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A Comparative Analysis of Dry Tea Yield from Ball Tea 1 and Ball Tea 2 during Green Tea Production

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ABSTRACT

The tea drying process is a crucial stage in determining the final quality of the product, particularly in meeting the Grade 1 standard. A green tea producer, applies the final drying process using two types of machines: Ball Tea 1 and Ball Tea 2. The issue addressed in this report concerns the differences in the distribution of dried tea output from both machines and the extent to which the drying results can serve as a reference in the sorting process for high-quality tea. The methods used during this internship included direct observation of the drying and sorting processes, interviews with technical experts, as well as data collection and processing from dried tea samples. The analysis involved weighing and categorizing the dried tea into four fractions: *Peko Super, Jikeng, Kempring*, and *Tulang*. The data from each fraction was calculated in percentage form and compared between Ball Tea 1 and Ball Tea 2 to identify the differences in distribution characteristics. The analysis results show that the fraction distribution between the two machines is still unbalanced. The *Peko Super* fraction in Ball Tea 2 is higher than that in Ball Tea 1, while the *Jikeng* fraction dominates in both machines. This analysis can serve as a reference in determining Grade 1 tea and highlights the need to evaluate drying parameters and raw material quality. With proper processing, the final tea product can meet the quality standards set by the company.

Keywords: Dry Analysis, Ball Tea, Drying Process, Grade 1

Introduction

Tea (Camellia sinensis) is one of the major plantation commodities in Indonesia due itshigh economic value and role as a non-oil and gas export product. A significant portion od Indoneisa's tea production is exported foreign exchange income (Salimah et al., 2023). Among the various type, green tea is notable for its high antioxidant content, especially catechins such as epicatechin (EC) and epigallocatechin gallate (EGG), which are beneficial for health (Leonardo et al., 2019).

The tea processing consist of several stages, namely plucking, wet analysis, withering, rolling, drying, and sorting. In this tea industry, tea shoots are plucked manually using the medium plucking method, then weight and analyzed through wet analysis to evaluate the quality of raw materials before entering the whitering stage (putri et al., 2021). Whitering aims to introduce moisture content and soften the leaves (Panggabean, 2022). Next, the tea leaves are rolled to break down cell structures and trigger chemical reactions that develop flavor and aroma (Iqbal & Setiawan, 2019). The drying process is carried out in stages using ECP (Endless Chain Pressure) mechine, rotary dryes, and finally the ball tea machine for final drying.

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After the drying process, organoleptic testing, moisture content testing using the Grand Moisture Texture tool, and dry analysis are conducted to determine tea fraction such as *Peko Super, Jikeng, Kempring*, and *Tulang*. These stages are important to maintain the quality of the tea, especially in terms of color, aroma, and steeping strength, to meet the Grade 1 standard set by the company. Optimal drying is crucial to achieve a maximum moisture content of 5% according to the company's internal standards, or up to 8% based on SNI 1902:2016. The result of this process are then evaluated through dry analysis, which involves separating the tea based on its fractions and calcuting their distribution percentages. This fraction distribution serves as the basis for determining the tea grade, particularly Grade 1, which hold high market value.

The analysis of dried tea is an evaluation process conducted after processing or drying, aimed at determining its quality and characteristics. Dry analysis includes moisture content, density, and quality assessment of the tea (Elvitriadi, 2020). It is carried out to determine the percentage of each green tea fraction, namely *Peko Super, Jikeng, Kempring*, and *Tulang*. The data obtained are used as a reference for assessing the percentage composition of the final sorted product and can serve as a correction indicator if any deviation occurs during processing. This dry analysis is performed by taking samples from the Ball Tea machine, separating the tea into its respective fractions (*Peko Super, Jikeng, Kempring, Tulang*), weighing each fraction, and calculating the percentage of each one. The desired standard is for the percentage of *Peko Super* obtained in the dry analysis to be higher than that in the wet analysis conducted before processing. The company's target standard is 30%.

