UTILIZING STATISTICAL QUALITY CONTROL TOOLS IN IMPROVING THE QUALITY OF THE WEIGHTS OF ANIMAL-FEED BAGS

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ABSTRACT: *The role of quality measurement and improvement in the examination of continuous product and service improvement has expanded over time. Control charts for statistical process control (SPC) are useful in assessing and optimizing industrial processes. The data were obtained during every batch of Feed types. The first three (3) bags output of the Automatic Bag Weighing Machine was monitored and recorded was entered into IBM SPSS Software for descriptive analysis of the mean, standard deviation, maximum and lowest values for the various types of Mash Feeds. The analysis of the reasons for the departure of some points from the control units discovered that they were caused by a change in machine settings. These charts will be used in the future to control the quality of the bag's weight, and the responsible parties will use these charts in the future by taking samples of the production and calculating each of the R, and these values on the monitoring charts, and making the appropriate decision in terms of the production process being under control or out of control.*

Keywords: Statistical Quality Control, Weights, Tool, Animal Feed, Bags, Batch, IBM SPSS software

1. INTRODUCTION

The importance of quality measurement and improvement has grown over time in the investigation of continuous product and service improvement. The use of control charts for statistical process control (SPC) has proven to be effective in assessing and improving manufacturing processes. Shewhart's SPC charts are the most commonly used (1925). Control charts are classified into two types based on the nature of the control characteristic. If the quality dimension is measured numerically, a control chart with variables is used. If the product can only be classified as defective or non-defective, a control chart by attributes is used [1].

Control charts are essential tools for improving statistical quality control. In the last ten years, quality improvement techniques have been used to [2] meet the needs of consumers. The product must sustain the desired properties with the fewest defects possible while maximizing profit. There are natural variations in production, but there are also assignable causes that are not random. Control charts are used to monitor production, and their use can serve as an "early warning" index for potential "out-of-control" processes. Different methods are used to keep production under control. Control charts are created for various causes, and upper and lower control limits are included. There are several types of control charts in use, which are classified primarily as control charts for variables and control charts for attributes. Points plotted on the charts, certain patterns may emerge, allowing the user to obtain particular data. Raw material, machine setting or measuring methods, human, and environmental factors all exhibit deviations from normal behavior, inadvertently affecting product quality. The evidence gathered from control charts enables the user to take corrective actions, such as opting for specified nominal values, thereby improving quality [2].

There will always be room for improvement as long as the company hasn’t achieved perfection or zero defects at the best price. Furthermore, quality illnesses can generally be cured and optimized by using combinations of statistical methods Effective SPC technique implementation necessitates a proper management climate with a good understanding of such techniques, which provides SPC training and education for labor and informs them about the key factors that will make application successful. Following these factors, Shari et al. [3] proposed five recommendations to reduce defects and improve product quality in a plastic packaging manufacturing company using SPC techniques. Implementing SPC techniques allows you to control variation and prevent not only defective products but also defective services, where a defect is a failure to meet customer requirements and satisfaction. Ross [4] used SPC techniques to reduce medication times that did not meet the desired standard in a medical organization. Das [5] used a histogram and a capability process index to run an ANOVA model and discovered significant differences between cement packing nozzles when the stochastic nature and economic factors of production were considered to account to determine the most cost-effective packing process setting.

Control charts are divided into two types: control charts for quantitative variables and control charts for traits or properties, with control charts for quantitative variables being the most relevant to the researcher. The arithmetic mean charts, which depict the amount to which the process is occupied, and the R range charts are the most effective charts for quantitative variables. When selecting what to measure and how to obtain samples, the combination of those charts is extremely useful [6].

Manufacturing quality is a property that can be assessed in practice and digitally expressed, this sort of chart is employed. It measures attributes that can be measured in units such as length, width, weight, temperature, time, speed, and so on. As a result, each property crosses a variable with a specific value. Typically, samples are picked at random from manufacturing, with tiny sample sizes. To minimize variances between sample items, samples are chosen at the same time or during the same production process, and sampling should be repeated at subsequent intervals to indicate differences, as recommended sampling sizes should be equal in number. The arithmetic mean (X-Chart) control charts are used to monitor the production process in terms of average quality and the generation of observation charts for computation mediation. The arithmetic mean is also a random variable that follows the normal distribution with mean and standard deviation if X is a random variable that follows the normal distribution with a mean and standard deviation

. $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$

Where:

σ = standard deviation.

n = number of samples

μ = mean

If μ and σ are known, then:

