

# Application of X-bar and R Control Chart on The Quality of The Final Product of Goat Milk Powder

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**Abstract:** Dairy products are prone to quality problems, including contamination by bacteria, microbes, and other harmful elements. Bumiku Hijau is a producer of goat milk powder with various flavors in Yogyakarta. This study aimed to determine the quality control process and the identification of the factors causing failure at the re-weighing stage of the final product of goat milk powder at Bumiku Hijau Yogyakarta. Data analysis used statistical quality control methods, which are the X-bar and R control chart to analyze the quality control of the final process of re-weighing goat milk powder. The causal diagram is used to identify the factors that cause the failure at the re-weighing step of the final product of goat milk powder. The results of the X-bar and R control chart analysis in the final product re-weighing process show that the overall final process of goat milk powder production is under statistical control. Identification of the factors that cause failure in the final process of goat milk powder production at Bumiku Hijau is the weight variability of the final product, where the variability of the weight of the final product is caused by human factors (employees), and machines (weighing the final product).

**Keywords:** Goat Milk Powder, Quality Control, Control Chart

## 1. INTRODUCTION

The development of the livestock sub-sector is part of the development of the agricultural sector which has strategic value in meeting the food needs which continues to increase over time. The increasing need for food is due to, among other things, an increase in population and an increase in the level of income of the population. One of the components of the livestock sub-sector that has many benefits and has the potential to be developed in Indonesia is dairy agribusiness [1]. However, according to the demand side, domestic milk production is still insufficient to meet the consumption needs of the Indonesian people. This is following data on milk consumption in Indonesia which is compiled in the [2], where the level of consumption of the Indonesian people is 11.09 liters per capita per year. This level of consumption is categorized as quite low compared to several countries in ASEAN whose milk consumption reaches 20 liters per capita per year.

In the current era of globalization and trade liberalization, competition in both service and manufacturing industries is no longer only focused on company scale or human resources, but also prioritizes the quality of the products produced. The quality of a product plays an important role in fulfilling consumer wants and needs. One of the positive impacts that will be obtained by a company that consistently maintains the quality of its products is to make the company able to compete with other competitors in maintaining customer satisfaction and loyalty [3]. According to [4], determined the Dairy Processing Industry in Indonesia as one of the industries that will continue to be prioritized.

One of the products that require strict quality control efforts is pure milk products and their derivatives. Milk is a product that is easily damaged, this is due to its high nutrient content and water activity, which is a very supportive place for the proliferation of harmful microbes [5]. This condition makes milk and its derivative products vulnerable to bacterial and microbial contamination. Good quality milk can be seen from the value of the protein, fat, and mineral content in the milk itself [6].

Previous research that discusses product quality control, whether products in the form of whole milk or processed products, has been widely applied. For example, research on quality control of pure cow's milk [7]; [8]; [9], quality control and business analysis of pure goat milk with Etawa breeds [10], quality control white tofu production process [11], quality control of tempe products [12], quality control of the ice cream production process [13], evaluation of the quality of the goat milk powder production process [14]. None of these studies have analyzed the quality control of goat milk powder. Research on quality control of goat milk powder raw materials has been previously researched by [15], but has not explained in more depth how quality control is in the production process and the final product. Based on this background, it is important to study the quality control of the final goat milk powder. The purpose of this study was to analyze the quality control of goat milk powder and identify the factors that cause the failure of the final product of goat milk powder in Bumiku Hijau Yogyakarta.

## 2. STUDY AREA

Bumiku Hijau is one of goat milk powder's producer in Yogyakarta, Indonesia. Bumiku Hijau was established since 2009. It is located on North Ring road No. 100, Yogyakarta city. Bumiku Hijau only produce goat milk powder with three flavour variants, there are original, chocolate, and vanilla.

## 3. RESEARCH METHODOLOGY

Data collection was carried out in January to May 2019, where during the implementation of the research testing the quality standards at the re-weighing step of final product weight. The research was conducted at Bumiku Hijau, which is one of the

producers of goat milk powder with various flavors (original, chocolate, and vanilla) in Yogyakarta. The research location is determined using the purposive sampling method, which is the deliberate taking of the research location.

