

Minimization of waste mix ice cream with 7 Tools method and Failure Mode and Effects Analysis in the ice cream production process

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Abstract. This research was conducted as a form of quality control to eliminate waste that occurs in ice cream company. From the analysis that has been carried out for 6 months, there are 3 types of waste from defect products in the ice cream production process, namely broken stick, cut off and open seal. Therefore, researchers feel the need to apply the concept of analysis with the method of 7 Tools and Failure Mode and Effect Analysis so that the waste in the Ice Cream Company can be minimized immediately. The stages performed using the FMEA method are identifying failure modes, identifying failure effects, applying severity rating values, event rating values, detection values, and calculating the Risk Priority Number (RPN). It is used as the basis for efforts to make improvements to improve product quality and reduce product defects. Then, the results and conclusions of this study were compared with the waste report in the previous year, to calculate the percentage of waste reduction that occurred during one year. Whether it succeeds in experiencing a decrease in waste or not. Thus, the improvements made can be considered as a feasible and appropriate application of technology in the project to reduce waste.

Keywords: Waste, Ice cream, 7 Tools, FMEA, RPN, severity, occurrence, detection.

1. Introduction

Unsustainable food production and consumption systems are emblematic of food waste. Based on a survey from the Boston Consulting Group (BCG) calculates that by 2030 the amount of food wasted will increase by one-third each year. “When 2.1 billion tons will be lost or thrown away, it is equivalent to 66 tons per second” [1]. Social pressures, economic damage and environmental disasters are part of food waste, as they all lead to natural ecosystems enriched by the services provided [2].

Every food produced must go through various steps of the food value chain process before it reaches the retail or consumer stage. Because in this process it is necessary to convert raw materials to products such as energy, water and other materials. This means that disposing of food includes also disposing of all other resources that have been used during production. Thus, the food industry must be able to accept responsibility for customers, society and the environmental for all impacts that occur [3].

Ice cream is one of the foods that has a fairly rapid development in the world. Vanilla and chocolate flavors became the most popular flavors, with sales accounting for almost 36% of the total market share, vanilla 18% and chocolate 18% respectively [4]. From this case, it can direct management to look for ways to reduce waste. Because 74% of the wastewater produced by the company comes from ice cream factories, and it was also found that the volume of wastewater produced in the treatment of ice cream products exceeded the predetermined benchmark [5]. Many ice cream products cannot be sent to retailers for various reasons, so ice cream becomes waste. Industries must seek to develop processes to reclaim value from waste ice cream or ice cream mixes so that the economic and ecological impact of wasted products can be reduced [6].

The variety of products produced in the ice cream industry is getting wider and more diverse, so the waste mix minimization program must be made more effective and involve improvements in work operations, processes and evaluations based on studies or past experiences as shown in Figure 1.

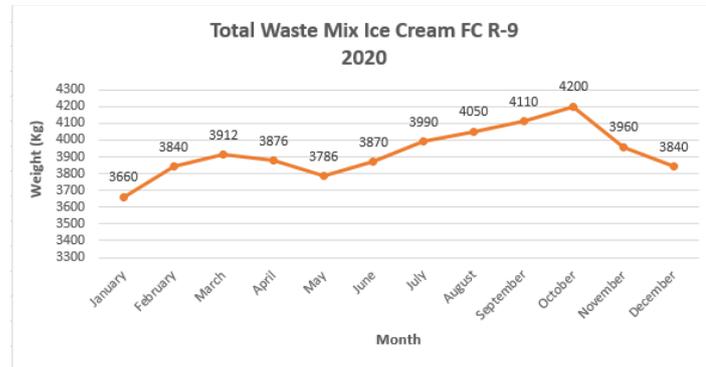


Figure 1 Graph of Total Waste Mix Ice Cream FC R-9

The results of interviews and environmental observations conducted in 2020 obtained several causes of the large amount of ice cream waste mix, such as broken sticks, open seals, and cut offs. Therefore, the company makes efforts to increase productivity without reducing the quality of performance and products produced, namely by using the 7 Tools approach. The concept of this method is that companies make efforts in suppressing and eliminating waste that can result in high production costs ranging from attribute data, stratification, pareto diagram, histogram, fishbone diagram, p-chart, and stocking diagram. So the company can maintain and develop its business by increasing activities or something of value (value added) and eliminating activities that are not worth (non-value added) that can cause waste.