Lower Control Limit, LCL = $\mu - Z_{\frac{\alpha}{2}} \sigma_{\bar{x}}$

$$LCL = \mu - Z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}}$$

Upper Control Limit, UCL = $\mu + Z_{\frac{\alpha}{2}} \sigma_{\bar{x}}$

$$UCL = \mu + Z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}}$$

Where:

$Z_{\frac{\alpha}{2}}$ = the z-value at the significance level

Control limits for the sample mean are as follows:

Lower Control Limit (LCL)

$$LCL = \mu - Z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}}$$

Middle Limit (CL)

$$CL = \mu$$

Upper Control Limit (UCL)

$$UCL = \mu + Z_{\frac{\alpha}{2}} \frac{\sigma}{\sqrt{n}}$$

If $Z_{\frac{\alpha}{2}} = 3$ then 3σ limits with (1- α) 100%

The study, therefore, aims to utilize statistical quality control to improve the quality of weights in feeds bags produced in the manufacturing industry. This involves data gathering via sampling of output product weights taken from the bag weighing machine. After the implementation of SQC Tools through control charts, the determination of the existence of out-of-control products was addressed through root cause analysis.

Methodology

The data were obtained during every batch of Feed types. The first three (3) bags output of the Automatic Bag Weighing Machine was monitored and recorded through the Daily Summary Production Report, and the nature of the data is the genuine weights of the Animal feed bags manufactured and distributed in the markets with a supposed weight of (50) kg and was checked using a high-quality electronic balance for the twenty-four (24) hour operation. Gathered data was analyzed via IBM SPSS software utilizing a quality control option and control chart for moving range.

2. RESULTS AND DISCUSSION

2.1 SQC Tools First Implementation for Feeds Bag Weight

The set of data taken from the Bag weight record of Feed types shown is shown in Table 1.

Table 1. Sample Data for Weight of Feeds in Bags

Sample No.	Feed Type		
	Mash Feed in Kgs	Pellet Feed in Kgs	Crumble Feed in Kgs
1	50.85	50.82	50.16
2	45.28	50.28	51.14
3	51.61	50.17	51.06
4	50.63	49.15	50.50
5	50.42	50.23	50.17
6	50.55	50.63	50.33
7	50.56	50.12	50.44
8	50.93	50.91	54.28
9	51.59	50.57	50.00
10	50.51	50.70	50.56
11	51.02	50.93	50.08
12	50.63	50.93	50.96
13	50.08	46.60	50.51
14	51.63	51.14	50.72
15	50.00	50.08	51.59

Figure 1 illustrates that the average of samples of different types of Feeds is within the arithmetic mean control chart while

there are violations shown in Table 2. The R chart in Figure 2 shows that the majority of the points are positioned between the control limits except for the violations found in Table 3. Thus, it is needed to remove the violated samples in Table 2 and recalculate the set of remaining data.

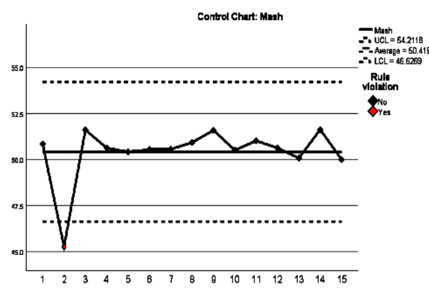

Figure 1a. Control Chart for Mash Feeds

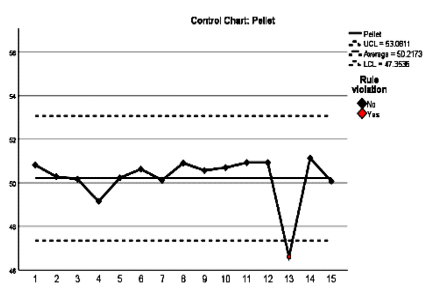

Figure 1b. Control Chart for Pellet Feed

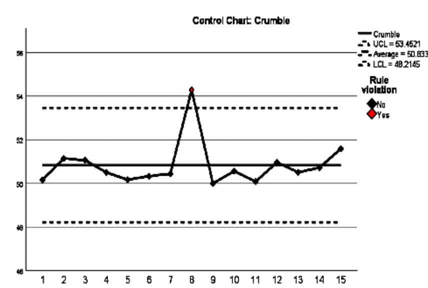

Figure 1c. Control Chart for Crumble Feed

2.2 Second SQC Tools Implementation for Feeds Bag Weight

The arithmetic means control chart and the R dimension after the modification is shown. The points representing R and X for the other samples were identified, and it was discovered that all of the samples, points are positioned inside the arithmetic mean chart's control boundaries (see Figure 3). While in Figure 4, the points on the R chart are within the boundaries of the control chart.

