Implementation of Six Sigma to Increase Sigma Level: A Case Study of Food Industry

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Abstract

Modern marketplaces need constant adaption of firm offerings due to their urgency. In order to fully satisfy the needs and expectations of each partner (workers, consumers, and other stakeholders) and to preserve competitive value, the creation and continuous improvement of the quality would be necessary. The company where we perform our experiment will attempt to enhance customer satisfaction while raising the quality. A well-known FMCG (Fast Moving Consumer Goods) company in Indonesia is the consumer product business group PT XYZ. The cashew version of the chocolate pasta stick is one of the goods created by PT XYZ's Chocolate Division. There is a packaging step involved in the flow process of creating these chocolate paste sticks with cashews. During the product's packing, there is a difficulty.

Finally, Six Sigma, a powerful approach, helps with cost cutting. Better products, more effective processes, and defect prevention lead to increased profitability and market share. This is accomplished using the Six Sigma sub-methodologies DMAIC and DMADV (Andersson et al., TQM Mag 18:282-296, 2006). The implementation of the six-sigma technique in a wider range of manufacturing activities is made possible by a case study that was presented. Researchers studying quality management, individuals working in the industrial sector, and anybody else interested in quality improvement should find this article informative. The findings of this study will improve the sigma level's worth and lessen business losses brought on by cases that involve both material and moral issues.

Keywords

Six Sigma, DMAIC, Sigma Level, Cost Reduction

1. Introduction

A company's production process can be evaluated using the Sigma quality level, which measures the process defect rate. The DMAIC methodology is one of the most often used approaches for achieving Six Sigma objectives, according to (Koning and Mast 2004). Numerous top-tier businesses have implemented Six Sigma, which has a proven track record of success (Maleyeff and Kaminsky 2002). According to (Rajagopalan et al. 2004), Six Sigma techniques enhance operational performance to raise client satisfaction with a company's goods and services. Six Sigma is defined in the first stream as a set of statistical techniques used in conjunction with quality management to build a framework

for process improvement (Goh and Xie, 2004; McAdam and Evans, 2004). Two Six Sigma sub methodologies are employed to achieve this: Define, Measurement, Analysis, Improvement, and Control (DMAIC).

Table .1 Sigma Level

Sigma Level	DPMO	Quality Level	COPQ (% of sales)
1	691.000	31%	
2	309.000	69%	>40%
3	67.000	93,3%	25-40%
4	6.200	99,4%	15-25%
5	230	99,98%	5-10%
6	3,4	99,997%	0-5%

The issue in this study is when the chocolate paste from the filling section is not wrapped in the outside package. A horizontal flow wrapping machine is used for the process of wrapping stick paste in an outer cello/packaging. The paste stick will be fed into the revolver, down the conveyor, into the sliding hopper, and lastly into the outer cello for packing. The issue with this packing procedure is that there are empty spaces in the revolver, forcing the operator to manually fill in the gaps on the conveyor. If the voids are not filled, the outer cello's contents stay empty; nevertheless, if there are too many vacant spaces and the operator must manually fill them, this could present workplace risks including being squeezed. This plan was put in place to lessen the quantity of empty outer cellos and the possibility of workplace injuries.

1.1 Objectives

The key objectives of this study are:

- To assess the most possible factors that lead to rejection.
- To prioritize the factors that influence the case of empty outer packaging in order to locate the source of 80 percent of the rejects.
- To suggest improvement to reduce the case of empty outer packaging.

2. Literature Review

To achieve the hard target of 3.4 ppm defects, or 3.4 faults per million opportunities, Motorola created and implemented the first six sigma concept in 1987 (Schroeder et al. 2008). Many businesses, including General Electric, Honeywell, Caterpillar, and Johnson Controls, have used Six Sigma in the past and reaped significant benefits (Zu et al., 2008). General Electric introduced Six Sigma and made a lot of noise about it in the mid-1990s (Thawani, 2004). To address quality issues before they become defects, Six Sigma focuses on the number of possibilities inside a process that could result in defects rather than the number of flaws themselves (Antony 2007).