Factors that affect the dry analysis results include the quality of the tea shoots, temperature and humidity during drying, as well as machine performance and operator skills. Processing discrepancies such as drying temperatures that are too high or low can impact the moisture content and quality of the resulting tea fraction (Mutia & Trimo, 2019). Tea processing such as withering, rolling and drying will also affect the moisture content and density of dried tea. In the drying process that is not optimal, such as temperatures that are too high can also result in tea that is too dry or still in a moist state, so that it can affect the results of moisture content and density analysis. In testing the quality of tea, the results of the separation of each fraction such *as Peko, Jikeng, Tulang*, And *Kempring* are strongly influenced by the quality of the machine used and the expertise in the processing process (Handjojo & Syarief, 2017).

Based on the above background, analysis of tea drying yield is an important aspect in maintaining the final quality of tea products. Therefore, it is necessary to conduct a Comparative Analysis of Tea Dry Yield on Ball Tea 1 and Ball Tea 2. The purpose of this study is to determine the distribution of tea dry yield fractions produced by two drying machines, namely Ball Tea 1 and Ball Tea 2, and to identify factors that affect the quality of tea from each machine. The results of this analysis are expected to be a reference in the tea sorting process, especially in determining Grade 1, as well as a basis for technical evaluation of drying parameters and the quality

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of raw materials used. In addition, the results of this study also contribute to the improvement of the overall tea production process, both in terms of drying efficiency and the consistency of the quality of the tea fractions produced. The industry can take the results of this analysis into consideration in setting more effective tea processing standards, so that product quality is maintained and has high competitiveness in the market.

Research Method

Materials

The materials used in this analysis are dried tea samples taken directly after passing through the final drying process using two units of Ball Tea machines, namely Ball Tea 1 and Ball Tea 2. Final drying is carried out after the tea has passed the initial drying stage using an ECP machine and a rotary dryer. The Ball Tea machine serves to reduce the moisture content of tea leaves to reach the range of 4-5%, according to company standards.

After the final drying process is complete, dry tea samples are taken from each machine by purposive sampling, which is deliberate sampling based on a specific purpose, namely to compare dry results between machines. The samples taken were then further analyzed using the dry analysis method to see the distribution of tea fractions based on the quality produced.

SPC (Statistical Process Control)

Statistical Process Control (SPC) is an approach used in industry to control and improve production processes continuously by using statistical concepts and techniques. The main objective is to ensure that the process runs consistently and produces products or services that meet established quality standards. The data obtained from the dry tea analysis, namely the percentage of each fraction (*Peko Super, Jikeng, Kempring, and Tulang*), was then analyzed using a Statistical Process Control (SPC) approach. SPC is a statistical method used to monitor, control, and evaluate the stability of a production process in order to stay within predetermined control limits.

Seven Tools (Control Chart)

In this approach, one of the Seven Tools of Quality is used, namely the control chart. A control chart is a graph used to view data variations over time and detect whether the process is in control or out of control. In this analysis, an $\bar{X}$ (X-bar Chart) type control chart is used because the data used is the average value of the fraction distribution over several observations.

$\bar{X}$ control charts are used to monitor changes in the average of a process. In use, the control map consists of three important lines, namely the center line CL (Central Line), the upper control limit UCL (Upper Control Limit), and the lower control limit LCL (Lower Control Limit). These lines are calculated based on the mean and range of the data.

The following formulas are used to calculate the control limits in an $\bar{X}$ (X-bar) control chart:

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$$CL = \bar{X}$$

$$UCL = \bar{X} + A_2 \times \bar{R}$$

$$LCL = \bar{X} - A_2 \times \bar{R}$$

Explanation:

$\bar{X}$ = the average of all subgroup means

$\bar{R}$ = the average of all subgroup ranges

A_2 = a constant based on the number of observations in each subgroup (n)

Dry Analysis Testing

Dry analysis is a tea analysis activity carried out after tea processing is completed. Dry analysis is carried out to determine the percentage of each green tea fraction, namely *Peko Super, Jikeng, Kempring,* And *Tulang*. Dry analysis produces a yield value in percent, which shows how much the percentage of each green tea fraction such as *Peko Super, Jikeng, Kempring,* And *Tulang* after the processing is done. The data obtained is used as a reference for considering the percentage of the final product resulting from sorting, which can be used as a correction during the processing process if there is a deviation process. The data from dry analysis is not only used as correction material in the processing process, but also a reference in the sorting stage (Salsabilla et al., 2023).