**Table 1.** Quality Standard of Final Product Weight in Bumiku Hijau

Indicator	Testing Standards	Target	Information
Product Weight	Weight analysis (Final product reconsideration)	> 205 gr	Rework
		200gr – 205gr	Normal
		< 200gr	Rework

Source: Bumiku Hijau, 2019

The average production of goat milk powder in Bumiku Hijau in one month reaches 2,500 packs per week with a size of 200 grams per one pack. The number of samples studied refers to the ANSI/ASQC ZI.9-1993 rules, normal inspection level 3 (adjusting the population) as presented in the following table:

**Table 2.** Sample Size According to ANSI/ASQC ZI.9-1993, normal inspection level 3

Number of Products (Unit)	Sample Size
91 – 150	10
151 – 280	15
281 – 400	20
401 – 500	25
501 – 1.200	35
1.201 – 3.200	50
3.201 – 10.000	75
10.001 – 35.000	100
35.001 – 15.000	150

Source: Ariani, 2004

The distribution of goat milk powder production at Bumiku Hijau in one week is 1,250 packs of original flavor, 750 packs of vanilla flavor, and 500 packs of chocolate flavor. Based on the table for determining the number of samples above, the samples studied in controlling the quality of the final product are as follows:

**Table 3.** The number of samples studied for each flavor variant of goat milk powder of Bumiku Hijau

Flavor variants	Sample (Pack)
Original	50
Vanilla	35
Chocolate	25

Quality control on the final product of goat milk powder, which is measured is the result of re-weighing the goat milk powder of each flavor variant that has been packaged in 200 grams of aluminum foil. The final product re-weighing process is carried out once a week, that is, every Friday. Analysis of data on the quality testing of the final product of Bumiku Hijau goat milk powder using the  $\bar{X}$  and R control charts, where the analysis steps are as follows [16] :

a. Calculating the  $\bar{X}$  Control chart

$$\bar{X} = \frac{\sum X}{n}$$

Information:

$\bar{X}$  = average value of recalculating product weight calculation per one re-weighing process

$\sum X$  = the total value of product weight re-weighing data per month

n = the number of repetitions of the product weighing re-weighing process per month

b. Calculating the centerline for computation of final product re-weighing data

$$\bar{X} = \frac{\sum \bar{X}}{n}$$

Information:

$\bar{X}$  = centerline recalculation of final product weight per one re-weighing process

$\sum \bar{X}$  = total average value of each final product reconsideration per month

n = the number of repetitions of the final product weighing process per month

c. Calculating the control limits from the  $\bar{X}$  control chart

By using a 3 sigma limit, the control limit for the  $\bar{X}$  graph is:

$$\text{Upper Control Limit} = \bar{X} + A_2 \bar{R}$$

$$\text{Lower Control Limit} = \bar{X} - A_2 \bar{R}$$

Where  $\bar{X}$  is the centerline of the control of  $\bar{X}$  chart,  $A_2$  is the control limit factor of the  $\bar{X}$  chart controller, and  $\bar{R}$  is the centerline of the control chart R.

d. Calculating the R control chart

$$\bar{R} = \frac{\sum R}{n}$$

Information:

$\bar{R}$  = Centerline of R control chart

$\sum R$  = The total range of data values per one re-weighing process ( $R_{\max} - R_{\min}$ )

n = Number of re-weighing processes per month

e. Calculating the control limit of the R control chart using the 3 sigma limit

$$\text{Upper Control Limit} = \bar{R} \cdot D_4$$

$$\text{Center limit} = \bar{R}$$

$$\text{Lower Control Limit} = \bar{R} \cdot D_3$$

f. Assessment criteria in analyzing process capability (only used for  $\bar{X}$  and R control chart)

- If  $C_p > 1,33$ , the process capability is very good
- If  $1,00 \leq C_p \leq 1,33$ , then the process capability is in good condition
- If  $C_p < 1,00$ , then the process capability is low, so the performance needs to be improved

In identifying the possible factors causing the failure of the final product quality of goat milk powder in Bumiku Hijau, a causal diagram is used. In determining the possible factors causing the problem of product failure, it will be related to various existing theoretical references, including human factors, production tools, and machines, methods during the production process (method), the raw materials used for the process, production (materials), and work environment factors [17].