Table 2. Rule Violations for X Bar Chart

Type of Feed	Case Number	Violations for Points	Remarks
Mash Feed	2	Less than -3 sigma	1 point violates control rules.
Pellet Feed	13	Less than -3 sigma	1 point violates control rules.
Crumble Feed	8	Greater than +3 sigma	1 point violates control rules.

Table 3. Rule Violations for R Bar Chart

Type of Feed	**Case Number**	**Violations for Points**	**Remarks**
Mash Feed	**2**	**Greater than +3 sigma**	**2 points violate control rules.**
	3	**Greater than +3 sigma**	
Pellet Feed	**13**	**Greater than +3 sigma**	**2 points violate control rules.**
	14	**Greater than +3 sigma**	
Crumble Feed	**8**	**Greater than +3 sigma**	**2 points violate control rules..**
	9	**Greater than +3 sigma**	

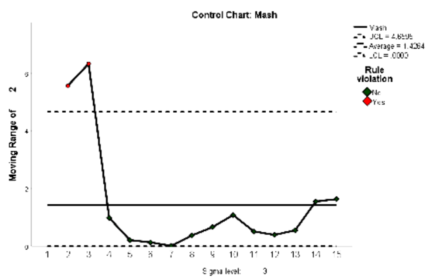

Figure 2a. R Chart for Mash Feed

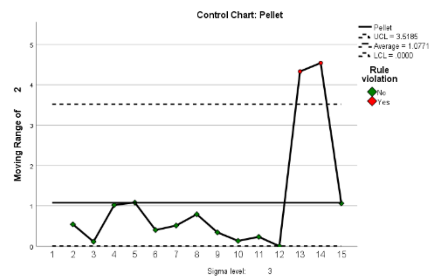

Figure 2b. R Chart for Pellet Feed

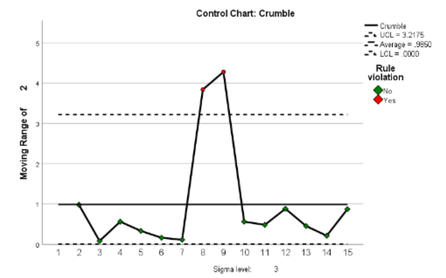

Figure 2c. R Chart for Crumble Feed

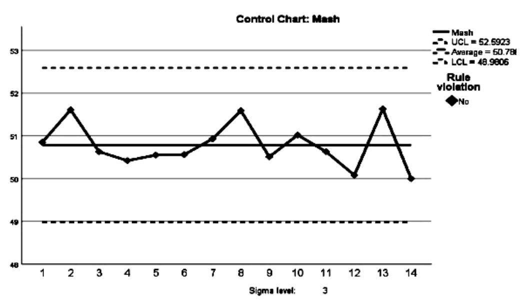

Figure 3a. Update 1 X Chart for Mash Feed

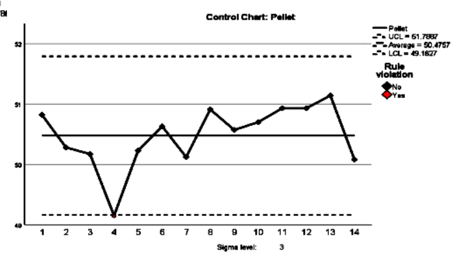

Figure 3b. Update 1 X Chart for Pellet Feed

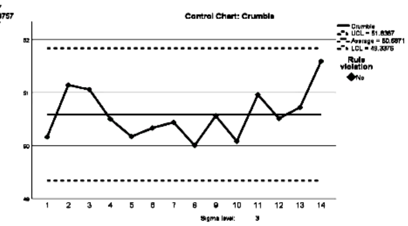

Figure 3c. Update 1 X Chart for Crumble Feed

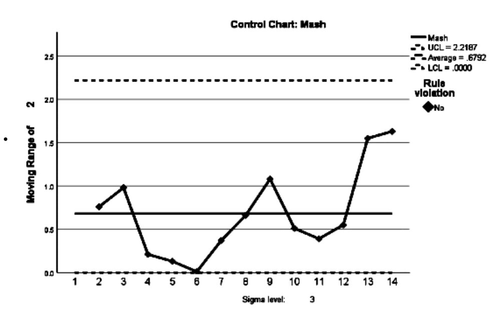

Figure 4a. Update 1 R Chart for Mash Feed