The fourth definition of Six Sigma describes it as an analysis strategy that uses scientific approaches. By reducing process variability and waste in business operations, it is viewed as a well-structured continuous improvement methodology by (Banuelas and Antony, 2004) and (Thawani 2004). According to (Black and Revere 2006), Six Sigma is a well-liked and widely applied quality improvement system. Design, Measure, Analyze, Improve, Control (DMAIC) is a Six Sigma technique that is comparable to Deming's PDCA. According to (Kumar et al. 2007), TQM and other quality improvement initiatives are an extension of Six Sigma (Plan, Do, Check and Act).

Define, Measure, Analyze, Improve, and Control, or DMAIC, is an effective data-driven tool and process improvement technique. DMAIC is one of the six sigma techniques, but it can also be used to enhance other processes or as a stand-alone quality improvement strategy (Neha, 2013).

3. Methods

Defining the problem, measuring the problem, analyzing the factors affecting the problem, suggesting improvements that can reduce the empty of outer packaging, controlling the empty of outer packaging under a target percentage after the improvements are implemented.

3.1 Company Background

PT XYZ is one of consumer product business groups in Indonesia is a subsidiary of the XYZ Group, which is one of the recognized FMCG (Fast Moving Consumer Goods) in Indonesia. PT XYZ is known as a successful market leader for products or the first food industry in Indonesia to produce new innovations in its category. Currently, XYZ's product are spread over 3 continents. There are Asia, Africa, and middle America. XYZ's products are divided into 2, namely beverages and processed foods with 6 divisions, there are biscuit, candy, wafer, chocolate, coffee, and healthy food.

3.2 Define Phase

The flow process for chocolate paste product packaging starts from the filling process, in this filling phase the chocolate will be put in a tank that is useful for storing chocolate from the central kitchen. After going through a metal detector, the product will be sent to the packing section, this packing phase starts from wrapping the product using outer packaging. (Figure 1)

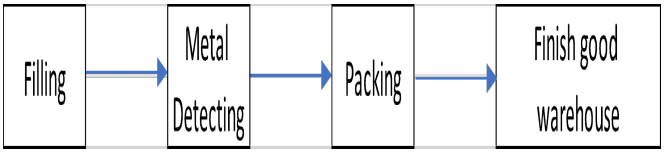

Figure 1 Flow Process of Chocolate Stick

It is this outer package that sometimes does not fill the product, which eventually results in a void in the outer packaging.

In this project, the goal setting based on the method owned by PT XYZ, the Chocolate Division, namely the SMART method. SMART means specific, measurable, achievable, realistic, and timetable

- Specific : Lower case outer empty chocolate paste cashew 10 gr
- Measurable : Reducing the case of empty outer packaging of 10-gram cashew chocolate paste sticks from 1.8% to 0.01%
- Achievable : the desired achievement of this project case decreased by 90-100%
- Realistic : Target in the case of the empty outer packaging is not equal to 0
- Timetable : The problem can solve as fast as possible.

3.3 Measure Phase

On August 5 to 14, 2021, the defect opportunity per million product is significant as seen in Table 2. Because there were so many cases on day 4, the data suggests that cases of empty exterior packing can occur up to 27946 times.

$$DPM\ (Defect\ per\ Million) = \frac{Total\ Number\ of\ Defects}{Sampe\ Size}\ x\ 1{,}000{,}000$$

Table 2 PPM Value

Defect Opportunity Per Product				
Date	Defect	S/S	PPM	Target
05-Aug	209	14850	14074	100
06-Aug	185	16200	11420	100
09-Aug	217	16200	13395	100
11-Aug	415	14850	27946	100
12-Aug	170	14850	11448	100
13-Aug	88	6750	13037	100
14-Aug	125	16200	7716	100

3.4Analyze Phase

Following the definition of the problem and the measurement of the flaw for the future, the analysis phase is required to further evaluate the problem. The data obtained previously, namely the defect data, will be evaluated. To fix this, a why analysis and cause-and-effect diagram tool, also known as a fishbone diagram, used to identify the problem's root cause.

