 cm for hand reach so that it can accommodate most users. The design of a soybean washing machine equipped with a skin separator system has been proven to be able to increase the efficiency of the production process, especially at the washing stage which was previously a bottleneck. The results of the productivity analysis using the POSPAC method show an increase in production productivity, organization, sales, labor, and products after the use of the machine, although capital productivity has decreased due to the initial investment, but overall the performance of the production system has increased. In addition, production capacity has increased significantly to be able to meet or even exceed market demand, and the efficiency of the washing process has also increased as indicated by the increase in capacity from 25 kg to 50 kg per process, although the process time is slightly longer, resulting in a greater increase in output compared to the additional time required. This study has several limitations. First, anthropometric measurements were conducted on only three operators because they represented the entire soybean washing workforce at UD. XYZ. Second, the productivity evaluation was performed over a limited observation period following machine implementation. Future studies are recommended to involve a larger number of production facilities, longer observation periods, and different soybean characteristics to improve the generalizability of the findings.

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