It is known that in 2010 the global consumption of ice cream was about 2.4 L per capita. This means that the ice cream industry has contributed to the growth and development of the world economy [7]. From this interesting point, many researchers have studied the influence of using ice cream ingredients and have different microstructures [8].

2. Research Methods

The research method used in this study is Failure Mode and Effect Analysis, which is in the form of depicting a map of production flow in a company. This study aims to identify every problem that causes waste in the ice cream production process, and then make strategies to minimize the waste and provide recommendations in the form of improvements or new policies in the company related to the waste minimization business.

This research begins with determining the type of defect product that is considered the cause of waste in the ice cream production process. Then, time standardization and data collection are carried out to find the best time needed by each operator to complete each process with the failure mode and effect analysis methods, after which machine repairs are carried out. After some time, comparisons can be made to find out the success rate of the improvement that have been made.

The following flowchart of some of the stages performed in the study can be seen in the chart figure 2

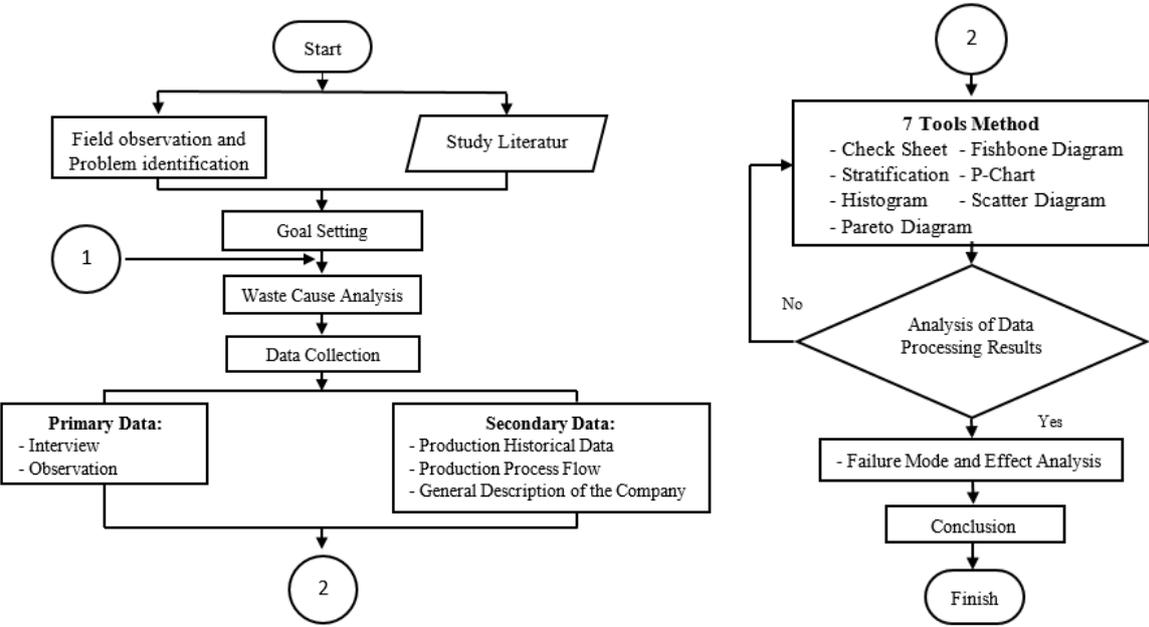


Figure 2 Research Flowchart

3. Results and Discussion

3.1 Check Sheet

Direct observations were made at the Ice Cream Company site within 2020. The main focus of this observation lies in controlling the company's production process with Ice Cream FC R-9 products in the molded stick department. In table 1, there are types of waste that occur every month.