3.4.1 Why Analysis

Table 3 WHY Analysis

Problem	Main cause	Why?	Why?	Why?	Why?	Why?
Empty Outer Packaging	Man	Lack of knowledge	Lack of Training	No SOP	Do not understand the defect	
	Machine	Infeed not filled with the chocolate stick	The sensor is not consistently function	Sensor sensitivity getting lower	No monitoring sensor sensitivity	
	Machine	Revolver not filled with chocolate stick	Condition of the direction on entering the chocolate stick into the revolver is flat	The angle of sliding hopper is not up to standard		
	Machine	As Revolver is Loose	Condition of As in the revolver not stick well to the revolver	Bolt and nuts in the revolver already loose		
	Material	Mushy chocolate stick	Size of the centre seal of inner packaging is not right	Operator can not set the size of the centre seal	There is no standard of mushy stick	

3.4.2 Sliding Hopper

The tilt angle of the sliding hopper is considered in this cause. It can be seen from the 3-month data that there are still a lot of varied angle sizes, which could be due to the intense pressure exerted by the chocolate paste stick. (Table 4)

Table 4 First Trial on Sliding Hopper

Slope Angle	Empty Cases	Total Sample	%Empty Cases
17-18	494	28350	1,74%
19,5-20,5	63	28350	0,22%

3.4.3 Sensitivity Sensor on Revolver

Testing causes this time discusses the sensitivity of the sensors in the revolver. there are cases where the sensitivity of this sensor drops which causes the sensor to not read the blanks on the revolver. According to the data, the case of decreased or inconsistent sensor sensitivity was 21.5%. Why this case can cause the outer packaging to be empty, because when the sensor does not read the void, then this blank will continue until the packing process. However, when the sensor is fully function, the cases can reduce until 100%.

3.4.4 Chocolate Stuck is Mushy

The chocolate stick that QC is looking for is a tight one. Because the chocolate stick is not captured in the revolver when it is soft or mushy like in the Figure 2 and 3, it has the potential to result in an empty outer package case.

Figure .2 Mushy Stick

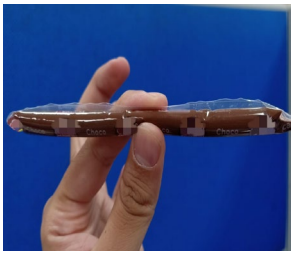

Figure 3 Tight Stick

First checked the size width of the inner packaging to wrap the chocolate. In the field, the width of the inner packaging has different sizes, the width of the inner packaging in the production section has a size of 41-43 mm, this study discussed with the QC team about the acceptance criteria for the chocolate paste stick. Tests were carried out using the width of the center seal with sizes 0.5 cm, 0.6 cm, 0.7 cm, and 0.8 cm. The Table 5 were obtained through testing samples for several days and references from previous studies.

Table 5 First Trial to Finding Best Size of Chocolate Stick

Inner Cello Width	Vertical Seal Width			
	0,5	0,6	0,7	0,8
4,1 cm	Mushy	V	twist	Did not pass seal test
4,2 cm	Mushy, Bubbling	Little bit Mushy	V	Twisted, Winged
4,3 cm	Very Mushy, Bubbling	Mushy	V	V

If use inner cello packaging with a width of 4.2 cm, the condition of the chocolate stick if using a center seal width of 0.5 cm is very soft, if using 0.6 cm it is a little soft, using 0.7 cm the condition of the chocolate stick will be solid, and using 0.8 cm makes the chocolate paste very dense and does not pass vacuum test.

