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Implementation of Statistical Process Control Method and Root Cause Analysis on Quality of Bitter Tannin Tea Tin

Implementation of Statistical Process Control Method and Root Cause Analysis on Quality of Bitter Tannin Tea Tin

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Abstract. The purpose of this study was to determine the quality control of tannin content of Bitter Liquid Tea (TCP). This study methodology is quantitative method with statistical process control method and root cause analysis approach. Based on the calculation and analysis of the control chart - p it can be seen that the tannery content of bitter liquid tea (TCP) in a state of uncontrollable. This can be demonstrated by the existence of data points outside the control limit (out of control) on the control chart-p and the point fluctuates very high and irregular, so it can be concluded that the process in a state of uncontrollable. Based on the results of analysis by using root cause analysis showed that the cause of variation in tannin content is the duration of brewing and the amount of dry tea. This result can be used by XYZ Company to assist in improving the quality of tannin in bitter liquid tea, so indirectly the quality of the product also increases. To increase knowledge about Statistical Process Control and Root Cause Analysis method application to improve product quality. This research is a direct implementation to the tea company, so that in accordance with the problems and applicative in providing solutions. The existence of new methods for the company in improving the quality of its tea products.

1. Introduction

The rapid development of the industrial world and the intense competition between products requires the company to produce products with high quality and competitive prices. One of the activities in creating quality is by applying the right quality control system. Quality is a product suitable for customer requirements. So, quality control is a technique a product to control that the quality as a customer want and suitable with the standard. Quality control is part of the production process that is very influential in improving product quality [1]. Product Quality is the key to win the market competition because it can earn the customer's trust to the product offered by the company, then, in the end, it will lead to customer loyalty [2]. So, quality control not only focuses on the finished goods, but also the whole process of production starting from the raw material, work-in-process goods, and finished goods ready to be sold [2].

PT.XYZ is a company engaged in the tea beverage industry in packaging located in Mojosari, Mojokerto. One of the excellent products of PT.XYZ is TBS products. In the first stage of TBS, production process begins with the process of brewing raw materials of hot tea with hot water in Extract Tank. The brewing process aims to extract the tannin content contained in the dried tea. Tannin is a tea component that can affect the taste, color and aroma in the results of steeping tea. After the tea brewing process is completed, then the results of the pour of boiling which is called Bitter Liquid Tea (TCP) is filtered in the bag filter and accommodated in Sediment Tank to wait for the next production process.

The problem that often occurs in tea brewing process is the tannin content contained in Bitter Liquid Tea (TCP) is not by the standard set by the company of > 1300 ppm, so the quality of Bitter Liquid Tea (TCP) is not optimal. To overcome these problems, determine the factors that influence the optimization of tannin content of Bitter Liquid Tea (TCP).

Based on the above problem, so the purpose of this research is the research is quality control on the tannery content of bitter liquid tea by using statistical process control method (SPC) and Root Cause Analysis (RCA). Control Chart is originally developed for use in mass production manufacturing [3]. SPC is an approach that has been broadly used in many industrial and non-industrial fields [3]. SPC by attributes is that even when the process operates normally (in control), a constant proportion of the units produced is defective [4]. SPC is the application of statistical methods to monitoring and control of a process to ensure that it operates at its full potential to produce a confirming product [5]. Statistical Process Control is widely used in manufacturing processed for process monitoring and anomaly detection [6]. Statistical Process Control is alarm for process manufacturing and operation detection anomaly process. RCA is to identify the problem [7]. Root cause identification (RCI) is critical to the quality control productivity improvement of manufacturing process [7]. Quality control is simply defined as the use techniques and activities towards achieving, sustaining and improving the quality of products or services [8]. Furthermore, quality control as all the features and characteristics of the product or service that contributes to the satisfaction of customer's needs [8]. The SPC tools were mainly applied for process control and improvement in manufacturing industries and control charting has been the most common process control technique [9]. And also that control chart is generally recommended for monitoring a process overtime to identify any changes or trends [9]. Control charts used to assess process stability and to identify the presence of specific causes [10]. SPC is a powerful collection of problem-solving tools useful in achieving manufacturing process stability and improving capability through the reduction of variability [11]. RCA is to identify the problem [6]. The aims to contribute to solve a quality problem and then search causes the problem using Statistical Process Control (SPC) and Root Cause Analysis (RCA) methods approach. Then, the result of the identification the nonstandard process, thus the purposes of this paper is to discuss the defective manufacturing process and analysis the cause that caused the problem of a nonstandard manufacturing process in bitter liquid tea.