Table 1 Types of Waste Mix Ice Cream FC R-9

Month	Produktivty (Fibrite)	Waste (Kg)			Total Waste (Kg)
		Broken Stick	Cut Off	Open Seal	
January	152.036	1.970	1.128	562	3.660
February	174.916	2.168	1.086	586	3.840
March	176.154	2.407	887	618	3.912
April	175.370	1.878	1.244	754	3.876
May	164.029	2.357	821	608	3.786
June	175.112	2.471	805	594	3.870
July	180.657	2.187	1.060	743	3.990
August	183.312	2.661	860	529	4.050
September	183.946	2.442	953	715	4.110
October	187.265	2.727	852	621	4.200
November	177.520	2.381	967	610	3.958
December	173.116	2.417	825	598	3.840

3.2 Pareto Diagram

The main purpose of the pareto diagram is to clarify the problem based on the order of its frequency and the importance of the problems to look for significant causal factors of the problem. Then the percentage

of waste is calculated by sorting the causes that have the most number. Table 2 lists the pareto diagram of was mix ice cream FC R-9.

Table 2 Pareto diagram data Waste Mix Ice Cream FC R-9

No	Waste	Total (Kg)	Percentage (%)	Cumulative Percentage (%)
1	Broken Stick	28.066	59,6	59,6%
2	Cut Off	11.488	24,4	84%
3	Open Seal	7.538	16	100%
Total		47.092	100	

From the calculations in the Table 1, it can be known the frequency and percentage of compulsive, then the next step is to make a pareto diagram in Figure 3.

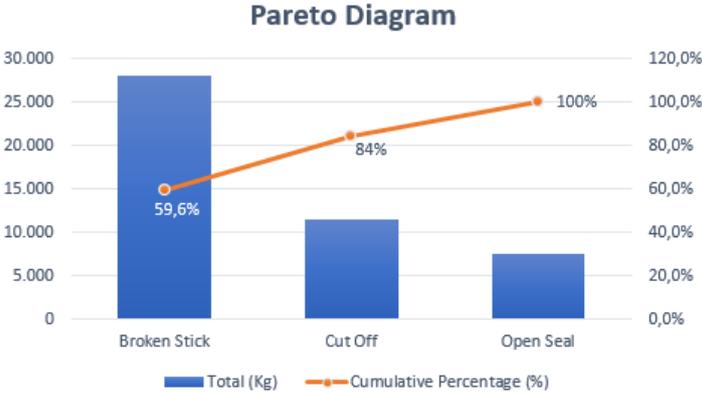


Figure 3 Pareto Diagram of Waste Mix Ice Cream FC R-9 2020

3.3 Histogram

After collecting the attribute data, furthermore a histogram has made to see the comparison of waste that occurs during the ice cream production process, as in figure 4

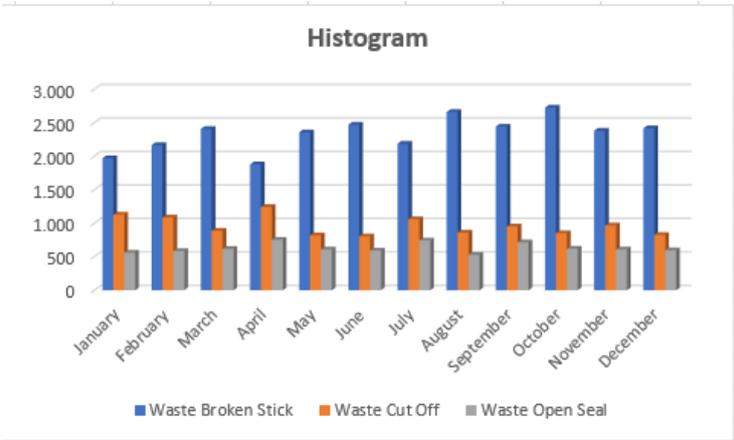


Figure 4 Histogram

3.4 Stratification

Stratification is an attempt to group waste data with cause and effect into groups that have the same characteristics in each month, as can be seen in table 3