3.4.5 Axle on Revolver is Loose

Table 6 Check Axle Revolver in Packing Machine

Checking As Revolver in Packing Machine							
Date	Test	08:00	09:00	10:00	11:00	12:00	13:00
6-11 Sep 2021	1	v	v	v	v	v	x
	2	v	v	x	v	v	v
	3	x	x	v	v	v	v
	4	v	v	v	v	x	x
	5	x	v	x	x	x	x
	6	v	x	v	v	v	v
	7	v	v	v	x	v	v
	8	x	v	v	v	x	x
	9	v	x	x	v	v	v
	10	x	v	x	x	x	x
Percentage		60%	70%	60%	70%	60%	50%
Average		61,7%					

According to the data Table 6 above, do up to ten times every hour. For example, at 8 a.m., the sensor can still read the blank fine on checks 1 and 2, but not on the third take. A loose revolver axle has this effect. The effect of this slack axle has the potential to cause cases of empty outer packaging as high as 61.7%

3.4.6 Fishbone Diagram

In six sigma technique, a fishbone diagram is one of the analytical methods used to determine the root cause of a problem. The diagram is known as a fishbone diagram because of its shape, which resembles the bones of a fish. This shows that the fishbone diagram for the cause that can reduce the cases more than 80%. (Figure 4).

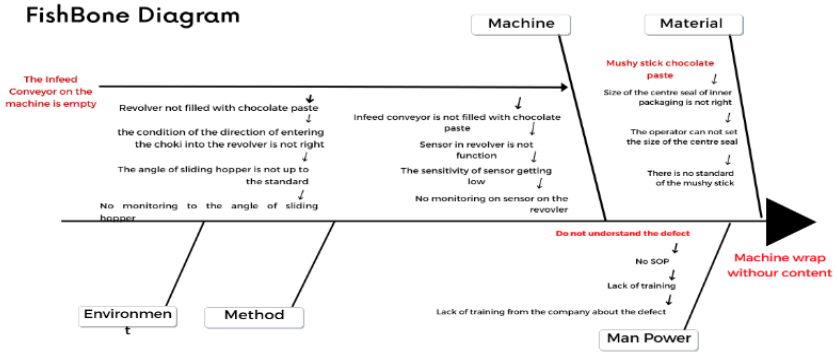

Figure 4 Fishbone Diagram

4. Data Collection

This chapter will demonstrate the results obtained after completing the design of the experiment, as well as some analysis of the experiment's findings and suggestions for improvement.

4.1 Improvement Phase

The DMAIC technique concludes with the improvement phase. This phase will detail the corrective activities done to address the issues that have arisen. There are three variables that contribute to the defect problem with items. The root cause and fishbone graphic above also describe the reasons that cause these faults. This section will describe the proposed enhancement to address the defect issue.

4.1.1 Prepare Repair Steps

At this point, some preparations are made to make improvements to problems that occur, problems that can cause cases to occur again. Existing problems began to be fixed from August to October, carried out by the author and in collaboration with the maintenance team.

4.1.2 Trial Improved the Angle of Sliding Hopper

Conducting the trial is required to improve and reduce the fault problem. The items were defective due to the auto feeder's high and angled sliding hopper. Because the height is insufficient to maintain the angle of the sliding hopper, the angle of the auto feeder must be recalculated. The corporation can discover the optimal high and angle for the auto feeder by running the trial, which will limit the number of cases where the chocolate stick does not fill in the hole of the auto feeder. (Table 7)

Table 7 Improvement Phase 1 in Sliding Hopper Angle

Improvement Phase 1						
Date	Machine	Angle	Empty	Sample	Percentage	PPM
3-24 Dec	**M.1**	18,2	322	113400	0,28%	2840
	M.2	16	588	113400	0,52%	5185
	M.15	17,3	404	113400	0,36%	3563
	M.4	19	275	113400	0,24%	2425
	M.5	18	365	113400	0,32%	3219
	M.16	18,6	320	113400	0,28%	2822
	M.33	16,7	621	113400	0,55%	5476
	M.8	18,9	290	113400	0,26%	2557
	M.9	18,4	319	113400	0,28%	2813
	M.10	15,6	823	113400	0,73%	7257
	M.11	19,2	236	113400	0,21%	2081
	M.12	16,5	640	113400	0,56%	5644
	M.13	17	612	113400	0,54%	5397
	M.14	19,8	150	113400	0,13%	1323
Avg		17,8	426,1		0,38%	3757
Sigma Level						4,2

the results of a significant decrease in phase measurement can be seen. The angle used is the angle that has been standardized by the company, which is 17.5 degrees. The result shown is that there is a decrease in outer empty cases on this packing machine, where the decrease in cases is 81.64%.

