JRSSEM 2025, Vol. 5, No. 01, 2090 – 2107
E-ISSN: 2807 - 6311, P-ISSN: 2807 - 6494

Quality Control in Coconut Sorting Process using Statistical Process Control (SPC) and Root Cause Analysis (RCA) (Case Research: UMKM Wika Kelapa)

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Abstract.
UMKM Wika Kelapa is a coconut shell (*endocarp*) supplier business in Pangandaran. The main problem faced is the high level of coconut defects, including broken coconuts, rotten coconuts, and sprouted coconuts, with an average percentage of 4.65%, exceeding the 3% tolerance limit that has been set. The high level of defects impacts business losses because defective coconuts are sold at lower prices. This research aims to determine whether quality control in the coconut sorting process is in control, identify factors causing defects, and provide suggestions for improvement to minimize coconut defects using Statistical Process Control (SPC) and Root Cause Analysis (RCA) methods. The sorting process is illustrated using the *SIPOC* (*Supplier, Input, Process, Output, and Customer*) approach. The results of SPC analysis using check sheets, histograms, Pareto diagrams, and *P-Charts* show that the coconut sorting process is not yet statistically controlled, with seven points outside the control limits, namely January (0.050), March (0.051), April (0.052), June (0.056), August (0.035), September (0.042), and November (0.040) during 2024. The RCA analysis using fishbone diagrams and five-whys revealed that broken coconut defects are dominantly caused by human factors, including lack of accuracy, unskilledness, and worker fatigue. Rotten coconut defects are dominantly caused by method factors, namely the absence of *SOPs*, resulting in prolonged storage in humid and unhygienic conditions. Sprouted coconut defects are primarily caused by method factors due to lack of *SOPs* or training on storage and absence of inspection protocols.

Keywords: Quality Control, Coconut Defects, Sorting Process, Statistical Process Control (SPC), Root Cause Analysis (RCA)

INTRODUCTION

The development of the industrial world continues to be faced with the challenge of providing the best products. Each product is inseparable from customer expectations; the resulting product is expected to meet customer wants and needs. Product quality control plays an important role for businesses to improve and maintain product quality, which is a factor that determines whether or not a company develops rapidly (Nurhasanah et al., 2024). Recent empirical data from Indonesia's agricultural

DOI : 10.59141/jrssem.v5i1.960

sector show that post-harvest losses account for 20–30% of total production, with quality control issues being a major contributing factor (Indonesian Ministry of Agriculture, 2023). The coconut industry, specifically, faces significant challenges with defect rates averaging 5–8% across small and medium enterprises (*SMEs*), substantially exceeding international standards of 2–3% (APCC, 2024). This situation highlights the urgent need for systematic quality control implementation in coconut processing operations. Quality control is essential for identifying failures in the production process and preventing substantial economic losses. In the context of coconut processing, effective quality control can reduce defect rates by 40–60% when properly implemented (Kumar et al., 2023). The integration of statistical methods with root cause analysis has proven particularly effective in agricultural processing operations, with documented success rates of 70–85% in defect reduction (Sharma & Patel, 2024).

UMKM Wika Kelapa is a business engaged in coconut supply operations, established in 2018 by Tuti Wika Winanti, and located in *Pananjung*, *Pangandaran District*, *Pangandaran Regency*. This *SME* sells coconut shells (*endocarp*) which are widely used for various products such as handicrafts, charcoal, and oil. The coconut shell is the hard protective part with a thickness of approximately 3–5 millimeters. The criteria for coconuts sold include weighing approximately 1 kilogram without defects such as breaking, rotting, or sprouting.

The coconut sorting activity operates from 08:00 to 22:00, beginning with collection of harvested coconuts transported via pickup truck to branch locations. The peeling process follows, separating coconut shells from *coir* using traditional tools including crowbars, knives, and machetes. Peeled coconuts are arranged systematically to facilitate transportation to storage warehouses. Subsequently, coconut shells are transported to storage facilities and distributed to customers via various transportation methods, including trucks, targeting factories and markets.

Despite well-structured sorting processes, quality problems persist, resulting in coconut defects and business losses. Current market data show defective coconuts sell for IDR 1,000 per piece compared to IDR 5,000 for standard quality coconuts, representing a significant revenue loss of IDR 4,000 per defective unit.

UMKM Wika Kelapa faces significant challenges related to defective coconuts produced during sorting, consisting of broken coconuts, rotten coconuts, and sprouted coconuts. International studies have demonstrated that similar agricultural processing operations achieve defect rates below 2% through systematic quality control implementation (Thompson et al., 2023). When shipped coconuts fail to meet quality standards, profit maximization becomes impossible due to reduced selling prices.

Coconut defect types include: broken coconuts, marked by cracks or holes; rotten coconuts, exhibiting unpleasant odors, mold, and black spots; and sprouted coconuts, producing shoots or prospective buds. 2024 sorting data reveal 363,153 total coconuts processed, with 16,909 defective units, yielding a 4.65% defect rate. The established tolerance limit is 3%, with peak defects occurring in June: 31,974 sorted items with 1,782 defects (5.57% defect rate). This indicates substantial quality issues requiring immediate attention to minimize defects, increase profits, and meet expected quality standards.