2 Methodologgy

The methods used are quantitative with statistical process control (SPC) and Root Cause Analysis (RCA) approach. There are several steps using this method, namely: (1). Identification frequency nonstandard (batch) with check sheet; (2). Identification high number of frequency nonstandard (batch) with Pareto

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diagram; (3). Count of nonstandard proportion; (4). Count of Line Center (CL); (5). Count of Upper Control Limit and Lower Control Limit (LCL); (6). Identification Root Cause Analysis with RCA method.

2.1 Identification Frequency Nonstandard (Batch) with Check Sheet
The first step to analyze the quality statistically is to make a check sheet. Making check sheets is to facilitate the process of collecting data about the amount of production and products that are not following quality standards. The results of data collection using the check sheet in Table 1.

Table 1. Tannin Levels Check Sheet

No	Month	Production Total (Batch)	Nonstandard Frequency (Batch)
1	February	122	36
2	March	155	55
3	April	146	31
	Total	423	122

2.2 Identification high number of frequency nonstandard (batch) with Pareto diagram
The next step is to make a Pareto diagram. Pareto diagrams are used to determine the frequency of standard non-standard tannin content that occurs on a monthly basis. Pareto diagram as shown in table 2.

Table 2 . Pareto Diagram

No	**Month**	**Frequency (Batch)**	**Cumulative Frequency**	**Percentage Total (%)**	**Cumulative Percentage (%)**
1	March	55	55	45	45
2	February	36	91	30	75
3	April	31	122	25	100
	Total	**122**		**100**	

Table 2 shows that the highest frequency of standard non-standard tannin in March was 55 batches (45%). While the rate of nonstandard tannin content at least occurred in April of 31 batches (25%). Table 2 shows that the highest frequency of standard non-standard tannin in March was 55 batches (45%). While the frequency of nonstandard tannin content at least occurred in April of 31 batches (25%).

2.3 Calculate of nonstandard proportion
Non-standard proportions are used to view the percentage of non-standard tannin content in each subgroup (production date). The formula for calculating non-standard proportions is:

$$p = \frac{\text{Number of nonstandard products}}{\text{Total Production}} \qquad \ldots\ldots\ldots\ldots (1).$$

2.4 Calculate of Line Center (CL)
The center line (CL) is a line representing the average non-standard level in a production process. To calculate the center line using the formula: The center line (CL) represents the line representing the average non-standard level in a production process. To calculate the center line using the formula:

$$CL = \bar{p} = \frac{\Sigma np}{\Sigma n} \qquad \ldots\ldots\ldots\ldots\ldots (2)$$

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2.5 Count of Upper Control Limit and Lower Control Limit (LCL)

The upper control limit (UCL) and lower control limit (LCL) are statistically sized indicators of a process that can be said to be distorted or not. The upper control limit (UCL) and the lower control limit is calculated using the formula:

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ (3)$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

After the non-standard proportion value of each subgroup, CL, UCL, and LCL values are obtained, the next step is to analyze the root cause of uncontrolled data by using root cause analysis.

3 Result and Discussion

Based on equation one concerning the calculation of non-standard proportions, equation two concerning the calculation of the middle line and equations three and four concerning upper and lower control limits. Table 3 is a recapitulation of calculations.

Table 3. Calculation of Control Chart –p

Sub Group	Date	Production Total (n)	Nonstandard Tannin (np)	P	CL	UCL	LCL
1	06/02/2013	7	4	0,57	0,288	0,801	-0,225
2	07/02/2013	9	3	0,33	0,288	0,741	-0,165
3	08/02/2013	2	0	0	0,288	1,249	-0,673
4	13/02/2013	7	1	0,14	0,288	0,801	-0,225
5	14/02/2013	13	6	0,46	0,288	0,665	-0,089
6	15/02/2013	14	4	0,29	0,288	0,651	-0,075
7	16/02/2013	2	2	1	0,288	1,249	-0,673
8	20/02/2013	4	0	0	0,288	0,967	-0,391
9	21/02/2013	15	3	0,2	0,288	0,693	-0,063
10	22/02/2013	10	6	0,6	0,288	0,718	-0,142
11	25/02/2013	2	0	0	0,288	1,249	-0,673
12	26/02/2013	12	2	0,17	0,288	0,68	-0,104
13	27/02/2013	10	3	0,3	0,288	0,718	-0,142
14	28/02/2013	15	2	0,13	0,288	0,639	-0,063
15	01/03/2013	13	3	0,23	0,288	0,665	-0,089
16	02/03/2013	7	0	0	0,288	0,801	-0,225
17	07/03/2013	5	2	0,4	0,288	0,896	-0,32
18	08/03/2013	12	3	0,25	0,288	0,68	-0,104
19	09/03/2013	13	1	0,08	0,288	0,665	-0,089
20	10/03/2013	8	4	0,5	0,288	0,768	-0,192
21	11/03/2013	6	2	0,33	0,288	0,843	-0,267
22	16/03/2013	13	3	0,23	0,288	0,665	-0,089
23	17/03/2013	10	2	0,2	0,288	0,718	-0,142
24	19/03/2013	2	2	1	0,288	1,249	-0,673
25	20/03/2013	12	8	0,67	0,288	0,68	-0,104
26	21/03/2013	13	6	0,46	0,288	0,665	-0,089
27	22/03/2013	2	0	0	0,288	1,249	-0,673