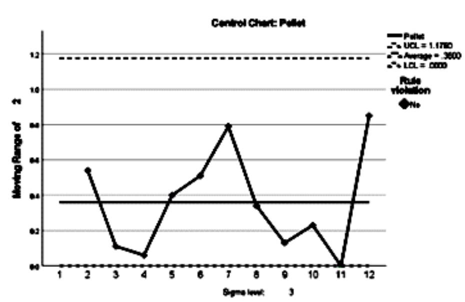

Figure 4b. Update 1 R Chart for Pellet Feed

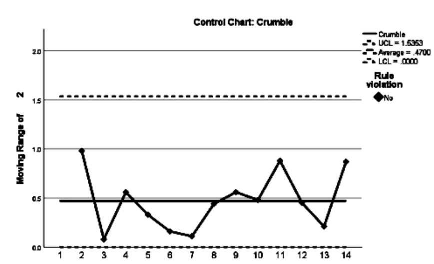

Figure 4c. Update 1 R Chart for Crumble Feed

However, it can be noticed that there are samples that go beyond the One (1) kg allowable weight tolerance as Company's Product Standard. Thus, the need to remove out of control samples and then recompute the data. The adjustments must be made to attain a much lesser deviation on the target weight of the feed bags which is 50 kg is now noticeable as shown in Figures 5 and 6.

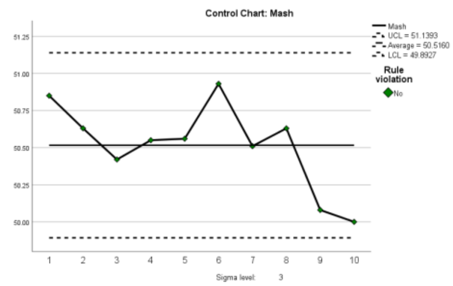

Figure 5a. Update 2 X Chart for Mash Feed

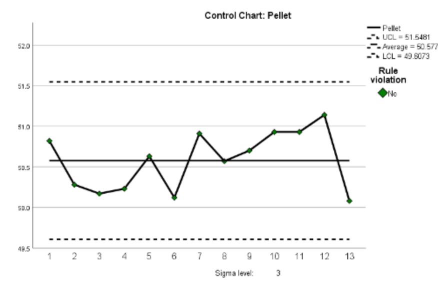

Figure 5b. Update 2 X Chart for Pellet Feed

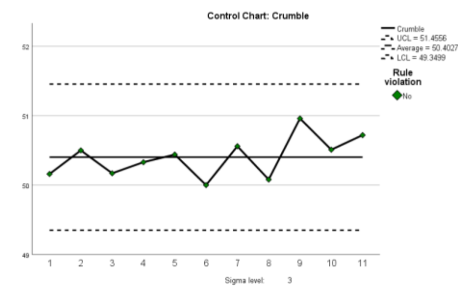

Figure 5c. Update 2 X Chart for Crumble Feed

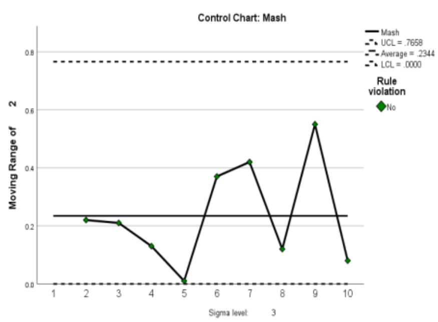

Figure 6a. Update 2 R Chart for Mash Feed

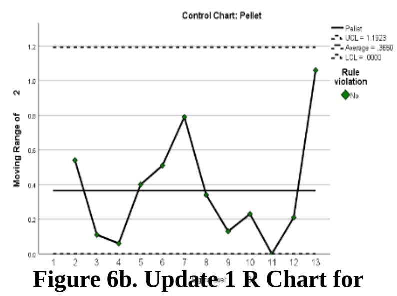

Figure 6b. Update 1 R Chart for Pellet Feed

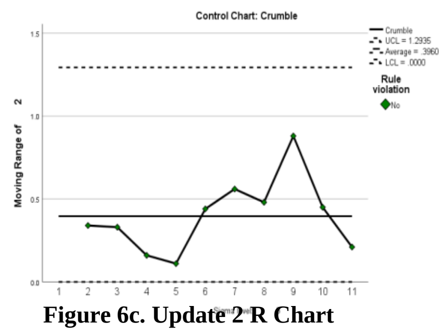

Figure 6c. Update 2 R Chart for Crumble Feed

Customers' satisfaction is now attained within the range and a deviation from the standard of less than 1.0 kg is already acceptable for marketing. Thus, the final control limits are shown in Table 4.