Effective quality control implementation positively impacts operations by minimizing defects, damages, and products misaligned with market requirements. Companies require quality control systems to reduce defective product quantities and prevent ongoing losses (Ardana & Widiasih, 2023; Sumarsono & Widiasih, 2024). Attention to quality provides customer satisfaction and optimizes business profits. High defect levels exceeding tolerance figures indicate inadequate quality control implementation, necessitating root cause identification and solution development.

Previous research demonstrates gaps in quality control applications within Indonesian coconut processing *SMEs*, particularly regarding systematic implementation of statistical process control methods. While international studies show successful *SPC* implementation in agricultural processing (Martinez & Lee, 2023), limited research addresses small-scale coconut operations in Indonesia. This research contributes new knowledge by providing a comprehensive framework for quality control implementation specifically tailored to Indonesian coconut processing *SMEs*, addressing unique challenges including traditional processing methods, limited technical expertise, and resource constraints.

Statistical Process Control (*SPC*) application helps determine product quality control by identifying, analyzing, and controlling process variations from initial to final stages. Root Cause Analysis (*RCA*) methodology identifies problem root causes comprehensively and designs improvement proposals to prevent ongoing issues. Several previous studies support similar methodological applications, including research by A. Agustin & Azis (2024), addressing high noodle product defects exceeding tolerance limits. Furthermore, Michael A. Irawan & Farida Pulansari (2024) addressed can defect problems with 98% defect rates. Komari et al. (2021) provided improvement proposals for paper product problems. These studies aimed to determine company quality control implementation, identify defect-affecting factors, and provide improvement suggestions for defect rate reduction.

Based on the background described above, this research aims to determine whether quality control in the sorting process has been adequately controlled. Additionally, deeper research is necessary to identify causes and implement improvements to minimize defective coconuts. Research results should provide new perspectives for *UMKM Wika Kelapa* in controlling coconut quality to increase optimal business profits.

The problems formulated include: how to apply quality control in *UMKM Wika Kelapa* sorting processes, factors causing coconut quality defects in these *SMEs*, and improvement suggestions and recommendations for minimizing coconut defects. The purpose of this research is to determine quality control application in sorting processes, identify factors causing coconut defects, and provide improvement suggestions to enhance coconut quality and minimize defects. Research benefits include contributions for authors in enriching insights and abilities in Statistical Process Control (*SPC*) and Root Cause Analysis (*RCA*) method applications, providing useful information for *UMKM Wika Kelapa* in quality control implementation, and adding reader insights about these methods as references for further studies and research.

MATERIALS AND METHODS

This research is descriptive quantitative research, which describes a certain event or situation systematically and factually, using quantitative data that can be measured (Sugiyono, 2017). This research uses numerical data such as the number of coconut sorting and the percentage of defects that are statistically analyzed, with the aim of providing a clear picture of the information and characteristics of an object according to actual conditions without manipulating variables. This research was carried out at *Wika Kelapa MSMEs* located on *Jln. Siliwangi*, *Bojong Gebang Hamlet*, *Pananjung Village*, *Pangandaran Regency*, West Java. The time of this research lasted from February 2025 to June 2025.

Population is a set of objects or subjects with certain characteristics and qualities as research material to draw conclusions. The *population* element is the entire subject to be measured, which is the unit being studied (Sugiyono, 2017). In this research, the population used was data on the number of coconut sorting's in *Wika Kelapa MSMEs* during the period January 2024 to December 2024. *Samples* are the part of the population that is used as the primary data source in the research. *Samples* are part of the *population* (Sugiyono, 2017). In this research, the sample used is data on the number of coconut defects which include broken, rotten, and sprouted coconuts during the period January 2024 to December 2024.

The data collection process utilized multiple techniques, including direct observation of sorting processes, storage conditions, and handling procedures; structured interviews with the business owner (Mrs. Tuti Wika Winanti) and workers to gather insights on operational procedures and challenges; document analysis of historical sorting records, defect logs, and operational documentation; as well as quantitative measurement and recording of sorting volumes, defect quantities, and classifications. For data analysis, two primary methodological approaches were employed: Statistical Process Control (*SPC*) analysis—using check sheets for systematic data recording, histograms for defect frequency visualization, Pareto diagrams for priority problem identification, and *P-Charts* for process control evaluation—and Root Cause Analysis (*RCA*), which involved fishbone diagrams for comprehensive cause identification, the five-whys methodology for root cause determination, and the 5W+1H framework for developing improvement proposals.

RESULTS AND DISCUSSION

Data Processing

1. Statistical Process Control (SPC)

A. Check Sheet

The first step in data processing is to compile a check sheet in the form of a table in Microsoft Excel. This table is used to record data on the number of sorting's and types of coconut defects that do not meet the standards in Wika Kelapa MSMEs. Check sheets collect and group data by type of defect and then analyze it to determine if changes need to be made, depending on the frequency of problems. The results of data processing through the check sheet that have been carried out can be seen in Table 1 below:

Table 1 Results of Coconut Sorting and Defects in 2024

Moon	Sorting (Item)	Coconut Defects (Granules)			Total Damage
		Broken	Rotten	Too Old	
January	29.986	723	482	307	1512
February	29.585	512	498	260	1270
March	30.273	634	489	424	1547
April	30.032	645	487	436	1568
May	30.588	532	485	447	1464
June	31.974	612	582	583	1777
July	29.697	485	472	464	1421
August	31.002	468	355	251	1074
September	31.629	550	537	256	1343
October	30.896	539	543	382	1464
November	28.236	376	401	359	1136
December	29.255	538	565	230	1333
Total	363.153	6.614	5.896	4.399	16.909

Based on Table 1 data, it is known that from January 2024 to December 2024, Wika Kelapa MSMEs sorted 363,153 coconut shells. In the data, it can be seen that the 2024 sorting per month is around 28,236 to 31,974 items. The lowest number of sorting was in November at 28,236 items, while the highest number of sorting reached 31,974 items in June 2024. With a high level of defects in coconuts, including cracked or split coconuts, rotten coconuts, and sprouted coconuts. This problem needs to be fixed so that the sorting process is more optimal, so that it can increase business revenue.