Sub Group	Date	Production Total (n)	Nonstandard Tannin (np)	P	CL	UCL	LCL
28	24/03/2013	9	0	0	0,288	0,741	-0,165
29	26/03/2013	7	2	0,29	0,288	0,801	-0,225
30	27/03/2013	12	6	0,5	0,288	0,68	-0,104
31	**28/03/2013**	**7**	**7**	**1**	**0,288**	**0,801**	**-0,225**
32	29/03/2013	1	1	1	0,288	1,646	-1,07
33	30/03/2013	3	3	1	0,288	1,072	-0,496
34	02/04/2013	7	2	0,29	0,288	0,801	-0,225
35	03/04/2013	13	4	0,31	0,288	0,665	-0,089
36	04/04/2013	12	3	0,25	0,288	0,68	-0,104
37	05/04/2013	6	2	0,33	0,288	0,843	-0,267
38	06/04/2013	1	1	1	0,288	1,646	-1,07
39	09/04/2013	3	1	0,33	0,288	1,072	-0,496
40	10/04/2013	13	3	0,23	0,288	1,249	-0,673
41	11/04/2013	13	2	0,15	0,288	1,249	-0,673
42	16/04/2013	5	0	0	0,288	0,896	-0,32
43	17/04/2013	12	1	0,08	0,288	0,68	-0,104
44	18/04/2013	13	3	0,23	0,288	1,249	-0,673
45	23/04/2013	4	2	0,5	0,288	0,967	-0,391
46	24/04/2013	12	1	0,08	0,288	0,68	-0,104
47	25/04/2013	12	2	0,17	0,288	0,68	-0,104
48	26/04/2013	11	2	0,18	0,288	0,698	-0,122
49	27/04/2013	9	2	0,22	0,288	0,741	-0,165

Based on table 3, can be concluded that the data is in a state of uncontrollable. Because of the 49 data, there is one data point that is outside the control limit (out of control), i.e., at point-31. The data has a value of the proportion of 1, outside the limit of Upper Control Limit (UCL) that is equal to 0.801. Control chart p can be said in a statistical control situation if no pattern arises and there is no data point that is outside the control limit.

The presence of fluctuating and irregular points indicates that the quality control of tannin content of Bitter Liquid Tea (TCP) is still experiencing deviation. Therefore, further analysis of why differences occur by using causal diagrams using fishbone diagrams or cause-effect diagram. The arrangement of the cause-effect diagram with brainstorming and direct observation on TBS production process. Figure 1 is cause-effect diagram nonstandard tannin level. Based on the cause-effect diagram, it can be seen the factors that cause the variance of tannin level of Bitter Liquid Tea (TCP). Here is the description:

1. Human Factors

Human influence on the process of brewing tea is significant, the operator of the kitchen must implement Standard Operating Procedure (SOP

2. Factor Method

Non-standard Titration of Non-standard Liquid Tannery (TCP) is one of the reasons for the duration of brewing and water temperature for tea brewing process not by Standard Operating Procedure (SOP). This causes the tea extraction process is not optimal so that the tannin content becomes nonstandard.

3. Machine Factor

The factor of the production machine is that the agitator is not operated in the Extract Tank. The function of agitators to speed up the homogeneous process of Bitter Liquid Tea (TCP) in tea brewing. With no agitator operated, the homogeneous process becomes longer and thus affects the tannin content of Bitter Liquid Tea (TCP). Due to efficiency considerations in the use of electrical resources, the agitator is not operated in the process of brewing tea.

4. Material Factor

The influence of material conditions in the form of moisture and dry tea tannin levels significantly affect in the process of brewing tea. When dry tea moisture is> 8%, dry tea becomes moist and causes mold on dry tea. As for dry tea tannin, if the tannin <850 ± 25 ppm, it will increase the use of dry tea in the process of brewing tea to tannin content of Bitter Liquid Tea (TCP)> 1300 ppm. And also concerning cleanliness in the production process. For example, before making tea brewing process, Extract Tank must be clean from tea waste from the previous brewing process. Operators of the kitchen must also have good control and care of the process of brewing tea. In the event of the variance in the process of brewing tea, the operator must communicate with QC analysts about the results of tea brewing process.