Table 3 Stratification

Month	Cause	Effect	Month	Cause	Effect
Jan - Mar	The Jig Stick Insert is loose	Broken Stick	Jun - Aug	Servomotor rotation is weak	Cut Off
	The position of the Wrapper with the Product does not match	Cut Off		The ushape sensor is broken	Cut Off
	The Wrapper folds	Open Seal		The stick broke and got stuck in the inserted line	Broken Stick
	Sticks are not straight	Broken Stick		Heater cable broken	Open Seal
	Heater is not hot	Open Seal		Wrapper over lap	Open Seal
	Abnormal wrapper (too thin)	Cut Off		Cross Seal does not heat	Cut Off
Apr - May	Dirty cutters	Cut Off	Sep - Dec	Stick won't poke	Broken Stick
	The Pullnose conveyor does not rotate stably	Cut Off		Wrapper off Heater line	Open Seal
	Cutter End Seal is blunt	Cut Off		Abnormal wrapper (blister after heating process)	Open Seal
	Double Stick often occurs	Broken Stick		The cutting process is not centered	Cut Off
	The stick is too slippery, the gripper can't take it	Broken Stick		Cutter will not cut	Cut Off
	Wrapper off Heater line	Open Seal		Cutter End Seal blunt	Cut Off
Low Heater Temperature	Open Seal	The position of the stick and ice cream is not centered	Broken Stick		
Wrong stick size	Broken Stick	The stick doesn't stick deep enough	Broken Stick		
Ushape plate torn	Open Seal	Wrapper off Heater line	Open Seal		

3.5 Fishbone Diagram

- Broken Stick and Cut Off

Broken sticks are ice cream sticks damage so that the product is not suitable for processing to the next stage. This happens due to several factors as shown in the Figure 5. Then Cut Off is ice cream cut by the cutter during the end seal process so that the product is not suitable for processing to the next stage. This happens due to several factors as shown in the Figure 6.

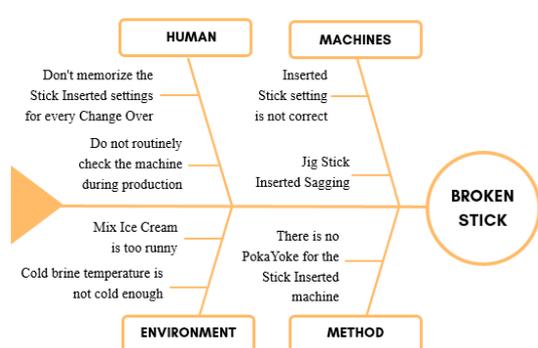


Figure 5 Broken Stick

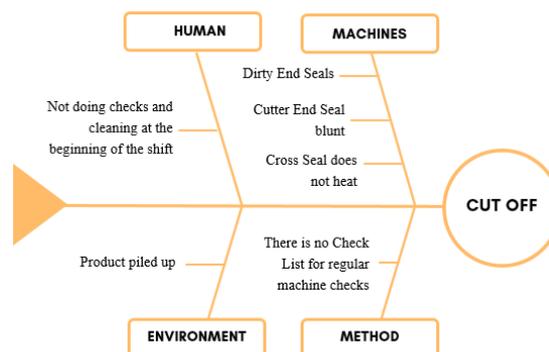


Figure 6 Cut Off

- Open Seal

Open Seal is Ice cream not wrapped tightly during the wrapping process so that the product is not suitable for processing to the next stage. This happens due to several factors as shown in the Figure 6.

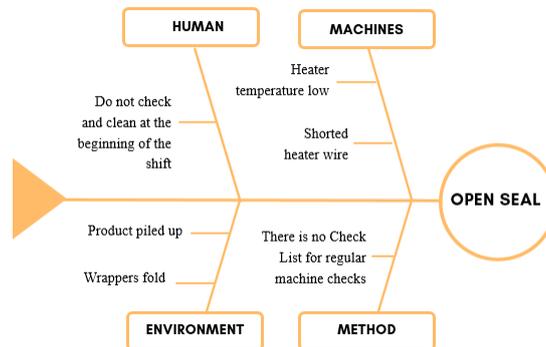


Figure 6 Open Seal

3.6 Control *p*-Chart

In the processing of waste data of this product, the control limit of each observation sample is used to find out the upper control limit (UCL), and the lower control limit (LCL), which was used to calculate the standard deviation (Sp), here is presented table 4 data processing for each sample