The highest number of defects during the sorting process is found in broken coconuts, which is 6,614 grains of total defects during 2024. This defect of broken coconuts often occurs when the coconut peeling process, transportation and storage process are stored. The second defect is rotten coconut, which is 5,896 grains. This defect often occurs when sorting in branches and warehouses, the condition of rotten coconuts has characteristics such as moldy coconut shells, black spots, and a pungent unpleasant smell. The third defect is sprouted coconut, which is as many as 4,399 seeds. This defect also occurs a lot when sorting branches or in the warehouse, the condition of sprouted coconuts tends to be light because coconut water has been absorbed by the embryo, and there are protrusions in certain parts.

Based on the observation results, it is shown that the coconut sorting process has not shown controlled quality control, because from the observations carried out at the sorting site, errors are still found in the sorting process that have an impact on the high level of coconut defects.

B. Histogram

The next stage is to compile a histogram diagram to present tabulation data that shows the most common types of coconut defects. Based on the results of the examination on the check sheet and data on the number of coconut defects in 2024, the information is then visualized in the form of a bar graph. The following is the damage data from January 2024 to December 2024:

Table 2 Results of Coconut Defect Histogram Data in 2024

Number of Sorting (Item)	Broken Coconut	Rotten Coconut	Sprouted Coconut	Amount of Damage
363.153	6.614	5.896	4.399	16.909

Based on Table 2, the number of coconut sorting is 363,153 grains with 16,909 defects during the sorting process. Some of the highest categories of defects were broken coconuts as many as 6,614 grains and the lowest defects, namely overly old coconuts as many as 4,399 grains.

The defects listed in Table 2 are the result of direct observation and interviews with Mrs. Tuti Wika Winanti as the owner of Wika Kelapa MSMEs. This observation covers the operational process during the sorting process as well as various problems faced in the MSMEs. Below displays a histogram showing data on coconut defects in

2024 as follows:

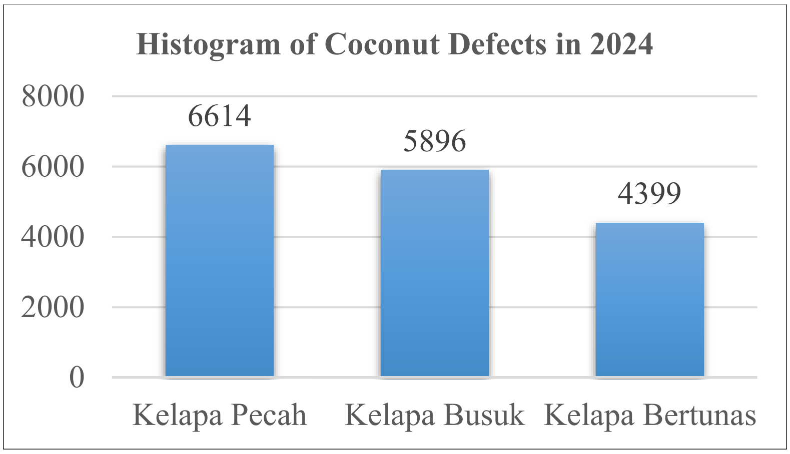

Figure 1 Coconut Defect Histogram

Based on the data, Figure 1 shows the histogram graph with the highest defect is broken coconut with a total of 6,614 grains. Broken coconuts often occur when the peeling process with excessive pressure, coconut accumulation and poorly paid attention to the transportation process can also cause coconuts to break easily. This must certainly be repaired immediately so that damage can be minimized and business profits are optimal.

The lowest defect was found in sprouted coconuts with a total of 4,399 damages. Sprouted coconuts cannot meet the needs of Wika Kelapa MSME customers. Coconuts that have shown bud growth cannot be shipped because they do not meet market standards so that they can cause losses for Wika Kelapa MSMEs.

C. Diagram Pareto

Once the histogram is complete, the next step is to create a Pareto chart. This diagram serves to define and select the main problems that need to be fixed to improve product quality, by sorting the problems from the most significant to the smallest.