The test method in this analysis focuses on evaluating the dried tea yield obtained from two drying machines, namely Ball Tea 1 and Ball Tea 2. After the final drying process, dried tea samples were taken from each machine and analyzed using the dry analysis method. Samples totaling 250 grams were manually separated based on the fractions, namely *Peko Super, Jikeng, Kempring*, and *Tulang*. Each fraction was then weighed using a digital scale, and the results were calculated as a percentage of the total sample weight. This percentage is used to compare the distribution of fractions produced by Ball Tea 1 and Ball Tea 2, and to evaluate whether the fraction results are in accordance with the quality standards set by the company, especially for Grade 1 fulfillment.

Formula:

$$\text{Dry Analysis} = \frac{\text{weight of the category}}{\text{total weight}} \times 100\%$$

Table 1. Characteristics of Dried Tea Fractions

Peko Super	Derived from fine and medium plucking (*peko* tops, young leaves and young bird leaves).
Jikeng	Derived from coarse plucking (old leaves) up to the 5th leaf and young bird leaves.
Kempring	In the form of powder which is a mixture of fine plucking, coarse plucking and young bird and medium bird leaves.
Tulang	Derived from the handle or stalk of tea buds.

Source: SOP tea factory

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Results and Discussion

Based on the results of the analysis using the control chart of the *Peko Super* and *Jikeng* fractions for 10 days of production, it can be concluded that the tea drying process on both Ball Tea machines is in a statistically stable condition (in control). For the *Peko Super* fraction in Ball Tea 1, the Center Line (CL) value is 14.82%, with an upper control limit (UCL) of 29.56% and a lower limit (LCL) of 0.087%. All observations were within the control limits, with the highest yield of 21.10% (day 1) and the lowest of 6.80% (day 6), indicating a consistent process. Meanwhile, the *Peko Super* fraction in Ball Tea 2 has a CL of 13.60%, UCL of 26.90%, and LCL of 0.30%. The data was also within the control limits, but the fluctuation between days was significant, with the highest yield of 22.10% (day 1) and the lowest of 8.50% (day 5). In *Jikeng* Ball Tea fraction 1, a CL of 53.59% was obtained, with a UCL of 68.78% and LCL of 38.40%. All data is within the control limits, indicating a stable process. The highest value occurred on day 4 at 62.40%, and the lowest value on day 1 at 46.50%. Interestingly, the yield of the *Jikeng* fraction exceeded the company standard (30%), indicating the dominance of this fraction in the final drying result.