Table 4. Control limits of Animal Feed Types

The control limits for this chart for the arithmetic mean			
	Mash	Pellet	Crumble
Upper Control Limit UCL	51.193	51.4880	51.4556
Center Line CL	50.51	50.53	50.4027
Lower Control Limit LCL	49.89	49.57	49.3499
The limits for the range			
Upper Control Limit UCL	0.7658	1.1760	1.2935
Center Line CL	0.2344	0.36	0.396
Lower Control Limit LCL	0	0	0

3.4 Root Cause Analysis

When a defect, fault, or error is discovered, the likely cause should be determined. When the complete number of causes of an issue is unknown or just two or a few of them have been recognized, the cause-and-effect diagram can be a valuable tool for identifying potential reasons. The cause-and-effect diagram is also known as the 'Ishikawa diagram' or the 'fishbone diagram,' after Dr. Ishikawa presented it in 1943. On the other hand, it is fashioned like a fish, with the qualitative characteristic situated at its head, and the causes forming its branches, all of which are shaped in the shape of a fishbone [7].

Table 5 Causes of Deviation from Standard Bag Weights

Cost deviation groups	Main causes	Symbols
Equipment	The setting of Machine Parameters	C1
Materials	Feed Type Classifications	C2
Men	Human Fatigue	C3
Measurement	Errors in Weight Readings	C4
Environment		C5
Process	Deviation of Weighing Procedures	C6

To discover and investigate the root causes of weighted variation, firsthand interviews with industry workers who were essentially chosen based on their position and qualifications. Figure 7 shows the Ishikawa Diagram relating the causes found in Table 5. It can be observed that the form of the product is related to the degree of deviated weights from the standard indicated in the summary of removed samples in Table 6.

Table 6. Summary of Out-of-Control Samples

Feed Type	Feed Type Form	Number of Samples Removed
Mash Feeds	Powder Form	5
Pellet Feeds	Cylindrical Form	3
Crumbles Feeds	Cracked Form	5

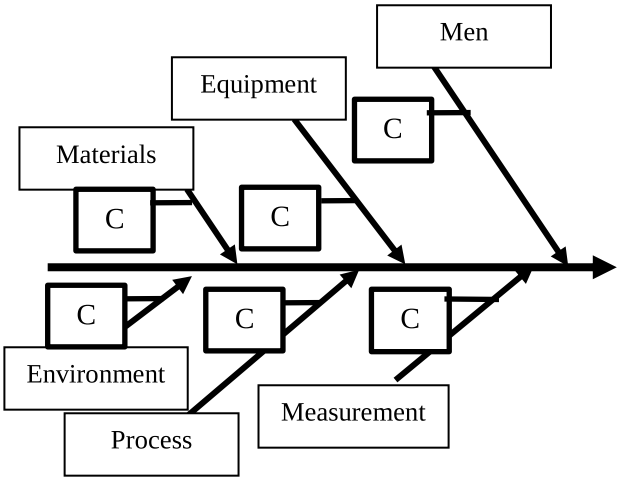

Figure 7 Ishikawa Diagram

It can be noticed that the powder and crack forms have more data with Out-of-control samples. Pellet Feeds has the least sample out of the standard weights in bags because of the product form (see Figure 8).

Figure 8. Physical Form of Animal Feed Types

3. DISCUSSIONS AND CONCLUSION

After drawing the identified sample feed types were measured and analyzed on the SQC Control charts, the result shows the deviation of some points on the control limits. This is evident after implementing the SQC tool process where the expected source of change is noted out of statistical control limits. The analysis of the reasons for the departure of some points from the control units discovered that they were caused by different categories depicted in the root cause analysis table. These charts will be used in the future to control the quality of the bag's weight, and the responsible parties will use these charts in the future by taking samples of the production and calculating each of the R, and these values on the monitoring charts, and making the appropriate decision in terms of the prduction process being under control or out of control.

The researcher proposes the following based on the findings:

1. In order to maintain quality, the process of adhering to these charts must be ongoing.
2. Future samples must be taken, and if any points are found to be out of control, the causes must be identified and eliminated in order to bring the production process back to normal.
3. reliance on the control charts' capacity to reveal issues that could lead to inaccurate production.
4. In order to support future plans that contribute to the development of a clear and accurate policy to obtain trustworthy future predictions in the field of statistics and other sciences, it is important to raise the level of documentation to keep up with scientific advancement.

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