Coconut defects that appear during the sorting process can be quickly identified, so that defective coconuts can be separated from coconuts that are in accordance with market standards. This process is carried out by sorting the number of disabilities from the most to the least, as well as calculating the cumulative percentage of the number of disabilities. $\times 100 = 26\%$

The following table 3 cumulative percentages are useful to state how much difference there is in frequency between several dominant problems occurring:

Table 3 Recap Results of the Percentage of Coconut Defects in 2024

Yes	Types of Damage	Sum	Percentage	Cumulative
1	Broken Coconut	6614	39%	39%
2	Rotten Coconut	5896	35%	74%

3	Coconut Too Old	4399	26%	100%

Pareto charts can be compiled by referring to the type of disability, the percentage of disability, as well as its cumulative percentage. The results of this data analysis are then processed using Minitab to obtain a more informative and structured pareto chart. The following is presented in Figure 2 which shows the results of the pareto chart processing:

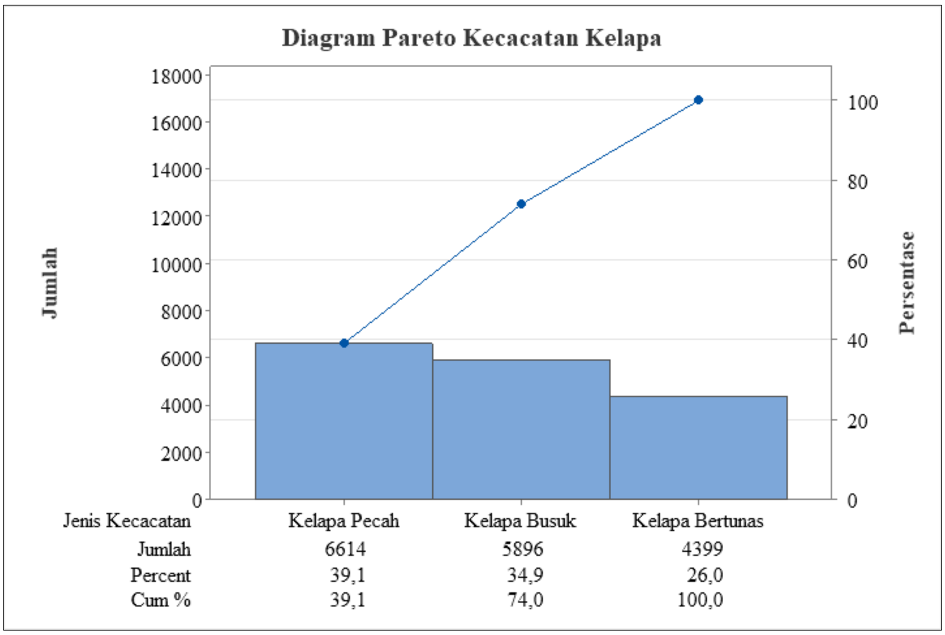

Figure 2. Pareto Diagram of Coconut Defects

Based on Figure 2 above, it shows that the largest percentage of defects that occurred was broken coconuts with a percentage of 39.1% with a total of 6,614 defects. This shows the priority of repairs that must be handled immediately by business owners, while the smallest percentage of defects is sprouted coconuts with a percentage of 26% with a total of 4,399 defects.

D. control map (P – Chart)

The next step is to compile a control map (p-chart) to evaluate whether the defects that occur in 2024 are still within the control limits. Further analysis of the p-chart or control map was carried out to ascertain conditions during the sorting process. Based on observations and historical data during the sorting from January 2024 to December 2024, the following is an analysis of the P-Chart calculation:

a) Calculating the Proportion of Damage using the formula of equation (2):

January 2024 $= \frac{np}{n} = \frac{1.512}{29.986} = 0{,}050$

February 2024 $= \frac{np}{n} = \frac{1.270}{29.585} = 0{,}043$

Information:

np = A lot of damaged coconuts

n = Quantity of samples

b) Calculating the *Center Line* using the equation formula (3):

$$\bar{p} = \frac{\sum np}{\sum n} = \frac{6.614}{363.153} = 0{,}047$$

Information:

$\sum np$ = Total number of damaged

$\sum n$ = Total number examined

c) Calculate the *Upper Control Limit* using the equation formula (4):

$$\mathrm{UCL} = \bar{p} + 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$$

$$= 0{,}047 + 3\sqrt{\frac{0{,}047\,(1-0{,}047)}{363.153}} = 0{,}050$$

Information:

$\bar{p}$ = Average coconut damage

n = Total group or sample

d) Calculate the *Lower Control Limit* using the equation formula (4):

$$\mathrm{LCL} = \bar{p} - 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$$

$$= 0{,}047 - 3\sqrt{\frac{0{,}047\,(1-0{,}047)}{363.153}} = 0{,}043$$

Information:

$\bar{p}$ = Average coconut damage

n = Total group or sample

Table 4. Recap of the 2024 Coconut Defect Control Map

Moon	Number of Sorting	Total Damage	Propose	CL	UCL	LCL
January	29.986	1512	0,050	0,047	0,050	0,043
February	29.585	1270	0,043	0,047	0,050	0,043
March	30.273	1547	0,051	0,047	0,050	0,043
April	30.032	1568	0,052	0,047	0,050	0,043
May	30.588	1464	0,048	0,047	0,050	0,043
June	31.974	1777	0,056	0,047	0,050	0,043
July	29.697	1421	0,048	0,047	0,050	0,043
August	31.002	1074	0,035	0,047	0,050	0,043
September	31.629	1343	0,042	0,047	0,050	0,043
October	30.896	1464	0,047	0,047	0,050	0,043
November	28.236	1136	0,040	0,047	0,050	0,043

December	29.255	1333	0,046	0,047	0,050	0,043

Based on the results of the calculation in Table 4, the following control map graph can be made:

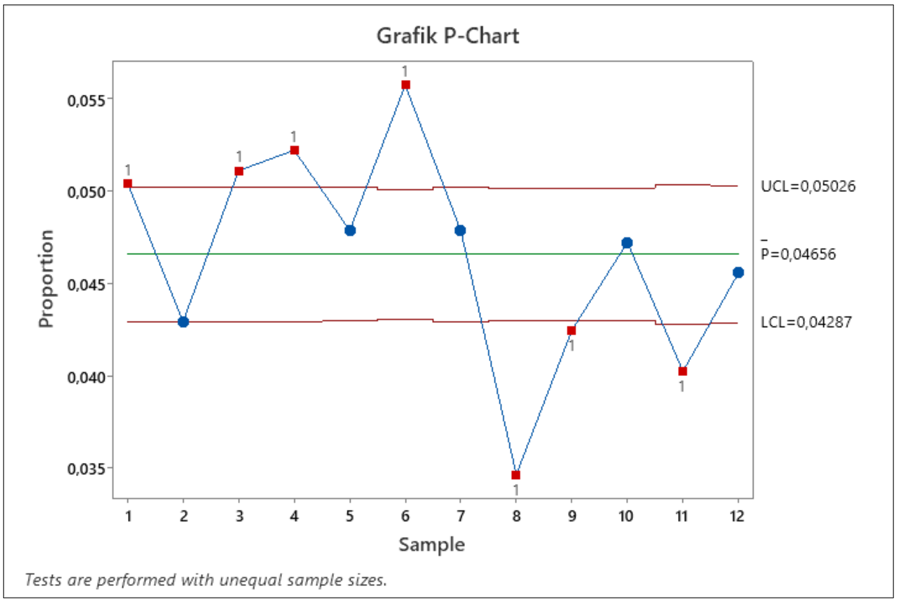

Figure 3. P-Chart Control Map

Based on Figure 3 showing the results of the calculations and graphs of the control map above, it can be seen that quality control during January 2024 to December 2024 is still uncontrollable and there are still irregularities. This is indicated by the presence of a point that passes the upper control limit and the lower control limit. In the control map, there are 7 points that exceed the statistical control limit that has been set, namely in January (0.050), March (0.051), April (0.052), June (0.056), August (0.035), September (0.042), and November (0.040)

The results of the calculation of the p-chart control map can be concluded that quality control in Wika Kelapa MSMEs has results that exceed the control limit, indicating irregularities in the sorting process. Therefore, further improvements are needed in the quality control system to overcome the problems that occur and prevent future problems.

2. Root Cause Analysis (RCA)

The next step in quality control analysis is to determine the factors that cause defects in the sorting process in Wika Kelapa MSMEs. To identify the cause of this problem use a cause-and-effect diagram, which is visually represented in the form of a fish bone diagram. The factors that generally cause coconut defects can be classified as follows:

1) Workers (People), i.e. workers who are directly involved in the sorting process.

2) Coconut (Material), which is coconut shells that will be sent to customers.
3) Method (Method), which is an instruction or work order that must be followed in the sorting process.
4) Environment, which is the situation around the sorting site that directly or indirectly affects the quality of coconuts.

Through interviews and direct observations with the business owner, Mrs. Tuti Wika Winanti, and workers, the causes of coconut defects—broken, rotten, and sprouted—were analyzed using fishbone diagrams and the five-whys method. For broken coconuts, the fishbone diagram identified human factors (worker carelessness, lack of skill, fatigue), method factors (improper peeling, rough transportation), material factors (poor-quality or cracked coconuts, inadequate storage), and environmental factors (rough travel conditions, humidity). The five-whys analysis further traced these issues to their root causes, such as insufficient worker training and poor handling techniques.

Similarly, rotten coconut defects were linked to human factors (worker inexperience, lack of precision), method factors (improper storage, delivery delays), material factors (contaminated coconuts), and environmental factors (mold growth, unhygienic warehouses). The five-whys method revealed underlying issues like delayed processing and unsanitary storage conditions. Meanwhile, sprouted coconuts were attributed to human factors (worker fatigue, inattention), method factors (late harvesting, prolonged storage), material factors (overripe coconuts), and environmental factors (poor ventilation, humidity), with the five-whys pinpointing causes such as untimely sorting and unsuitable storage environments.

Following the identification of these defects, corrective actions were designed using the 5W+1H method to address the root causes. This approach structured improvements by defining what needed to be fixed (e.g., worker training, storage practices), why it was necessary (to reduce defects), where and when changes should be implemented (e.g., in storage areas, during sorting), who would be responsible (workers, supervisors), and how solutions would be applied (e.g., revised procedures, better facilities). By systematically addressing each factor, the proposed measures aim to enhance the sorting process and minimize coconut defects in Wika Kelapa MSMEs.