Table 8 Improvement Phase 2 in Sliding Hopper Angle

Improvement Phase 2						
Date	Machine	Angle	Empty	Sample	Percentage	PPM
3 - 24 Jan	**M.1**	20	6	178200	0,00%	34
	M.2	18,2	22	178200	0,01%	123
	M.15	19,1	11	178200	0,01%	62
	M.4	19,5	9	178200	0,01%	51
	M.5	19	38	178200	0,02%	213
	M.16	19,5	12	178200	0,01%	67
	M.33	18,5	186	178200	0,10%	1044
	M.8	20	17	178200	0,01%	95
	M.9	20	14	178200	0,01%	79
	M.10	17,8	43	178200	0,02%	241
	M.11	19,8	3	178200	0,00%	17
	M.12	17,5	56	178200	0,03%	314
	M.13	18	26	178200	0,01%	146
	M.14	19,5	8	178200	0,00%	45
Avg		19,03	32,2		0,0181%	181
Sigma Level						5,1

The angle that is set in phase 2 is obtained through a random trial on several machines at the time of improvement phase 1. Then a 19-degree angle is found, indicating that the outer empty case is reduced at that angle, leading to the notion that the larger the angle, the less empty the outer case. After that, studies were conducted on all sliding hoppers using an angle of 19 degrees or greater, with the number of samples as the improvement phase 178200 samples. (Table 8)

4.1.3 Trial Improved Sensor

The second problem in this case is the sensitivity of the sensor on the side of the revolver. The function of this sensor is to read the void in the revolver in the auto feeder. When there is a void in the revolver hole, the sensor will read the void and make the revolver spin faster so that the revolver hole that is not filled with chocolate sticks does not fall into the infeed conveyor. (Figure 5)

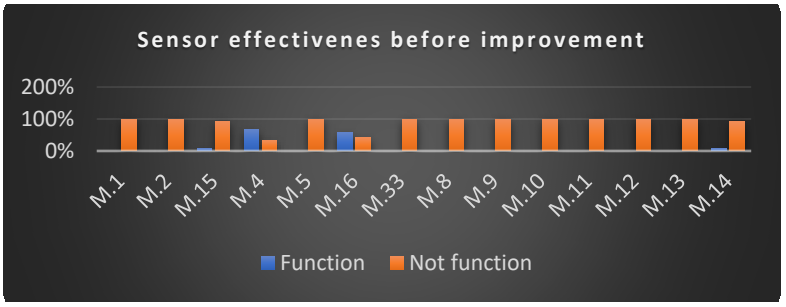

Figure 5 Sensor effectiveness before Improvement

After the first stage of improvement is carried out, the results obtained are as follows in the Figure 6:

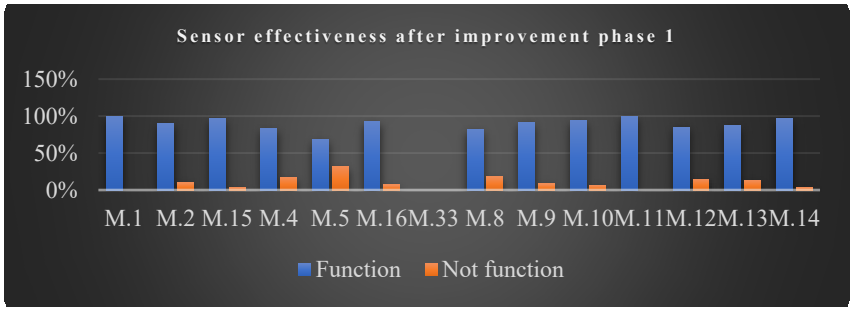

Figure 6 Sensor Effectiveness After Improvement 1

Where 5 months ago there were still a lot of sensors from the packing machine that did not work with a presentation of 89.88% and only functioned at 10.21% of the total of all sensors in the packing machine as seen in the Figure 5. After improvement, the effectiveness and sensitivity of the sensor is active again and the percentage level of sensor activity reaches 83.32% with a not function level of 16.68%.