Table 4 Waste data processing with control limits

Month	Total Waste (Kg)	Average	UCL	LCL
1	3660	3924,5	4368,1	3480,9
2	3840	3924,5	4368,1	3480,9
3	3912	3924,5	4368,1	3480,9
4	3876	3924,5	4368,1	3480,9
5	3786	3924,5	4368,1	3480,9
6	3870	3924,5	4368,1	3480,9
7	3990	3924,5	4368,1	3480,9
8	4050	3924,5	4368,1	3480,9
9	4110	3924,5	4368,1	3480,9
10	4200	3924,5	4368,1	3480,9
11	3960	3924,5	4368,1	3480,9
12	3840	3924,5	4368,1	3480,9
Total	47094			
Std. Deviation	147,9			

It is then scattered into the *p*-control to examine the variation or diversity of data, as shown in figure 7

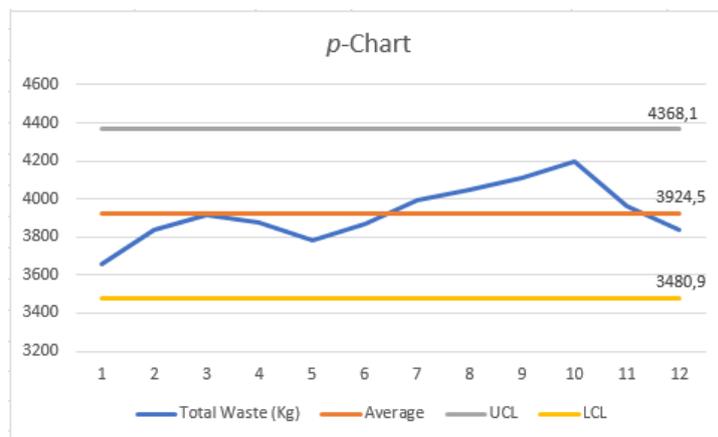


Figure 7 Control *p*-chart map from observations of Table 4

3.7 Scatter Diagram

From the form of the graph produced in figure 8, it can be known that this graph has a positive correlation which means that the higher abnormality that occurs in the production machine, the increase in the amount of ice cream waste. So if you want to reduce the amount of waste, one of the actions that must be done is to reduce the level of abnormality.



Figure 8 Scatter Diagram

3.8 Severity, Occurrence, Detection, and RPN Analysis

Identification of the mode of failure and its effects is used to obtain alternative fixes to the failure. FMEA is a tool used to determine the severity, occurrence, and detection value of each waste where the highest RPN value was obtained. The value was used to determine alternative improvements for the company in improving the quality of its production process. Alternative improvements are arranged based on RPN values exceeding points by 80. Table 5 lists the calculation of FMEA analysis.

Table 5 Severity, Occurrence, Detection and RPN Analysis

Waste	Sub-waste	Potential Effect	S	Cause	O	Control	D	RPN
Squishy Stick		The product easily falls when the Gripper Extractor is lifted	6	The vendor's Stick design is not quite right	5	Product material inspection, Communication with vendors, upgrading	6	180
		The product cannot be removed by Gripper Extractor, rejected	6	Machine stick inserted error	8	Preventive maintenance	2	96
Broken Stick	Italic Stick	Product does not lift Gripper Extractor	6	Mix is still liquid, the operator doesn't check the condition of the mix	7	Dissemination of work rules	2	84
		The stick position is not centered	7	The operator does not memorize the machine settings	6	Created Poka Yoke	2	84
	Double Stick	Product falls when the extractor lifts, reject	6	Loose jig sticks	5	Improvement machine	3	90
Cut Off	Blunt cutters	Wrapper is not cut	7	life of the cutter has long	5	Replace Cutter with a new one	3	105
	Cutter will not cut	Products stack and connect	6	The Marking Wrapper cannot be read by the usape sensor	6	Rearrange the wrapper according to the ushape path	2	72
Dirty End Seals		Wrapper is not cut to the maximum	7	Operators do not routinely clean End Seals	7	Created a point check cleaning machine	3	147
	Cross Seal does not heat	The product wrapper opens after the cutting process	7	The cable is damaged	4	Repair by Engineering	2	56
Open Seal	Low heater temperature	Split product wrapper	7	The cable is damaged	4	Repair by Engineering	2	56
	Wrappers fold	Product piled up	6	Operators do not routinely check the machine	5	Created check point machine	2	60
			6	The wrapper is off the heater path	9	Rearrange the wrapper according to the heater path	2	108

3.9 Before and After

Total Production, waste, percentage, and production cost in one year before improvement as listed in Table 7. Then, total Production, waste, percentage, and production cost in one year after improvement as listed in Table 8.