This method helps in understanding the root of the problem as well as designing effective solutions to prevent the recurrence of coconut defects. The following are proposed improvements for Wika Kelapa MSMEs using the 5W + 1H method:

a) Proposed Repair of Broken Coconut

Table 5. Proposed Repair of 5W + 1H Broken Coconut

Yes	**Factor**	***What***		***Why***	***Where***	***When***	***Who***	***How***
		Cause	**Repair**					
1	Human	Lack of worker skills, lack	Be selective in selecting	To prevent the	Twigs and	Stages of coconut	Business	Implement good working

		of thoroughness, and worker fatigue	workers and setting working hours to avoid worker negligence	coconut from breaking or cracking	storage sheds	peeling, transportation and storage	Owner	hours such as *shifts* and employee performance evaluations
2	Method	Absence of standardization of stripping, storage, and transportation	Perform monitoring and checking during sorting	To anticipate breakable coconuts	Entire sorting area	During the sorting activity	Worker	Improve stripping, transport, and storage processes as well as daily *checklists* for each process
3	Material	Coconuts have cracks since harvest, and the warehouse is inadequate	Implementation of coconut inspection before stripping on twigs	Because the poor quality of the coconut will be further damaged during the sorting process	Coconut collection location (twigs)	Before transportation to the warehouse	Worker	Conducting *coconut quality* grading and *tracking* inspection results
4	Milieu	High humidity, and poor travel conditions	Improving warehouse infrastructure and good route selection	Due to humid conditions and shocks, the coconut breaks	Storage and transportation warehouse area	During coconut storage and transportation activities	Employees and Business Owners	Adequate ventilation installation, using rubber or wooden mats and warehouse layout for air circulation

b) Proposed Repair of Rotten Coconut

Table 6. Proposed Improvement of 5W + 1H Rotten Coconut

Yes	Factor	*What*		*Why*	*Where*	*When*	*Who*	*How*
		Cause	**Repair**					
1	Human	Not checking and laymen related to coconut handling	Routinely inspect and supervise the quality of coconuts	To anticipate spoilage in coconuts during the sorting process	Twigs and storage sheds	During the sorting activity	Worker	Make a *checklist* of coconuts that can decay, and sort the coconuts regularly
2	Method	Delivery delays and incorrect storage methods	Implement FIFO system, and design good warehouse conditions	To prevent coconuts from rotting due to long storage	Storage warehouse	Storage activities before shipment	Employees and Business Owners	Completing the warehouse infrastructure (base, ventilation) and scheduling the FIFO system so that the old coconuts are distributed first
3	Material	The condition of the coconut is already contaminated with fungi and the delay in harvesting	Supervise and check the condition of the coconut	To prevent contaminated coconuts from getting into the twigs	Coconut collection location (twigs)	Before transportation to the warehouse	Employees and Business Owners	Evaluate the collection site and apply coconut inspection before it is sent to twigs and warehouses
4	Milieu	Lack of air circulation, and unhygienic areas	Pay attention to the environmental conditions of coconut storage	To prevent the growth of fungi and bacteria	Twigs and storage sheds	During the sorting activity	Worker	Clean the area regularly and use hygienic tools

c) Proposal for Improvement of Sprouted Coconut

Table 7. Proposed Improvement of 5W + 1H Sprouted Coconut

Yes	Factor	*What*		*Why*	*Where*	*When*	*Who*	*How*
		Cause	**Repair**					
1	Human	Lack of thoroughness and no monitoring of late harvested coconuts	Conducting supervision and inspection of coconut quality	To anticipate coconuts that have germinated from the beginning	Coconut collection location (twigs)	Before stripping on the twigs	Worker	Making a *checklist* of coconuts that are starting to sprout, and the implementation of SOPs for coconut inspections
2	Method	Delivery and storage delays that accelerate bud growth	Controlling the storage conditions and deployment of FIFO systems	To find out which coconuts are older to be sorted first	Twigs and storage sheds	During coconut storage and transportation/transfer activities	Worker	Make a schedule of coconut entry time and routine checks before transport and storage
3	Material	The condition of the coconut has sprouted from the beginning	Perform coconut monitoring, and sort coconuts as needed	To prevent coconuts from sprouting	Coconut collection location (twigs)	Before transportation to the warehouse	Worker	Checking coconuts and ensuring that the ripeness meets the standards

Yes	Factor	*What*		*Why*	*Where*	*When*	*Who*	*How*
		Cause	Repair					
4	Milieu	Area conditions that accelerate bud growth	Control and repair the sorting area	To prevent the growth of sprouts or coconut shoots	Entire sorting area	During the sorting activity	Business owners and employees	Perform regular monitoring, ventilation and humidity controlled

Analysis of Research Results

Based on the results of the research listed above, the analysis of the results is as follows:

1. **Percentage of Coconut Defects during the Sorting Process**

The results of the check sheet calculation in this research show that Wika Kelapa MSMEs during 2024 will be sorting 363,153 coconuts, with a total of 16,909 coconut defects consisting of broken coconuts, rotting coconuts, and sprouted coconuts. From January 2024 to December 2024, the percentage of coconut defects during the sorting process reached 55.82% and an average of 4.65%.

2. **Identification of Dominant Coconut Defects**

The results of the calculation of histograms and pareto diagrams in this research show that the highest number of defects and the dominant one is broken coconut, which is 6,614 grains with a percentage of 39.1% with a cumulative value of 39.1%. Based on the pareto principle which states the 80/20 rule which means that 80% of productivity only improves 20% of the problem, assuming that 20% of the problems of the type of coconut defect represent all types of coconut defects that occur. This research was carried out to propose improvements to the three types of damage, namely broken coconuts, rotten coconuts, and sprouted coconuts with the assumption that if repairs are made to these three types of defects, it is hoped that it can help Wika Kelapa MSMEs in overcoming and preventing the problem of defects in coconuts.

3. **Evaluation of the Coconut Sorting Process**

The results of the control map calculation (P-Chart) in this research show that:

a. The 7 points that went out of control were January (0.050), March (0.051), April (0.052), June (0.056), August (0.035), September (0.042), and November (0.040).
b. 5 points within the control limit, namely February (0.043), May (0.048), July (0.048), October (0.047), and December (0.046).

