

# Integrating Behavior and Technology-based Quality Management System to Improve Raw Milk Quality Collected by Bandung Dairy Cooperative

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**Abstract.** Milk quality is represented by Total Plate Count (TPC) value, the indicator of microbial contamination number in milk after production. The standard value is determined and set by the Codex and SNI 3141:1:2011 standards. The higher the TPC value, the lower the quality of the raw milk. This value determines the category of milk quality which impacts the payment scheme and the quantity of milk supplied to the Milk Processing Industry. As a consequence, farmers who collected lower quality milk received unfavorable financial outcomes. The aim of the research was to eliminate defects in milk quality by focusing on the quality control in the production system using Six Sigma approach. The Defects per Million Opportunity (DPMO) calculation was used to measure the quality of product in every one million opportunities. In this study, the DPMO showed 155,854 defects in every one million milk bulk collection held in 5 TPK. Two factors which decreased milk quality were the contamination in the milking process and in the milk collection process. To overcome the issue, technology and behavioral-based quality management systems are integrated to control the milk production and collection effectively and efficiently. Digital milk collection point is proposed to avoid contamination during milk collection through digitalization of data recording, milk test performed to individual samples, and access to test results. The digitalization can decrease the required time of milk collection and testing process. To raise the awareness of farmers towards quality and good farming practice, barn inspection is implemented using farming procedure infographics, Good Farming Practice training, and farmer certification.

**Keyword.** quality management system; dairy industry; digital milk collection; technology; behavior

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## INTRODUCTION

Grade is the most important factor which determines the price of milk purchased by the dairy cooperative from the farmers. The lower the grade, the lower the price of milk. Therefore, this quality grade affects the amount of fresh milk absorbed by the Milk Processing Industry (MPI) and will also impact the profitability of the dairy cooperative and farmers of the particular Group Milk Collection Point (GMCP). If the current GMCP's fresh milk quality cannot be increased, it affects the welfare of the farmers and continuation of dairy farming activity in these areas.

In a dairy cooperative, fresh milk with excellent quality is considered as the first-grade milk. They make a grading system to determine which fresh milk with the best and lowest quality. The best grade is represented with G1 code as the highest grade, while the lowest is represented with G4 as the lowest grade. The grading is determined by the total plate count (TPC) value representing the number of bacteria contained in the fresh milk produced on the farmer level. The higher the TPC value, the lower the quality of the milk, the lower the grade of the milk.

The grading determines which fresh milk to be distributed to the MPI and the amount of payment received by the farmer. The higher the grade, the higher the opportunity of the milk to be distributed, and the higher the payment made by the dairy cooperative to the farmer. In purchasing fresh milk from a dairy cooperative, the MPI set their own requirement to be fulfilled. MPI requires fresh milk with G1, minimal TPC value of 11.3%, and no minimum quantity required. There were 5 Group Milk Collecting Points (GMCP) found collected milk with G3 and G4 quality producing 155,854 defects among 1000,000 milk bulk collected. Two factors causing low quality milk; contamination during milking and contamination in the milk collection process. As a consequence, those GMCP received unfavorable payments.

In obtaining the most feasible and possible solutions to be implemented, there are several research objectives to be performed: (1) Discovering the possible factors causing the low quality of milk in 5 GMCP; (2) Developing and selecting the most suitable solutions which helps to increase the quality of milk in 5 GMCP; (3) Proposing the recommendation and implementation plan to increase the quality of milk in 5 GMCP

To overcome the problem, two categories of solution namely technology and behavioral categories are proposed. As a technology category, digital milk collection point (DMCP) is proposed to avoid milk contamination during milk collection. DMCP is performed by implementing the digital process of data recording, digital milk test performed to individual samples, digital access of milk test results which can lower the required time of the whole milk collection and milk testing process.

The behavioral category is used to raise the awareness of farmers towards quality and good farming practice by performing barn inspection, using infographics to ease understanding the farming procedure, Good Farming Practice training, and farmer certification. The digital milk collection process will help the quality control unit to easier detect the target of behavior based QMS.