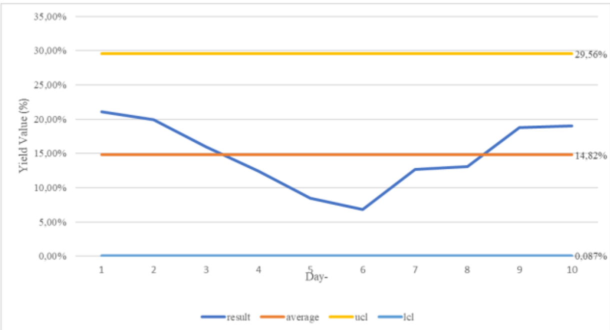

Figure 1. Control Chart of *Peko Super* Fraction Type on Ball Tea 1

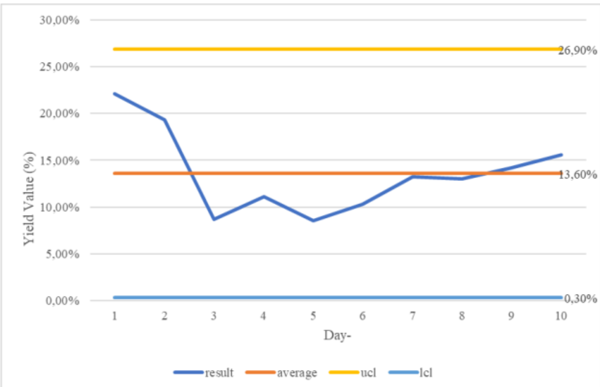

Figure 2. Control Chart of *Peko Super* Fraction Type on Ball Tea 2

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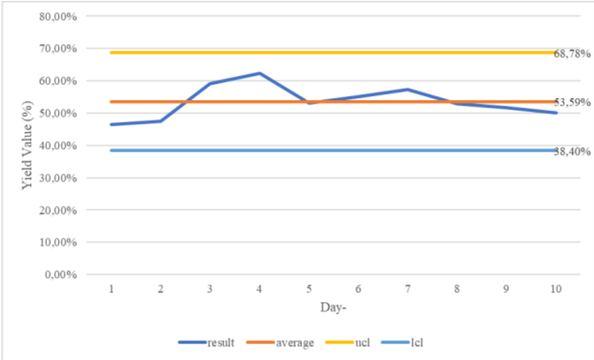

Figure 3. Control Chart of *Jikeng* Fraction Type on Ball Tea 1

In *Jikeng* Ball Tea fraction 2, the CL value was 53.93%, with a UCL of 83.36% and LCL of 24.50%. All results were within the control limits, indicating a statistically stable process. The highest yield occurred on day 3 (69.30%) and the lowest on day 5 (38.00%). The values tended to stabilize on days 6 to 10. This result exceeds the company's target of 30%. For *Kempring* Ball Tea fraction 1, a CL of 19.55%, UCL of 37.08%, and LCL of 2.02% were obtained. All data were within control limits, with the highest yield of 28.10% (day 6) and the lowest of 11.80% (day 3). The average value is still below the 30% target. *Kempring* Ball Tea fraction 2 had a CL of 17.91%, UCL of 32.83%, and LCL of 2.99%. The daily results were also within the control limits. The highest value was recorded on day 1 (27.40%) and the lowest on day 5 (10.50%). Although there were initial fluctuations, the process began to stabilize at the end of the period, but the average was still below the company standard.

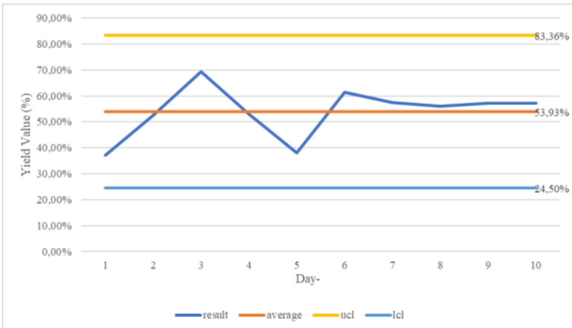

Figure 4. Control Chart of *Jikeng* Fraction Type on Ball Tea 2

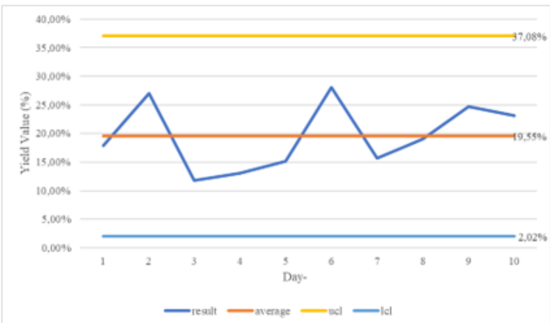

Figure 5. Control Chart of Kempring Fraction Type on Ball Tea 1

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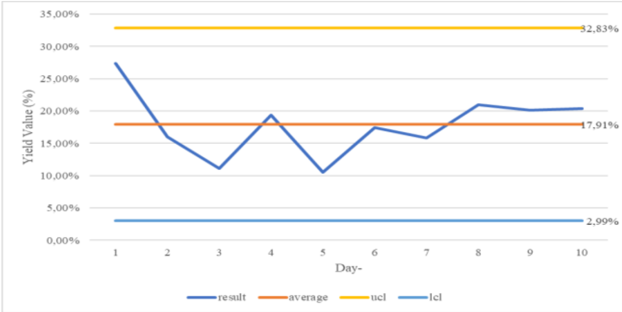