So it can be said that the number of defects that occur is less controlled and fluctuates every month, which means that it is necessary to take steps to improve the sorting process with the aim of preventing and minimizing coconut defects in Wika Kelapa MSMEs.

4. **Identify Factors Causing Coconut Defects**

This research investigated the sorting process thoroughly so as to obtain the results of the cause-and-effect diagram (Fishbone Diagram) and Five-Whys as follows:

A. Defects of Broken Coconut

Based on the results of the cause-and-effect diagram of broken coconut defects, the causes of the problem were obtained as follows:

a) Man comes from a lack of thoroughness, unskillfulness and worker fatigue. Often cracked coconuts go unmonitored because there are no clear procedures, and working hours are also irregular as workers chase targets.
b) Method (Method) comes from a peeling error because it is too rough when peeling coconut coir with a knife, the sharpness of the knife can also affect. In addition, storage and transportation procedures need to be taken into account to avoid buildup.
c) The material (Coconut) comes from the condition of the coconut from the beginning where there are cracks, and the accumulation of the warehouse can cause cracks or breaks.
d) Environment comes from a hard shock when the squeaky and humid conditions for a long time can cause the coconut to break.

Based on the results of the five-whys of broken coconut defects, the root of the problem was obtained as follows:

a) Why – 1: The peeling technique used puts excessive pressure on the coconut.
b) Why – 2: Excessive and rough pressure when coconut peeling occurs because workers do not follow proper techniques and are often in a hurry.
c) Why – 3: Hasty peeling because the workers are unskilled and do not understand the correct work techniques in peeling coconuts.
d) Why – 4: Workers are unskilled due to lack of knowledge and lack of technical training related to safe and effective coconut peeling.
e) Why – 5: The absence of standardization of work methods certainly makes workers less skilled and triggers the occurrence of broken coconuts when peeling.
f) The root of the problem: The absence of Standard Operating Procedures (SOPs) and technical training for workers led to the breakage of coconuts due to excessive pressure and unskilling. These results show that human factors are the most dominant cause.

B. Rotten Coconut Defects

Based on the results of the cause-and-effect diagram of rotten coconut damage, the causes of the problem were obtained as follows:

a) Man comes from the lack of precision and knowledge of workers. Decaying coconuts need to be anticipated when on the twigs, so it is necessary to check the condition of the coconut to prevent spoilage during the sorting process.
b) Methods derived from baseless storage can lead to contaminated coconuts, delivery delays and no implementation of the FIFO (First In, First Out) system.

c) The material (Coconut) comes from the condition of the coconut that has been contaminated since the beginning.
d) Environment comes from unhygienic storage and moisture that accelerates the growth of fungi and bacteria.

Based on the results of the five-whys of rotten coconut defects, the root of the problem was obtained as follows:

a) Why – 1: Coconuts stored for too long either on twigs or warehouses can cause shipping delays.
b) Why – 2: Coconut shipments are delayed because there is no structured coconut stock rotation system.
c) Why – 3: Coconut stock rotation is unstructured due to the absence of the implementation of good storage methods, such as FIFO (First In First Out).
d) Why – 4: The management and workers have not understood the correct storage method and do not check the condition of the coconuts regularly.
e) Why – 5: There is no standardization related to storage management so that coconuts are stored for too long until they decay.
f) The root of the problem: The absence of storage SOPs causes coconuts to be stored for too long in humid and unhygienic conditions. These results show that the method factor is the most dominant cause.

C. Defects of Sprouted Coconut

Based on the results of the cause-and-effect diagram of rotten coconut defects, the causes of the problem were obtained as follows:

a) Man (Human) comes from the lack of supervision of the condition of the coconut, and the negligence of the workers so that the coconuts sprout on the twigs are still sorted.
b) The method comes from delays in harvesting and long storage can accelerate the growth of shoots.
c) The material (Coconut) comes from the condition of coconuts that have sprouted or germinated from the beginning.
d) Environment comes from humid environmental conditions because it can support the growth of shoots.

Based on the results of the five-whys defects of sprouting coconuts, the root of the problem was obtained as follows:

a) Why – 1: Incorrect storage causes coconuts to be stored for too long before being shipped or sorted.
b) Why – 2: Too long storage occurs due to the absence of regular inspections to ensure the ripeness condition of the coconut.
c) Why – 3: The inspection was not carried out properly because there was no rotation

system for coconut stock.

d) Why – 4: The implementation of rotation and inspection was not carried out due to lack of knowledge of workers and management.

e) Why – 5: The absence of clear standardization of working methods regarding storage standards causes coconuts to sprout because they are stored for too long and weather conditions favor the growth of shoots in coconuts.

f) The root of the problem: There are no SOPs or training on storage and no inspections for the detection of sprouting coconuts. These results show that the method factor is the most dominant cause.