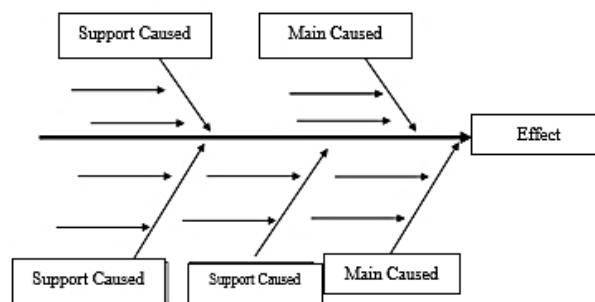


Figure 1. Identify the Dominant Causes of Product Failure with a Cause and Effect Diagram

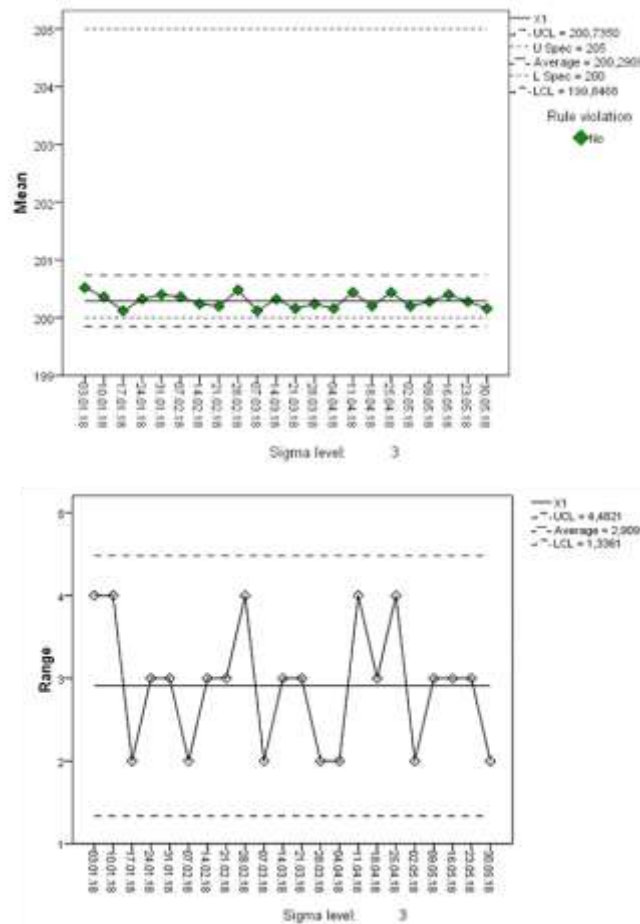
## 4. RESULTS AND DISCUSSION

### Quality Control of the Final Product

The quality control test on the final product is carried out at the time of re-weighing the product after packaging the aluminium foil. Variable data were measured for analysis using  $\bar{X}$  and R-chart, namely in the form of product weight in goat milk powder with original flavor variants, chocolate, and vanilla. Weighing the final product every Friday. At the stage of re-weighing the final product before being packaged in cardboard packaging.

### Re-weighing of Chocolate Flavor Variants

In the previous discussion, it has been explained that Bumiku Hijau produces goat milk powder with three flavors, which are chocolate, original, and vanilla. Based on the results of the re-weighing data analysis of the final product of goat milk powder of Bumiku Hijau, chocolate flavor variants using the  $\bar{X}$  and R control chart from January to May 2019 are as follows:



**Figure 2.** Control chart  $\bar{X}$  and R Weighing Final Product of Chocolate Flavor Variants January - May 2019  
 Source: Primary data processed, 2019

**Table 4.** Capability index of the re-weighing process of goat milk powder with chocolate flavor variants in January – May 2019

Months	Process Capability Index (CP)
January	0,862
February	0,873
March	1,310
April	1,008
May	1,365
<b>January - May</b>	<b>1,126</b>

Source: Primary data processed, 2019

From January to May 2019, there were 22 re-weighing processes of goat milk powder Bumiku Hijau with a chocolate flavor variant, wherein each weighing there were 25 samples. In the graph above, it can be seen that the UCL and LCL values on the  $\bar{X}$  control chart are 200.73 and 199.84, with a mean value of 200.29. The UCL and LCL values on the R control chart are 4.48 and 1.33, with a mean value of 2.90. The graph of the  $\bar{X}$  and R control chart shows that there are no measurement points that exceed the upper control limit or the lower statistical control limit, thus the whole process of re-weighing the final product of goat milk powder with chocolate flavor from January to May 2019 is within the control limit statistics.