Table 7 Before analysis and improvement

Table 8 After analysis and improvement

Total			
Production (Fibrite)	Waste (Kg)	Persentase (%)	Cost
2.103.433	47.094	10%	Rp 612.222.000

Total			
Production (Fibrite)	Waste (Kg)	Persentase (%)	Cost
2.315.200	28.310	6%	Rp 368.030.000

Based on Figure 9, the comparison chart of waste in 2021 after analysis and improvement looks to have decreased when compared to 2020, this indicates that the improvement activities that have been carried out are running well.

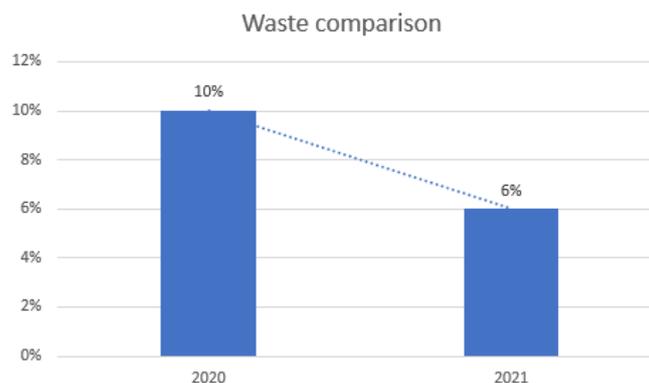


Figure 9 Comparison chart of Waste Mix Ice Cream FC R-9

4. Conclusion

From the data, it can be concluded to be some of the main alternative improvements. This is necessary so that the composed alternatives become more focused on the company's problems and facilitate the calculation of alternative combinations in value engineering:

1. Communicating with vendors to upgrade material specifications that are considered incompatible with existing machines in the company. Upgrading material specifications is very important because it can reduce waste.
2. Improving the machine as an effort to fix every problem that has occurred and increase production capacity so that the output produced is in accordance with the target.
3. Socialization of work rules, making checklists, and loading Poka Yoke so that operators better understand the specifications of products and machines.

5. References

- [1] Hegnsholt E, Unnikrishnan S, Pollmann-Larsen M, Askelsdottir B and Gerard M 2018 *Tackling the 1.6 Billion Ton Food Loss and Waste Crisis*. (Switzerland: The Boston Consulting Group Geneva).
- [2] Caldeira C, Laurentiis V, Corrado S, and Sala S 2019 *Quantification of food waste per product group along the food supply chain: A mass flow analysis*. (Italy: European Commission-Joint Research Center) p 479-488.
- [3] Christina S, Silke F, Judith K, Guido R and Petra T 2017 *A Participatory Approach to Minimizing Food Waste in the Food Industry*. (Germany: Munster University of Applied Science)
- [4] Antonios K, Laurence S and Adisa A 2019 *Environmental impacts of ice cream*. (UK: The University of Manchester) p 259-272.
- [5] Sing R and Imam M 2014 *Waste Water Management In Dairy Industry*. (India: Motilal Nehru National Institute of Engineering and Technology). Vol.33, p 672-683
- [6] Rafael A, Benjamin M, Changhoon L and Chen L 2022 *Passive separation of waste ice cream*. (USA: Agricultural Research Service). Vol.139.

- [7] Majid D, Mortaza A and Mojarab S 2017 *Exergetic performance analysis of an ice cream manufacturing plant: A comprehensive survey*. (Iran: University of Tehran). Vol.123, p 445-459
- [8] Vanelle M, Valeria P, Marco A, Pedro H, Liliane E and Luis A 2014 *Study of the perception of consumers in relation to different ice cream concepts*. (Brazil: Universidade Federal de Vicosa). Vol.36. p 161-168.