5. Proposed Improvements to Minimize Coconut Defects

Based on the results of the identification of coconut defects and their causes using the 5W + 1H method, the proposed improvements with the aim of minimizing coconut defects are as follows:

1) Proposed Repair of Broken Coconut Damage

Table 8. Proposed Repair of Broken Coconut Defects

Factor	Problem	Result	Proposed Improvements
Human	Lack of worker skills, lack of thoroughness, and worker fatigue	Potential damage to broken or split coconuts	Implement good working hours such as *shifts* and employee performance evaluations
Method	Absence of standardization of stripping, storage, and transportation	Potential damage to broken or split coconuts	Improve stripping, transport, and storage processes as well as daily *checklists* for each process
Material	Coconuts have cracks since harvest, and the warehouse is inadequate	Potential damage to broken or split coconuts	Conducting *coconut quality* grading and *tracking* inspection results
Milieu	High humidity, and poor travel conditions	Potential damage to broken or split coconuts	Adequate ventilation installation, using rubber or wooden mats and warehouse layout for air circulation

2) Proposed Repair of Rotten Coconut Defects

Table 9. Proposed Improvement of Rotten Coconut Defects

Factor	Problem	Result	Proposed Improvements
Human	Not checking and laymen related to coconut handling	Potential damage to rotting and contaminated coconuts	Make a *checklist* of coconuts that can decay, and sort the coconuts regularly
Method	Delivery delays and	Potential damage to rotting and contaminated	Equipping warehouse infrastructure (base,

	coconuts		
Factor	**Problem**	**Result**	**Proposed Improvements**
	Incorrect storage method		ventilation) and scheduling the FIFO system so that the old coconuts are distributed first
Material	The condition of the coconut is already contaminated with fungi and the delay in harvesting	Potential damage to rotting and contaminated coconuts	Evaluate the collection site and apply coconut inspection before it is sent to twigs and warehouses
Milieu	Lack of air circulation, and unhygienic areas	Potential damage to rotting and contaminated coconuts	Clean the area regularly and use hygienic tools

3) Proposal to Fix Sprouted Coconut Defects

Table 10. Proposed Improvement of Sprouted Coconut Defects

Factor	Problem	Result	Proposed Improvements
Human	Potential damage to the coconut is too old and sprouts	Potential damage to the coconut is too old and sprouts	Making a *checklist* of coconuts that are starting to sprout, and the implementation of SOPs for coconut inspections
Method	Potential damage to the coconut is too old and sprouts	Potential damage to the coconut is too old and sprouts	Make coconut entry time scheduling and regular checks
Material	Potential damage to the coconut is too old and sprouts	Potential damage to the coconut is too old and sprouts	Checking coconuts and ensuring that the ripeness meets the standards
Milieu	Potential damage to the coconut is too old and sprouts	Potential damage to the coconut is too old and sprouts	Perform regular monitoring, ventilation and humidity controlled

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Analysis of Research Results

Research analysis supporting previous studies demonstrates:

1. Coconut Defect Percentages During Sorting Check sheet calculations show UMKM Wika Kelapa processed 363,153 coconuts in 2024, with 16,909 total defects (4.65% average defect rate), exceeding the 3% tolerance limit. These findings align with Santosa et al. (2022) research on bakpia production quality control, which identified similar defect rate patterns exceeding tolerance limits in small-scale food processing operations.

2. Dominant Coconut Defect Identification Histogram and Pareto diagram calculations reveal broken coconuts as dominant defects (6,614 items, 39.1%), consistent with Panjaitan et al. (2024) findings that physical damage represents primary defect categories in manufacturing processes. The Pareto principle application successfully identified priority improvement areas, supporting Oemar et al. (2021) research demonstrating SPC effectiveness in defect prioritization.

3. Coconut Sorting Process Evaluation P-Chart calculations show 7 out of 12 months exceeded control limits, indicating uncontrolled processes. These results parallel Michael A. Irawan & Farida Pulansari (2024) findings of high defect rates in manufacturing operations requiring systematic quality control implementation.

4. Defect-Causing Factor Identification RCA analysis revealed human factors dominating broken coconut defects, method factors dominating rotten and sprouted coconut defects. These findings support Saputra & Santoso (2024) research identifying similar factor patterns in production defect analysis, emphasizing the importance of systematic root cause identification.

Comparative analysis with international studies shows Indonesian SMEs face unique challenges including limited technical training, traditional processing methods, and resource constraints (Kumar et al., 2023). However, systematic SPC and RCA implementation demonstrates potential for significant improvement, as evidenced by similar agricultural processing operations achieving 40-60% defect reduction rates (Sharma & Patel, 2024).

CONCLUSIONS

Based on the research results, conclusions addressing the research objectives include: coconut quality control implementation in *UMKM Wika Kelapa* remains uncontrolled, requiring improvement steps to overcome deviations, as evidenced by 7 out of 12 months exceeding the Upper and Lower Control Limits. Factors causing coconut defects include human factors for broken coconuts (worker skill deficiencies, unclear procedures, uncontrolled working hours); method factors for rotten coconuts (absence of monitoring, unhygienic sorting areas, humidity exposure, no *FIFO* system); and method factors for sprouted coconuts (absence of monitoring/inspection, delayed harvesting, prolonged storage, adverse weather conditions). Improvement suggestions using the 5W+1H methodology include worker performance evaluation, improved working hours through shifts, clear *SOP* implementation, coconut condition checklists, grading and tracking systems, *FIFO* scheduling, and infrastructure improvements such as flooring, ventilation, and upgrades to tools and equipment.

Future research contributions should focus on developing automated quality detection systems for small-scale coconut processing operations, investigating the economic impact of quality control implementation on *SME* profitability, and creating comprehensive training programs for traditional agricultural processors transitioning to systematic quality management approaches.

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