## **METHOD**

This research adapts the DMAIC (define, measure, analyze, improve, control) approach in Six Sigma Quality as the method of research. Since quality plays a very important role in the food industry, especially in the dairy industry, the Six Sigma concept is chosen. The research began with defining the business issue encountered by the dairy cooperative. The issue was discovered from the interview arranged with the personnel of the milk handling unit, specifically on the milk production sub-unit.

In collecting the data, two sources were used namely primary and secondary data. The primary data was obtained through in-depth interviews and questionnaires to related interviewees to dig information of the issue under the study from the personnel of the organization's perspectives. The data collected in this research are used to discover and measure the defects. The data taken from the daily milk quality test of each milk collection point was measured by using a run chart. This data presents the daily quality of milk produced in terms of TPC (total plate count) value of each milk collection point within 3 months.

While the secondary data is obtained from several literatures of previous studies held on the same topic in general discussing the operations management of fresh milk production. In addition, the numerical data is also obtained to provide additional information mainly as numerical evidence of the existing problem from the cooperative data record. In addition, literary study is held to check the theoretical information, textual and legal standard about milk cow raising and milking itself in detail mainly related to quality, such SNI's standard of fresh milk quality.

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### In-depth interview

The participants of the in-depth interviews were those responsible for the production of fresh milk starting from the top management to the lower level. The aim of the interview was finding the root cause of the issue, supporting and assisting information in developing the most feasible solution that can be proposed and implemented by the organization. The form of this interview was the assistance of structured and spontaneous questions.

The in-depth interview began with the Head of Production Unit and Vice of Head of Production Unit to identify the problem faced by the organization. It started with the discussion of the basic operations of fresh milk production until it is supplied to the milk processing industry. Further, the interview focused on the topic of fresh milk quality starting from the general overview until the detailed step by step of quality control and quality standard. To get another perspective, the interview was also conducted with tester teams in each of milk collection points being observed, and instructor/training team who are responsible to inspect any deviation in milking and handling practice. The information obtained from these personnel is helpful to check the real-time operations occurred on site and seek whether any additional issue may arise. In addition, the interview is performed to the farmers in selected milk collection points.

### Sampling Method

There were 29 group milk collection points (GMCP) with various farmer population numbers in each point – the population in this case is the only number of farmers registered as members of the dairy cooperative. In determining the sample size, GMCP were selected and categorized based on the average quality of milk produced and collected: low and good quality. The quality was represented by its G1 & G2 fulfillment percentage within 3 months respectively. GMCP collected fresh milk with G1 & G2 target fulfillment percentage under 50% was categorized as low quality. While the GMCP with good quality fresh milk were those above 50%.

As presented in Table 1, 5 milk collection points harvested low quality fresh milk. As a benchmark, 5 GMCP harvested good quality fresh milk were chosen. The benchmark was determined by the 54 highest percentage (above 96%) and limited to 54 milk collection points which showed an increasing percentage.

Table 1. Ten Selected Group Milk Collection Point

No.	GMCP under 50% of G1 & G2 Fulfillment	GMCP above 50% of G1 & G2 Fulfillment
1	NMP	MNO 1
2	PHL	CBDB
3	PLG	CDBD
4	CBL	CBDS
5	KPB	BKNR

Each group of milk collection points had various farmer populations registered as members of the dairy cooperative. As the milk collection points were selected, the next step was determining the sample size of the total milk collection point population chosen and sample size of each milk collection point's population. Slovin's sample size formula is used

as the method to limit the persons to be observed/interviewed due to limited time, high effort and cost needed in performing questionnaires. Slovin's sampling formula is represented as follows:

$$n = N / (1 + N e^2)$$

n = sample size needs to take

N = total population

e = margin of error = 1 - confidence level

In applying the formula, the first step to take is determining the confidence level which represents error tolerance level in the accuracy of data. In the research, the confidence level is 90% in which the margin of error is 10%. Then, the total farmer population of the 10 GMCP and the margin of error are plugged into the formula as 'N' and e respectively.