When viewed from the process capability index for each month, it can be seen that in January and February the process capability was in a low condition ( $0.8 < 1.00$ ). According to the information the researchers got from the Head of Processing and Sales of Liquid and Powdered Milk, the low capability index for the two months was due to the inaccuracy of the weighing device owned by Bumiku Hijau, because the condition of the weighing equipment needed to be updated, but it was also caused by inaccuracy of weighers. product, because in those two months the weighing of the product is more often conducted by vocational students who are doing industrial work practice at Bumiku Hijau.

Even though in January and February the process capability index was low, when viewed as a whole from January to February, the process capability index (CP) value was 1.126. Based on the test criteria, because  $1.00 \leq Cp (1.126) \leq 1.33$ , it can be concluded that the capability of the re-weighing process of goat milk powder of Bumiku Hijau in chocolate flavor from January to May is already in good condition.

Re-weighing of Original Flavor Variants of Final Products

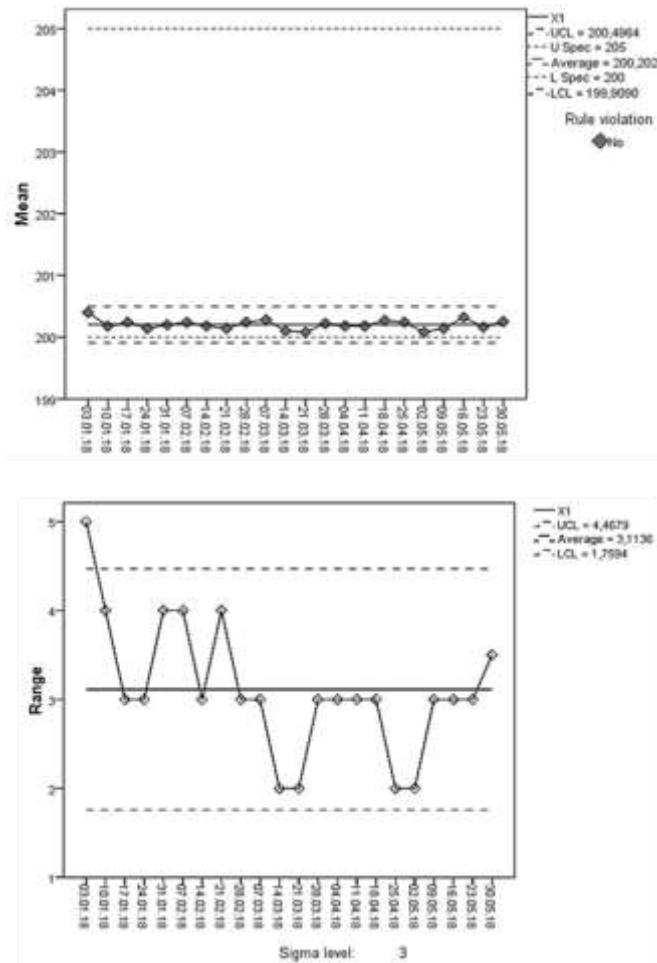


Figure 3. Control chart  $\bar{X}$  and R Weighing Original Flavor Variant Final Product January-May 2019  
Source: Primary data processed, 2019

Table 5. Capability index of the re-weighing process of goat milk powder with original flavor variants in January-May 2019

Months	Process Capability Index (CP)
January	0,872
February	1,071
March	1,499
April	1,170
May	1,293
<b>January - May</b>	<b>1,204</b>

Source: Primary data processed, 2019

It was recorded that there were 22 times the process of re-weighing the original flavor variant of goat milk powder Bumiku Hijau, wherein each weighing there were 75 samples. In the graph above, it can be seen that the UCL and LCL values on the  $\bar{X}$  control chart are 200.49 and 199.90, with a mean value of 200.20. The UCL and LCL values on the R control chart are 4.46 and 1.75, with a mean value of 3.11. The  $\bar{X}$  control chart graphic image shows that the overall re-weighing process of the original flavor variant powdered goat's milk from January to May 2019 is within statistical control limits, but the R control chart image shows that there is one point that exceeds the upper control limit. statistics (UCL), namely on January 3rd.