5. Environmental Factors

The environmental factor is the unavailability of temporary storage for an excess of dry tea from the previous tea brewing process. In the absence of temporary storage, it will cause the moisture of the residue of the dry tea to exceed the standard. This will cause the quality of dry tea is not optimal.

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2. Factor Method

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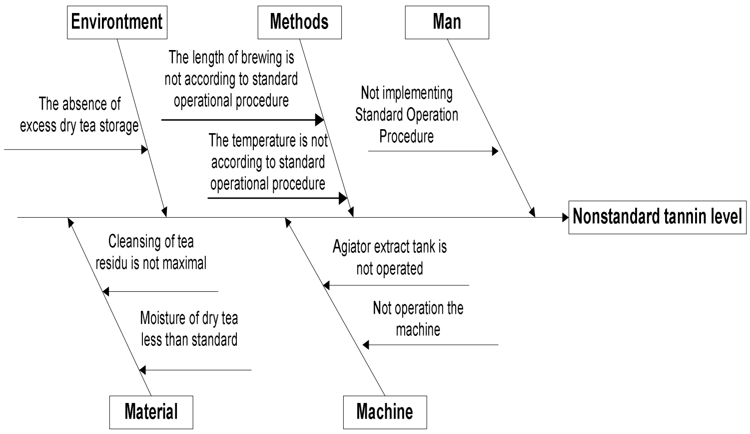

Figure 1. Cause effect diagram of nonstandard tannin level

After the know factors cause nonstandard tannin level of bitter liquid tea, then performed further analysis using cause analysis. Based on figure 2 cause analysis of nonstandard tannin level of bitter liquid tea. The cause of nonstandard tannin level these are the brewing method not standard, dry tea quality is not optimal, and power efficiency.

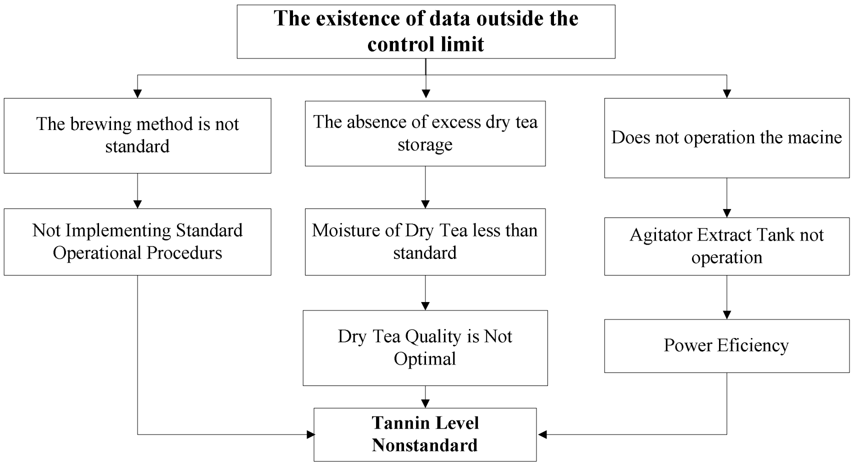

Figure 2 Root Cause Analysis of Nonstandard Tannin Level

Based on the result of this study, using Statistical Process Control (SPC) can be known whether there is a process have a deviation or not in the process of brewing tea, so it's known that the tannin level of bitter liquid tea following what standards are not. If appropriate then it can improve TBS product quality. If not appropriate then it can be known the cause of the factor using cause-effect diagram after it got the cause of the problem with cause analysis.

The result supporting by Oberoi, et.al (2016), with entitled “SPC (Statistical Process Control): A Quality Control Technique for Confirmation to Ability of Process”, that SPC is an effective tool of quality and process control in all type of industry not only manufacturing industry where quality and customer satisfaction is a major concern [11]. The result of this research support those of research by Godina., et.al (2017), entitled “Quality Improvement With Statistical Process Control in The Automotive Industry”, based on the analysis of the result of attribute control chart have demonstrated that the process is not capable of producing 100% of the specified pieces within required specifications [10].

The suggestions for further research are the design of components of bitter liquid tea with the design of experiment method, for example, Taguchi method and analysis with failure mode effect analysis (FMEA) if the deviation of the production process is high. With FMEA, we will calculate risk priority number, so we can take action of priority to improve the process.

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