N	= 2270
Confidence level	= 90%
e	= 10%
n	= 2270

The *n* represents the sample size or the number of farmers to be involved in the interview. To make it more specific, the proportion of each GMCP's population is calculated and multiplied to the sample size results from Slovin's formula. It is shown as follows:

Table 2. Population, Proportion and Sample Size of Excellent & Poor Group Milk Collecting Point

No.	GMCP	Population	Proportion	Sample Size
1	NMP	207	9%	9
2	PHL	68	3%	3
3	KPB	48	2%	2
4	PLG	196	9%	8
5	CBL	319	14%	13
6	CDBD	524	23%	22
7	MNO 1	15257	711%	611
8	MNO 2	100	4%	3
9	BKNR	296	13%	12
10	CBDS	355	16%	15
	Total Population	2270	Total Sample Size	96

In calculating the proportion, the formula used as follows:

$$\text{Proportion of a certain GMCP} = \text{Number population of GMCP X/Total Population}$$

If the formula is applied in the above GMCP, for example to find proportion of GMCP NMP:

$$\text{Proportion of GMCP NMP} = \text{Number population of GMCP NMP/Total Population}$$

Proportion of a certain GMCP = 207/2270

Proportion of a certain GMCP = 9%

To find the sample size of each GMCP, the proportion that has been found is multiplied into the sample size (n) result from the Slovin formula. The calculation is shown as follows:

$$\text{Sample size of a certain GMCP} = (n)(\text{proportion of GMCP } X)$$

If the formula is applied in the above GMCP, for example to find sample size of GMCP Nyampay:

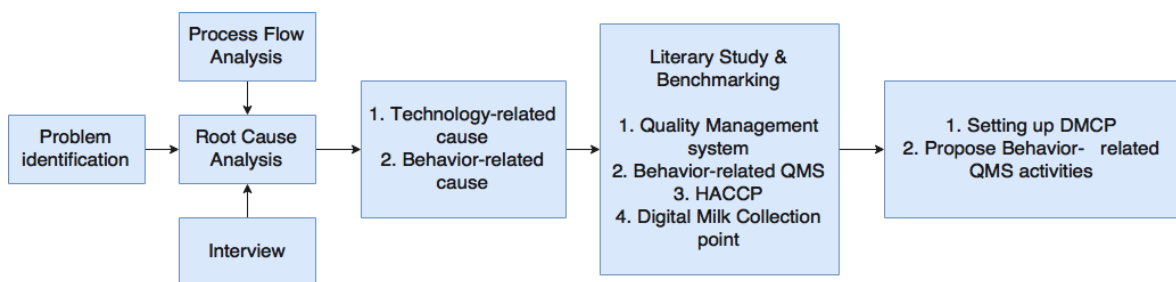
$$\text{Sample size of GMCP Nyampay} = (n)(\text{proportion of GMCP Nyampay})$$

Sample size of GMCP Nyampay = (96)(10%)

Sample size of GMCP Nyampay = 9.6 or 10 person

In analyzing the data gathered from several research activities, four methods of analysis were used in chronological order: Critical to Quality, Process Map Analysis using SIPOC, and Root Cause Analysis.

Figure 1 - Framework of Analysis



In formulating a suggested solution, the research continued with constructing a conceptual framework related to the business issue which is about poor quality of fresh milk produced on several farmer levels. It started by identifying and analyzing the organization's strength, weakness, opportunity, and threats. Then followed by defining the target customer, customer's basic needs, leading to defining the Critical-To-Quality (CTQ) characteristics of fresh milk. These characteristics were obtained from both literary study and interviews with the KPSBU milk handling unit and quality control unit personnel.