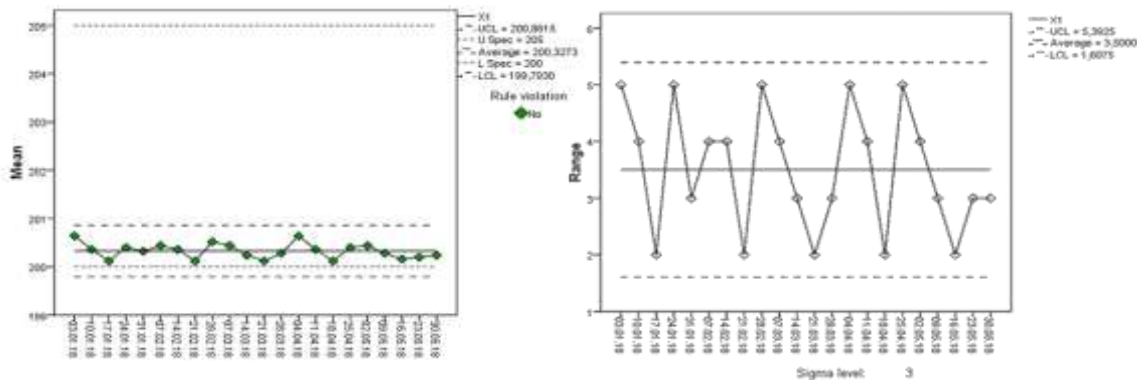
When viewed from the process capability index for each month, it can be seen that in January the process capability was in a low condition ( $0.872 < 1.00$ ). According to the information the researchers got from the Head of Processing and Sales of Liquid and Powdered Milk, the low capability index for the two months was due to the inaccuracy of the weighing device owned by Bumiku Hijau, because the condition of the weighing equipment needed to be updated, but it was also caused by inaccuracy of weighing product because in those two months the weighing of the product is more often done by vocational students who are doing industrial work practice at Bumiku Hijau.

Even though in January and February the process capability index was low, when viewed as a whole from January to May 2019, the process capability index (CP) value was 1.204. Based on the test criteria, because  $1.00 \leq Cp (1.204) \leq 1.33$ , it can be concluded

that the capability of the process of re-weighing the original flavor variant of Bumiku Hijau goat milk powder from January to May 2019 is in good condition.

**Vanilla Flavor Variant Final Product Re-weighing**

The results of the re-weighing data analysis of the final product of goat milk powder Bumiku Hijau with vanilla flavor using the  $\bar{X}$  and R control chart from January to May 2019 are as follows:



**Figure 4.** Control chart  $\bar{X}$  and R Weighing Final Product Vanilla Flavor in January-May 2019

**Table 6.** The capability index of the re-weighing process of goat milk powder with vanilla flavor variants in January-May 2019

Month	Process Capability Index (CP)
January	0,862
February	0,936
March	1,170
April	1,363
May	1,170
<b>January - May</b>	<b>0,936</b>

Source: Primary data processed, 2019

From January to May 2019, there were 22 re-weighing processes of vanilla-flavored goat milk powder of Bumiku Hijau, wherein each weighing there were 35 samples. In the graph above, it can be seen that the UCL and LCL values on the  $\bar{X}$  control chart are 200.86 and 199.79, with a mean value of 200.32. The UCL and LCL values on the R control chart are 5.39 and 1.60, with a mean value of 3.50. The graph of the  $\bar{X}$  and R control chart shows that there are no measurement points that exceeded the upper control limit or the lower statistical control limit so that the whole process of re-weighing the final product of vanilla-flavored goat milk from January to May 2019 is within the control limit. Statistics.