4.1.4 Trial Improvement of Chocolate Stick Size

The size of the chocolate paste stick is one of the reasons for the empty outer case. The chocolate paste stick will become mushy if the size of the chocolate stick exceeds the standard. As a result, the authors sought a new metric for the existence of chocolate paste stick length and center seal width. Of course, in the case of mushy sticks, this is also related to the width of the raw material packaging itself, namely the width of the inner packaging. There are 3 width sizes of the inner packaging, namely 4.1 cm, 4.2 cm, and 4.3 cm. then tried a variety of widths, including 0.5 cm, 0.6 cm, 0.7 cm, and 0.8 cm. As a result, the following are the outcomes. The width of the center seal/vertical seal of 0.7 mm is the width that most enters the quality requirements, as can be observed. (Figure 7)

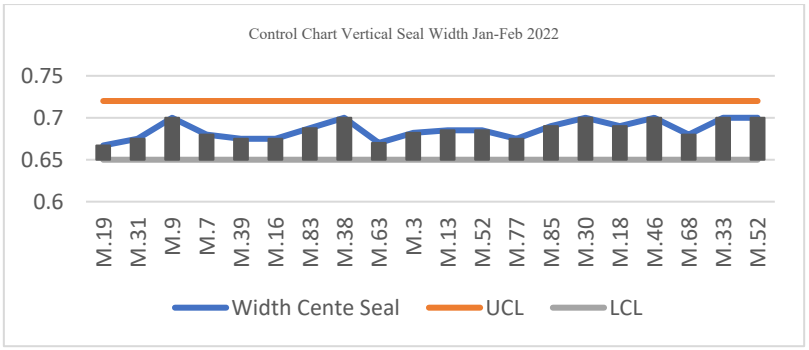

Figure 7 Control Chart Vertical Seal After Improvement

Therefore, one of the improvement steps taken is to determine the latest size of the center seal width of the chocolate paste stick.

Table 9 Result After Improvement

Avg from 20-29 Sept 2021	Width 0,6	Sample	Percentage	Width 0,7	Sample	Percentage	Reduce
SH Angle Below 19	682	47250	1,44%	112	47250	0,24%	83,58%
SH Angle Above 19	65	47250	0,14%	9	47250	0,02%	86,15%
Avg							84,87%

As shown in the Table 9 It can deduct from the statistics that a trial was conducted to determine the effective size on the seal's vertical width. After that, a trial with a vertical seal width of 0.7 cm and a trial with two circumstances with the same sliding hopper angle were conducted. As a result, there are 112 vacancies in the sliding hopper with an angle of less than 19 degrees, but only 9 times in the sliding hopper with an angle of greater than 19 degrees. This demonstrates that the vertical seal's breadth can assist prevent the occurrence of outer banks in the flow process of creating chocolate pasta sticks. The reduction in instances aided by the width of this vertical seal was 84.87 percent.

4.1.5 Conduct Training and Create Proper SOP

To solve the problem that exist, conduct the training to every warehouse worker is needed. The training was done in 3 weeks, during training the warehouse worker was taught about how to measure the angle of sliding hopper, fix the bug on the sensor, and create the width of vertical seal to reach up in 0.7 cm width. The warehouse worker also taught about the defect categories, defect causes, and how to reduce the defect, so they are having a knowledge about the defect and have to follow the SOP as shows in the Figure 8 and 9.