In developing the CTQ there are three aspects to be considered: (1) Customer's needs; (2) Quality Driver; (3) Quality Requirements. In addition, the process mapping of milking and milk handling is defined and explained by the mapping of SIPOC flowchart to the deployment chart. This mapping helped in identifying process inputs and outputs, identifying process owner, customers and suppliers, and identifying and establishing boundaries for the process. Further, the mapping helped in identifying and analyzing the important process influencing the CTQ. This method of analysis is used to identify the root causes for a factor which then leads to possible corrective action that should be proposed and taken. It identified the symptoms, causal factors which lead to the problem and help a company to find a recommended solution. This research uses Current Reality Tree to find the main cause of low milk quality.

## RESULTS AND DISCUSSION

Two factors causing the low quality of milk in the 5 GMCP related to the existing quality management system of KPSBU were discovered, they are:

### **Behavioral factors**

The behavioral factors are related to how the farmer behaves and performs their job in milking. The milking personnel had limited knowledge on Good Farming Practice, farmers were not disciplined, and farmers were unaware of the progress of their milk quality. These factors occur due to the absence of regular training, unavailable SOP provided in the barn, infrequent milking inspection, weak penalty policy, and complicated procedure in delivering information. As a consequence, the dairy cooperative has to develop a behavioral-based quality management strategy in increasing the farmers' awareness.

### **Technology factors**

The contamination during milk collection occurred because the milk tank was not hygienic and milk with G3 contaminated the other milk. The contamination of this G3 milk happens due to the limited milk test performed in MCP and the dairy cooperative personnel had to make the collection process fast. These factors were caused due to the absence of technology supporting an effective daily milk collection process. The dairy cooperative needed a faster and immediate milk evaluation tool to quickly, easily, and transparently inform the result towards the whole parts of the organization including farmers. This immediate and transparent information can help increase farmer's awareness in improving their milk quality.

An appropriate quality management system regarding the raw milk production in the dairy cooperative is required to help in increasing the quality of milk in 5 group milk collection points. This quality management system will help in increasing the awareness of farmers towards a good farming practice which then reduces the possibility of microbial contamination during the milking process. In addition, the dairy cooperative needed a supporting process technology which can detect the TPC value earlier before the milk bulk collection is performed in the central point. The organization focused its activity in the milk production and milk supply to the dairy industry, a related food manufacturing safety objective must be met.

The required value of total plate count of pure milk produced is G1 or the total bacteria value below 500,000 bacteria/cc. The value is in accordance with the requirements specified by the dairy industry where the milk they receive should be on G1 grade. The high value of total plate count represents the low quality of raw milk. There are two factors which cause the low milk quality: (1) Contamination during the milking process; (2) Contamination during the milk collection

The main cause of the two factors were located in the farmers' low awareness towards good dairy practice and the delay in detecting milk quality through TPC value. These factors were related to the behavior and the existing procedure of milk collection related to technology. The two aspects cannot be separately chosen due to their interrelatedness. A good technology supporting the whole organization's activity will provide maximum results if it is supported by manpower who has excellent awareness towards the importance of quality. The main manpower in the dairy cooperative are farmers who regularly produce and collect milk. Thus, the control over quality lies in their own hands. KPSBU serves as the supporting unit of the whole milk supply activity. The main objective is to increase the farmer's awareness so that they produce milk with good quality by preventing them from committing non-compliant activity and performing a regular communication about the progress of milk quality through a faster technology supporting

the whole process. As a response to this issue, alternatives to be proposed are divided into two categories: technology-based and behavioral-based.

Table 3. Categories of Proposed Alternatives

No.	Category	Solution Alternatives
1	Technology-based used to overcome contamination during milk collection	Setting up digital milk collection point (DMCP) with following location options of milk collection point: 1. DMCP placed in every TPS 2. DMCP placed in every TPK 3. DMCP placed in the central office
2	Behavioral-based used to overcome contamination during milking process	Setting up behavior-based QMS: a. Make easy-to-understand milking procedure in the barn through infographic b. Training “good farming practices” c. Routine barn inspection every 2 weeks d. Routine Farmer’s certification every 3 to 6 months

**CONCLUSION**

By implementing the Digital Milk Collection Point concept, the milk handling and Quality Control units will receive faster test results. Hence, TPC value, the location of milk collection point, and farmers producing low quality raw milk can be detected earlier. Early detection through digital milk collection points will help the quality control team to find a more objective target in performing behavior-related quality management system activities, especially preventive actions such as faster training and routine barn inspection. In addition, the organization members will have more flexible data access and transparency related to milk quality which also will raise farmers’ awareness towards the importance of milk quality and good farming practice. Performing the behavior-related quality management system activity is mandatory as the preventive action after the early detection of TPC value.