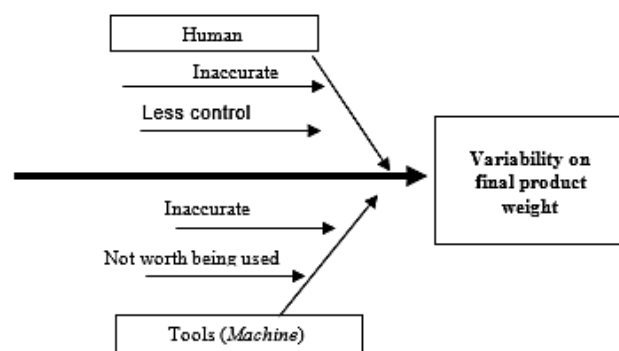
When viewed from the process capability index for each month, apart from January and February, all process capabilities are in good condition. The result of the overall process capability index from January to May 2019 (CP) was 0.936. Based on the test criteria, because  $0.936 > 1.00$ , it can be concluded that the capability of the process of re-weighing the powdered vanilla-flavored goat milk of Bumiku Hijau from January to May 2019 is already in a low condition.

In line with the previous explanation regarding the reasons why the process capability index was low in January and February 2019, the inaccuracy of the weighing equipment owned by Bumiku Hijau, and the inaccuracy of product weighers that were not on the part of Bumiku Hijau staff itself were the main factors causing the low process capability.

**Identification of Causes of Low Process Capability in Final Product Reconsideration in Bumiku Hijau**

Based on the information obtained from Bumiku Hijau management regarding the causes of low process capability and variability of the results of re-weighing of goat milk powder for each flavor variant (original, chocolate, and vanilla), the priority of problems and factors causing low process capability and variability of weighing results. The final product of Bumiku Hijau can be organized into a cause-and-effect diagram (fishbone diagram). The preparation of a fishbone chart of the low process capability during the production process is the result of direct field observations and interviews with related parties, including the head of processing and sales of liquid and powder goat milk, and staff of the processing of goat milk powder.

The results of compiling the dominant factors causing variability of the final product weighing back into the cause and effect diagram (fishbone diagram) are presented in the image below:



**Figure 5.** Cause and Effect Diagram of Weight Variability of the Final Product of Goat Milk Powder of Bumiku Hijau  
Source: Primary data processed, 2019

The re-weighing variability of the final product is caused by 2 main factors, which are human factors and machine factors.

a. From the human factor (man), it is caused by a lack of accuracy when reconsidering the weight of the final product. Based on information obtained from Bumiku Hijau, the cause of the low capability of the final product weighing re-weighing process that occurred in January and February was because in that month the weighing process was more often carried out by vocational students who at that time carried out Industrial Work Practices at Bumiku Hijau. Observers' inaccuracy and lack of supervision from the staff of the goat milk powder processing section at Bumiku Hijau are the main causes of variability in the re-weighing of the final product.

b. According to the machine factor, the condition of the weighing equipment owned by Bumiku Hijau needs to be recalibrated, or a tool update should be held. Product weighers that have not been calibrated for a long time can result in inaccuracies in the weighing results so that it affects the low process capability when re-weighing the final product.

## 5. CONCLUSION

Overall, from twenty-two observation points, the re-weighing process of goat milk powder for each flavor variant was under statistical control. In re-weighing the final product, the dominant factor causing the variability of the weight of the final product in Bumiku Hijau is due to human factors (weighers), and machine. In increasing the capability of the low-end product reconsideration process, the management of Bumiku Hijau needs to carry out evaluations in the form of direction, training, and guidance regarding procedures or ways to minimize the variability of the final product weight.