Figure 6. Control Chart of *Kempring* Fraction Type on Ball Tea 2

For the *Tulang* fraction of Ball Tea 1, a Center Line (CL) value of 18.30% was obtained, with an Upper Control Limit (UCL) of 36.30% and a Lower Control Limit (LCL) of 0.293%. All daily results during the 10 days of observation were within the control limits, indicating a stable process and no significant quality deviations. The lowest result was recorded on day 6 at 9.50%, and the highest on day 8 at 25.16%. Although the initial value was below the company's ideal target of 30%, there was an increase on the final days, indicating an improving trend in production quality. Meanwhile, the *Tulang* fraction in Ball Tea 2 had a CL value of 14.59%, with a UCL of 25.86% and LCL of 3.32%. All data points for 10 days were within the control limits, indicating a statistically stable production process. The highest value was achieved on day 5 at 24.20%, which was still below the UCL. Daily results tend to be close to the average, with no extreme fluctuation patterns, so it can be said to be fairly consistent. Nonetheless, this *Tulang* fraction result can still be improved to be closer to the ideal composition target if set by the company.

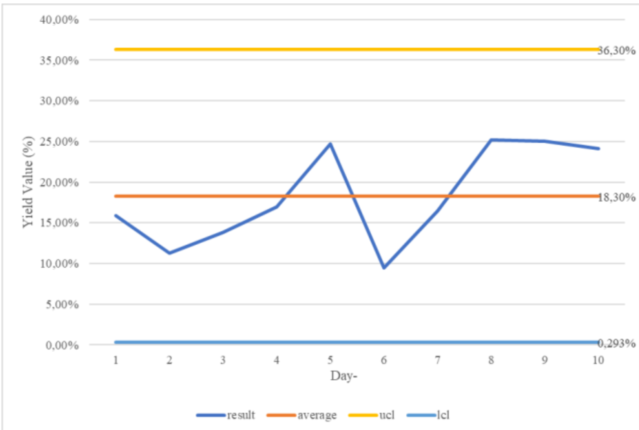

Figure 7. Control Chart of *Tulang* Fraction Type on Ball Tea 1

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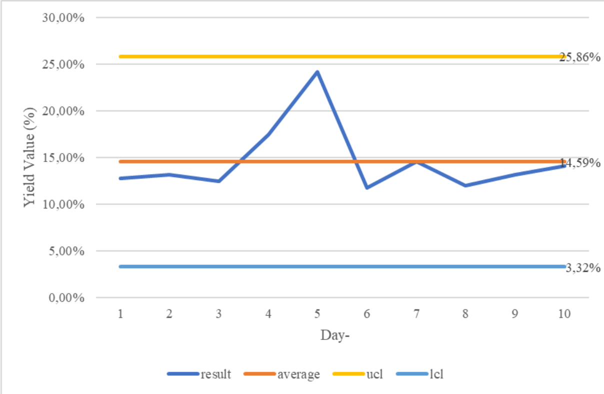

Figure 8. Control Chart of *Tulang* Fraction Type on Ball Tea 2

Based on the analysis, several tea fractions such as *Peko Super, Kempring*, and *Tulang* showed average percentages below the company's ideal target of 30%. Although these percentages are still within acceptable limits, consistently low yields in these fractions may negatively impact the final tea quality if not addressed. Several factors may contribute to this condition, including the characteristics of the raw material such as the size and maturity level of the tea leaves entering the drying process as well as drying parameters like temperature and duration. Suboptimal drying can result in fragile or poorly formed leaves, which affects the composition of the final fractions (Nuraini & Hermanuadi, 2023). Although the data were collected before the sorting process, they remain highly relevant as an initial evaluation reference. If high-grade fractions such as *Peko Super* fall significantly below target, early-stage processing and drying methods should be reviewed to ensure the final product still meets Grade 1 quality standards.

To further analyze the spread of UCL (Upper Control Limit) and LCL (Lower Control Limit) values from each Ball Tea machine, the data were visualized using box plots. These charts were generated based on calculated UCL and LCL values from the observational data processed in Excel. A box plot is a statistical graphic that displays data distribution using five key values: minimum, first quartile (Q1), median, third quartile (Q3), and maximum. Box plots are also useful for identifying potential outliers within the data. This method of visualization helps in assessing process consistency and detecting irregularities that may occur during production (Sari, 2019). The box plot results can be seen in Figures 9 and 10.