**The Difference of the Conventional Milk Collection & Digital Milk Collection Point**

The conventional milk collection process begins with manual data record, organoleptic tests, and ends with mixing the milk into the milk tank truck. This ‘group-collected’ milk was then tested and evaluated in KPSBU central laboratory which took about 3 days. While the DMCP process includes the on-site milk test, the milk is ‘group-collected’ after the test result appears and takes only a half day even in hours. The difference of conventional and digital milk collection points is depicted in table 4.

Table 4. The Difference of Conventional & Digital Milk Collection Point

No.	Aspect	Conventional Milk Collection Point	Digital Milk Collection Point
1.	Process	Requires laboratory for milk test (a more detail process flow see figure 3.4)	On-site milk test

No.	Aspect	Conventional Milk Collection Point	Digital Milk Collection Point
2.	Data Record	Manual data record	Barcode system: farmers ID, milk can identification through barcode label, individual milk sample with barcode label for consistent data input
3.	Length of Test	3-4 days	Maximum 1 day
4.	Milk Collection	Before the TPC test, milk is collected in group based on TPK	After the TPC result appears, milk is collected based on grade classification (G1, G2, G3, G4)
5.	Data Flow & Information Access	<ul style="list-style-type: none"> <li>Printed data only</li> <li>Farmers receive payment after 15 days</li> <li>Farmers knows the TPC value through information board installed in TPS MCP</li> </ul>	<ul style="list-style-type: none"> <li>Printed through 'invoice-like' printer or digital through SMS/mobile Apps notification</li> <li>Farmers receive payment in the afternoon of the same day of milk collection</li> <li>Farmers can access their TPC value through SMS/mobile apps notification or</li> <li>Fully monitored data flow</li> <li>Real-time data display</li> <li>Easy to trace previous test result data</li> </ul>
6.	Milk Contamination during Milk Collection	High	Low

### The Difference of Implementing Digital Milk Collection Point in Each Temporary Milk Collection Point (TMCP), GMCP, and Centralized

To make it easy in analyzing the implementation of Digital Milk Collection Point in each proposed location, the differences are depicted as follows:

Table 5. The Difference of Implementing DMCP in Each TMCP, GMCP, and Centralized

No.	Category	TMCP	GMCP	Centralized
1.	Quantity of Required Instrument	There are 760 TMCP, so each instrument should meet the individual TMCP amount.	There are 29 GMCP, so each instrument should meet the individual GMCP amount, 29 sets	The registration instrument needed can be similar to the total amount of TMCP, 760 sets. However, it can be resolved with only using 29 sets, because the registration team can be mobile. While the digital milk test instrument needed is only 1 set because it is only used in central milk collection point.



2.	Transport Support	Need cold box truck with in amount of 29 units	Need cold box truck with in amount of 29 units	Need cold box truck with in amount of 29 units
3.	Capital Investment Needed	High <sup>o</sup>	High <sup>o</sup>	Medium <sup>o</sup>
4.	Complexity of process flow	Low	Complex	Low
5.	Complexity of Data Configuration & Monitor	High	Medium	Low
6.	Milk Test Duration Needed	Under 1 hour for less than 200 samples (due to few farmers in each TMCP)	Under 1 hour for less than 200 samples (due to few farmers in each TMCP)	Requires maximum 180 minutes for milk testing because its max capacity is 600 samples/per hour
7.	Additional Manpower & Training Needs	Requires 760 BactoScan operators and large-scale training of operating the instrument	Requires 29 BactoScan operators and large-scale training of operating the instrument	Only requires 1-2 BactoScan operators Requires 2-3 milk handling PIC in cold storage Only need small-scale training of operating instruments
8.	Power Supply Needs	High	High	Low

According to the difference between DMCP located in TMCP, GMCP, and Central, it is found that implementing digital milk collection point in the central collection point by maintaining the old process and removing the bulk collection into milk tank trucks is less risky financially, operationally, and in terms of manpower needs. Therefore, the DMCP located in the central milk collection point is the selected solution to overcome the business issue related to milk quality.