Date : Name : Process : Filling Shift / Date :	PT XYZ	Action		Worker	Supervisor	Note
No	Task	Done	Not Yet			
1	Check the condition of the weight of the stick					
2	Check the condition of the stick length					
3	Check the condition of the stick width (0.7 cm)					
4	Take a sample of 10 sticks for QC check					
5	Do not play with mobile phones, telephone, or do activities that interfere with concentration at work					
6	Mandatory to wear safety attributes when working					
7	Mandatory to use the attributes listed in the food safety management regulations and ISO 22000					

Figure 8 SOP in Filling Section

Date : Name : Process : Packing Shift / Date :	PT XYZ	Action		Worker	Supervisor	Note
No	Task	Done	Not Yet			
1	Checking the sliding hopper angle using a water pass					
2	Sensor check of revolver					
3	Taking 20 chocolate sticks to ensure sensor effectiveness					
4	Checking the home button test on the autofeeder control panel					
5	Do not play with mobile phones, telephone, or do activities that interfere with concentration at work					
6	Mandatory to wear safety attributes when working					
7	Mandatory to use the attributes listed in the food safety management regulations and ISO 22000					

Figure 9 SOP in Packing Section

4.1.6 Quantity Defect After Improvement

To determine if the improvements made have had an influence on the quantity of defects found in the packing process, defect data from the packing process was collected in May 2022. (Table 10)

Table 10 PPM After Improvement

Defect Opportunity Per Product				
Date	Defect	S/S	PPM	Target
09-May	13	777600	17	100
10-May	10	777600	13	100
11-May	10	777600	13	100
12-May	1	777600	1	100
13-May	9	777600	12	100
14-May	0	777600	0	100
17-May	2	777600	3	100
18-May	8	777600	10	100
19-May	8	777600	10	100
20-May	13	777600	17	100
21-May	0	777600	0	100
23-May	5	777600	6	100
24-May	3	777600	4	100
25-May	0	777600	0	100
26-May	5	777600	6	100
27-May	5	777600	6	100
30-May	7	777600	9	100
31-May	0	777600	0	100
Avg	5,5		7	

Table 11 Comparation of Sigma Level Before and After

Metric	Currrent level	Sigma Level
PPM Before	14148	3,693
PPM After	7	5,84

The Table 11 above shows the results obtained after making several improvements to the problem of the empty outer case. In the table showing a significant decrease in cases, the PPM value has met the target set at the beginning of the study. The average case per day is 5.5 outer empty cases, it managed to fall below the target of only 100 cases.

Table 12 Reducing the Cases

TYPE OF BS OUTER	2021			2022		
	AUG	SEPT	OKT	MARCH	APRIL	MAY
TOTAL CLEAN BS	125,67	136,15	146,83	85,05	82,87	50,7
TOTAL DIRTY BS	139,22	133,12	154,01	87,86	95,24	54,16
TOTAL	264,89	269,27	300,84	172,91	178,11	104,86
TOTAL IN 3 MONTH	835			455,88		
TOTAL CLEAN BS	408,65			218,62		

3 months before the improvement, the total clean BS reached 408.65 rolls, where one roll can produce 50,000 chocolate sticks. If it is calculated, the company suffers a loss of approximately 7 million sticks every month or around Rp. 2 billion approx. After improvisation, the total clean BS in 3 months is only 218.62 rolls, or about 3 million chocolate sticks per month. If converted in material form, the total loss is reduced to Rp 1 billion per 3 months. (Table 12)

4.2 Control Phase

The control phase of the DMAIC approach is the final step. This phase is to determine whether the project that has been implemented has been successful in maintaining the process or not.

4.2.1 Conduct Audit Checklist

An audit of the manufacturing line should be performed to confirm that the process followed the existing procedure and that the defect amount did not rise. A checklist can make the audit go more smoothly and control the current work system like in the Figure 10.