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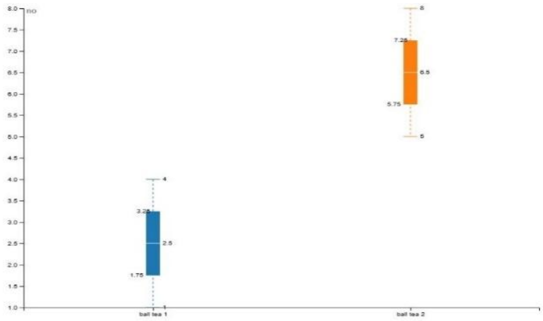

Figure 9. Results of Data Presentation of Comparison Value between Ball Tea 1 and Ball Tea 2 with Box Plot Chart Based on UCL Value

The results of data presentation in the form of box plots show a comparison of the distribution between Ball Tea 1 and Ball Tea 2. In Ball Tea 1, the data distribution appears tighter and more consistent, with a minimum value of 1.75, a maximum of 4, and a median of 2.5. The interquartile range (IQR) was between 1.75 and 3.25, and no outliers were found, indicating stable and relatively homogeneous data. In contrast, Ball Tea 2 showed a wider spread of data, with a minimum value of 5, a maximum of 8, a median of 6.5, and an IQR between 5.75 and 7.25. Although there were no outliers, the data variation in Ball Tea 2 was higher, indicating a less consistent process than Ball Tea 1. Overall, it can be concluded that Ball Tea 1 is more stable and uniform, while Ball Tea 2 has higher variability, requiring an evaluation of the process factors that affect its production.

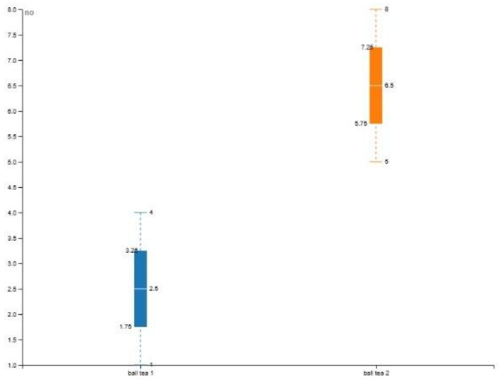

Figure 10. Results of Data Presentation of Comparison Value between Ball Tea 1 and Ball Tea 2 with Box Plot Chart Based on LCL Value

Based on the box plot graph, the Lower Control Limit (LCL) value for both types of machines, namely Ball Tea 1 and Ball Tea 2, was analyzed. In Ball Tea 1, the LCL is at 1, while all data such as the minimum (1.75), first quartile (1.75), median (2.5), and maximum (4) values are all above this limit. This indicates that the Ball Tea 1 production process is in statistical control and shows no deviation below the lower limit of control. For Ball Tea 2, the LCL value was recorded as 5, and all the data displayed were also above it, with a minimum value of 5.75 and a maximum of 8. Just like Ball Tea 1, this condition indicates that Ball Tea 2 is also still within the

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quality control limits. Thus, it can be concluded that both machines show stable and statistically controlled production performance, as none of the data crossed the lower limit of control.

Conclusion

The analysis shows that the distribution of tea fractions in Ball Tea 1 and Ball Tea 2 machines is not fully balanced according to the Grade 1 standard set by the company. Some fractions such as *Peko Super, Tulang*, and *Kempring* still have percentages below 30%, while the *Jikeng* fraction dominates in both machines, especially in BT 2. This dominance of the *Jikeng* fraction indicates a tendency for uneven yields, which can affect the final quality classification of tea. In addition, there are differences in yield characteristics between Ball Tea 1 and Ball Tea 2 that impact the potential for achieving Grade 1. The *Peko Super* fraction in BT 2 shows a higher percentage than Ball Tea 1, indicating that Ball Tea 2 has greater potential to produce high-quality tea. Meanwhile, the *Tulang* and *Kempring* fractions tended to have a relatively stable pattern across both machines, although Ball Tea 1 produced a slightly higher *Kempring* fraction. Overall, these findings can serve as a basis for evaluation for the company in optimizing the drying process and distribution of tea fractions to achieve a more balanced result that meets the set quality standards.

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