## REFERENCES

- Amam, A., & Harsita, P. A. (2019). Tiga pilar usaha ternak: breeding, feeding, and management. *Jurnal Sain Peternakan Indonesia*, 14(4), 431-439.
- Abo-Gamil, Z., El-Qaliouby, H., Manaa, E., & Ramadan, S. (2021). Effect of Some Non-Genetic Factors on 305-day Milk Yield and Lactation Persistency in Holstein Friesian Cows. *Benha Veterinary Medical Journal*, 40(2), 189-194.
- Banerjee, M., & Kunamaneni, S. (2019). The Farm-to-Fridge Value Chain: Participants' Roles and Driving Productivity through Technology Interventions (No. 2308-2019-4875).

- Farid, M., & Sukei, H. (2011). Pengembangan susu segar dalam negeri untuk pemenuhan kebutuhan susu nasional. *Buletin Ilmiah Litbang Perdagangan*, 5(2), 196-221.
- Goldratt, E. M. (1990). *Theory of constraints* (pp. 1-159). Croton-on-Hudson: North River.
- Gitau, K. J. (2013). Factors influencing milk production among small scale dairy farmers in Mirangine in Nyandarua county and Mauche in Nakuru county, Kenya (Doctoral dissertation, University of Nairobi).
- Indonesia, K. P. R. (2017). *Perkembangan Ekspor Indonesia Berdasarkan Sektor*.
- M'hamdi, N., Bouallegue, M., Frouja, S., Ressaissi, Y., Brar, S. K., & Hamouda, M. B. (2012). Effects of environmental factors on milk yield, lactation length and dry period in Tunisian Holstein cows. In *Milk Production-An Up-to-Date Overview of Animal Nutrition, Management and Health*. IntechOpen.
- Martindah, E., Sani, Y., & Noor, S. M. (2009). Penyakit endemis pada sapi perah dan penanggulangannya. Dalam: Santosa KA, Diwyanto K, Toharmat T, penyunting. *Profil usaha peternakan sapi perah di Indonesia*. Jakarta (Indonesia): LIPI Press. hlm, 209-257.
- Nugroho, B. A. (2010). Pasar susu dunia dan posisi Indonesia. *Jurnal Ilmu-Ilmu Peternakan (Indonesian Journal of Animal Science)*, 20(1), 65-76.
- Perindustrian, K. (2016). *Perkembangan Ekspor Indonesia Berdasarkan Sektor*. Kelompok Has. Ind, 1.
- Rozentale, Rita. 2015. Characteristics of Dairy Supply Chains: The Case of the Baltic States. *European Scientific Journal* October 2015. e - ISSN: 1857 – 7431
- Standar Nasional Indonesia. 2011. SNI 3141.1:2011 Susu Segar-Bagian 1: Sapi. Jakarta: Badan Standardisasi Nasional. Retrieved from: <http://sispk.bsn.go.id/SNI/DetailSNI/8654>
- Talib, F., & Rahman, Z. (2015). Identification and prioritization of barriers to total quality management implementation in service industry: an analytic hierarchy process approach. *The TQM Journal*.
- Walstra, P., Walstra, P., Wouters, J. T., & Geurts, T. J. (2005). *Dairy science and technology*. CRC press.
- Zeinhom, M. M., Aziz, R. L. A., Mohammed, A. N., & Bernabucci, U. (2016). Impact of seasonal conditions on quality and pathogens content of milk in Friesian cows. *Asian-Australasian Journal of Animal Sciences*, 29(8), 1207.