Quality Control Checklist

Date :
Name :
Process : **Packing**
Shift / Date :

No	Checklist	Check	No	Notes
1	The angle of sliding hopper already in 19-20 degrees			
2	All sensor in the packing machine is active			
3	The packing machine has been clean up			
4	The autofeeder control panel is fully function			
5	The worker already trial taking chocolate stick to test the sensor			
6	The output product has been checked by the QC team			

Worker	**PT. XYZ**	Supervisor Field
Name :		Name :

Quality Control Checklist

Date :
Name :
Process : **Filling**
Shift / Date :

No	Checklist	Check	No	Notes
1	The width size of vertical seal has been 0,65-0,75 mm			
2	The chocolate stick pass the QC test			
3	The filling machine has been clean up			
4	The filling machine is fully function			
5	The worker already taking chocolate stick to check refer the QC guidelines			
6	The output product has been checked by the QC team			

Worker	**PT. XYZ**	Supervisor Field
Name :		Name :

Figure 10 Audit Checklist in Packing and filling Section

5. Conclusion and Recommendation

5.1 Conclusion

Chocolate pasta has several flavors, one of which is a cashew chocolate variant with a 10-gram package. The flow process in the manufacture of chocolate paste, starting from the raw material transit warehouse, central kitchen, filling section, metal detecting, and packing section. There is a problem with the packing machine, namely the empty outer packaging. This is caused by several factors, the size of the chocolate paste, the sensor of the packing machine, the angle of the sliding hopper, and the brush in the auto feeder.

The modification has the potential to drastically reduce the total cost of the defect. The corporation may save 46.5 percent on costs. The whole cost before improvement was $47.628 per month, however after improvement, the total cost was only $22,148 per month.

In conclusion, the aim of this project was successful to apply systematic technique line efficiency for identification, determining solution, planning improvement, implementing the improvement plan, and evaluating solutions at the packing section and filling section to suggest the appropriate solution to reduce the cases of empty outer package

5.2 Recommendation

As a result, several projects and manufactured products in which was involved are considered state confidential information, and only a few specific projects were given permission to be discussed because they have a lower level of confidentiality.

Aside from the issue of confidentiality, A few suggestions for the overall research that could make:

- To reduce cases of empty outer packaging, activating sensors on all packing machines both on line 1 or line 2 must be done immediately
- The ideal center seal size for reducing cases of empty outer packaging is between 0.65 and 0.75 cm. The middle seal's width can accommodate all inner packaging widths.
- The slope angle of the sliding hopper on the packing machine can be standardized in the range of 19 - 20 degrees, because it has been proven to reduce the case of empty outer packaging.

Monitoring activities on the tilt angle of the sliding hopper, sensor, and revolver axles should be started in order to maintain the trend of no cases of empty outer packaging.

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Biography

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Jafri Bin Mohd Rohani is senior lecturer at School of Mechanical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Skudai, Johor. He graduated PhD from Universiti Teknologi Malaysia (UTM) in 2014, obtained his M.Sc (Industrial Systems Engineering) from Ohio University, USA in 1995 and B.Sc (Industrial Enginnering), New Mexico State University, USA (1988. He has been teaching at UTM specializing Industrial Engineering courses for more than 30 years. He is now supervising undergraduate and postgraduate students as part of academic responsibilities. He is very active in journal and conference publications with a total of 23 Indexed Journals and 6 of them from ISI Index Journal. His H-Index is currently stands at 8. He has published 1 research book and 2 book chapters. The total research funding received so far is RM 569,500 with the amount of RM 106,400 as Principal Investigator. With his experience, he actively participated in various Scientific, Technical committees and Conferences. He has been invited as 2 keynote speaker at International Conferences and invited speaker at Universitas Sebelah Maret, Surakarta, Indonesia. He is appointed as Editorial Boards at one local journal and one international journal. He has also being appointed as Technical Committee at various International and Local conferences. He is also appointed as NIOSH expert consultant to assist NIOSH staffs to conduct research and training activities. He is also currently engaged with DOSH, Malaysia to carryout OSHCIM Implementation Project in Construction Industry with a total consultancy services of RM 748,000. He is involve in various committee at School of Mechanical Enginnering and also become resource person in Occupational and Safety Health at UTM. He is now project coordinator for 2 MOUs with NIOSH Malaysia and Universitas Sebelas Maret, Surakarta, Indonesia.