## References

- Agustina Yohana, Mulyo Jangkung Handoyo, Waluyati Rahayu (2020). Analysis of Quality Control on Raw Materials of Goat Milk Powder at Bumiku Hijau Yogyakarta. *Jurnal Teknosains*, 9 (2)(Juni), 91–180
- Ahmedsham M, Amza N, Tamiru M (2018). Review on milk and milk product safety, quality assurance and control. *International Journal of Livestock Production*, 9 (April), 67–78. DOI: [10.5897/IJLP2017.0403](https://doi.org/10.5897/IJLP2017.0403)
- Arief Rusdimasnyah, Sowmen S, Pazla R, Rizqan (2020). Milk production and quality of Etawa crossbred dairy goat that given *Tithonia diversifolia*, corn waste and concentrate based palm kernel cake. *Jurnal Biodiversitas*, 21 (9), 4004–4009. DOI: [10.13057/biodiv/d210910](https://doi.org/10.13057/biodiv/d210910)
- Bakti C S, Kartika H (2020). Analysis of Quality Control Ice Cream Product Using Six Sigma Method. *Journal of Industrial Engineering & Management Research (JIEMAR)*, 1 (June), 63–69
- Bolatan G I S, Gozlu S, Alpkhan L, Zaim S (2016). The Impact of Technology Transfer Performance on Total Quality Management and Quality Performance. *Procedia - Social and Behavioral Sciences*, 235 (October), 746–755. DOI: [10.1016/j.sbspro.2016.11.076](https://doi.org/10.1016/j.sbspro.2016.11.076)
- Burke N, Zacharski K A, Southern M, Hogan P, Ryan M P, Adley C C (2017). The Dairy Industry : Process, Monitoring, Standards, and Quality. In *IntechOpen*, pp. 1–25
- Cyrilla L, Purwanto B P, Atabany A, Astuti D A, Sukmawati A (2015). Improving Milk Quality for Dairy Goat Farm Development. *Media Peternakan*, 38 (December), pp. 204–211. DOI: [10.5398/medpet.2015.38.3.204](https://doi.org/10.5398/medpet.2015.38.3.204)
- Dabija A, Mironeasa S, Oroian M, Sion I (2018). Study Concerning Milk Quality – Raw Material for Dairy Industry. *International Journal of Food Engineering*, 4 (July), pp. 14–21. DOI: [10.18178/ijfe.4.1.14-21](https://doi.org/10.18178/ijfe.4.1.14-21)
- Idris I, Sari R A, Wulandari, Uthumporn (2016). Quality Control of Tempe Using Seven Tools Method. *Journal Teknovasi*, 03 (1), pp. 66–80
- Kataneh A (2017). Processing and Storage stability of Skim Milk Powder Monitoring Early and Advanced Stages of the Maillard Reaction Document Version : Publisher's PDF, also known as Version of record Processing and Storage Stability of Skim Milk Powder. Sweden: Media-tryck, Lund University
- Kushwah A, Agarwal Y (2017). Study of Quality Testing of Milk Powder in Sterling Agro Industries Limited - Nova. *Acta Chemica Malaysia*, 1 (2), 8–10
- Ma Y, Dong W, Fan C, Wang E (2017). Identification of Cow Milk in Goat Milk by Nonlinear Chemical Fingerprint Technique. *Journal of Food and Drug Analysis*, 25 (4), pp. 751–758. DOI: [10.1016/j.jfda.2017.05.008](https://doi.org/10.1016/j.jfda.2017.05.008)

13. Montgomery D C (2009). Introduction to Statistical Quality Control 6th Edition (Sixth Edit). USA: John Wiley & Sons
14. Perera P, Munasinghe H, Marapana R A U (2019). Quality Assessment of Selected Dairy Products in Sri Lankan Market. Hindawi Journal of Food Quality, 1, pp. 1-10
15. Data Center and Agriculture Information System, K. P. R. (2015). Outlook Agricultural Commodity Sub Sector Milk. Jakarta
16. Data Center and Agriculture Information System, K. P. R. (2019). Outlook Komoditas Peternakan Susu Sapi. Jakarta
17. Sari N K R, Purnawati N K (2018). Analisis Pengendalian Kualitas Proses Produksi Pie Susu Pada Perusahaan Pie Susu Di Kota Denpasar. INOBIS : Jurnal Inovasi Bisnis Dan Manajemen Indonesia, 1(Juni), pp. 290–304
18. Tamime A Y (2009). Milk Processing and Quality Management. United Kingdom: Blackwell Publishing Ltd.