FOOD QUALITY CONTROL USING THE METHOD OF STATISTICAL PROCESS CONTROL (SPC)

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Abstract

This work is on food quality control using the method of statistical process control (SPC). The study examined some aspects of product quality from different professional approaches and gave eight dimensions of quality such as performance, features, reliability, conformance, durability, serviceability, aesthetic, and perceived quality. Furthermore, it demonstrated how statistical process control (SPC) was used to check whether X-Food production process was in a state of control or out of control. Two hundred random samples of yoghurt were periodically selected and the numbers of defectives were correspondingly recorded. The Minitab's statistical software was used to construct the P-chart, capable of tracking processes in real – time and provide automatic notification of non-conformance. The implications of this chart plotted is that the process is in a state of control as all points plotted are within the upper control limit and the lower control limit while data points rally round the P-bar.

Key words: Quality control, statistical process control, dimensions, p-chart, control limits, state of control.

Quality control is becoming a key issue in every aspect of human endeavour. Be it in the food industry, banking sector, beverage industries, chemicals and petrochemical companies, cement industries, automobile and other sectors of the world economy. The Japanese Automobile manufacturers are in the forefront in Statistical Process Control (SPC) which accounts for market availability for their products. Quality is viewed

differently by scholars and professionals alike simply on the basis of available knowledge and experiences.

Aim and objectives

The aim of this work is to show the nature of product quality and how statistical process control (SPC) can be used to assist manufacturers to minimize cost of production while maintaining their product unique characteristics. Consequently, the objectives include:

i. Description of various approaches to product quality;

ii. Analysis and synthesis of some aspects of product attributes and how to recognize them; and

iii. Construction of a p-chart to test X-company for product quality conformance.

Background of the Study

Five major approaches to the definition of quality can be identified:

The Transcendent Approach of Philosophy

According to the transcendent view, quality is synonymous with "innate excellence"(Tuchman, 1980). It is both absolute and universally recognizable, a mark of uncompromising standards and high achievement. Nevertheless, proponents of this view claim that quality cannot be defined precisely; rather, it is a simple, unanalyzable property that we learn to recognize only through experience. This definition borrows heavily from Plato's discussion of beauty. In the Symposium, he argues that beauty is one of the "platonic forms," and, therefore, a term that cannot be defined. Like other such terms that philosophers consider to be "logically primitive," beauty (and perhaps quality as well) can be understood only after one is exposed to a succession of objects that display its characteristics(Buchanen, 1948).

The Product-based Approach of Economics

Product-based definitions are quite different; they view quality as a precise and measurable variable. According to this view, differences in quality reflect differences in the quantity of some ingredients or attributes possessed by a product. For example, high-quality ice cream has high butterfat content, just as fine rugs have a large number of knots per square inch. Early economic research on quality focused almost exclusively on durability, simply because it was so easily translated into the above framework (Swan, 1982). Since durable goods provide a stream of services over time, increased durability implies a longer stream of services — in effect, more of the good. Quality differences could, therefore, be treated as differences in quantity.

The User-based Approach of Economics, Marketing and Operations Management

User-based definitions start from the opposite premise that quality "lies in the eyes of the beholder." Individual consumers are assumed to have different wants or needs, and those goods that best satisfy their preferences are those that they regard as having the highest quality (Kuehn and Day, 1962).

The basic problem with the user-based approach is its equation of quality with maximum satisfaction. While the two are related, they are by no means identical. A product that maximizes satisfaction is certainly preferable to one that meets fewer needs, but is it necessarily *better* as well? The implied equivalence often breaks down in practice. A consumer may enjoy a particular brand because of its unusual taste or features, yet may still regard some other brand as being of higher quality. In the latter assessment, the product's objective characteristics are also being considered. Today, durability is regarded as an important element of quality. Long-lived products are generally preferred to those that wear out more quickly. This was not always true: until the late nineteenth century, durable goods were primarily possessions of the poor, for only wealthy individuals could afford delicate products that required frequent replacement or repair (Yepsen, 1982).

The Manufacturing-based Approach of Operations Management

User-based definitions of quality incorporate subjective elements, for they are rooted in consumer preferences — the determinants of demand. In contrast, manufacturing-based definitions focus on the supply side of the equation, and are primarily concerned with engineering and manufacturing practice. According to Boehm (1963), virtually all manufacturing-based definitions identify quality as "conformance to requirements." Once a design or a specification has been established, any deviation implies a reduction in quality. Excellence is equated with meeting specifications, and with "making it right the first time." In these terms, a well-made Mercedes is a high-quality automobile, as is a well-made Kia.

While this approach recognizes the consumer's interest in quality — a product that deviates from specifications is likely to be poorly made and unreliable, providing less satisfaction than one that is properly constructed — its primary focus is internal. Quality is defined in a manner that simplifies engineering and production control. On the design side, this has led to an emphasis on reliability engineering (Feigenbaum, 1961); and on the manufacturing side, to an emphasis on statistical quality control (Juran and Gryna, 1980). Both techniques are designed to weed deviations early: the former, by analyzing a product's basic components, identifying possible failure modes, and then proposing alternative designs to enhance reliability; the latter, by employing statistical techniques to discover when a production process is performing within/outside acceptable limits.

The Value-based Approach of Operational Management

Value-based definitions take this idea one step further. They actually define quality in terms of costs and prices. According to this view, a quality product is one that provides performance at an acceptable price or conformance at an acceptable cost – "affordable excellence". Under this approach, a ₦10,000 running shoe, no matter how well constructed, could not be a quality product, for it would find few buyers.A recent survey of consumer perceptions of quality in twenty-eight product categories suggests that the value-based view is becoming more prevalent (Consumer Network, 1983).

Eight Dimensions of Quality

Eight dimensions can be identified as a framework for thinking about the basic elements of product quality:

i. Performance,
ii. Features,
iii. Reliability,
iv. Conformance,
v. Durability,
vi. Serviceability,
vii. Aesthetics,
viii. Perceived Quality.

Each is self-contained and distinct, for a product can be ranked high on one dimension while being low on another. A careful review of these dimensions can thus be presented in a lighter mood.

Performance

First on the list is performance, which refers to the primary operating characteristics of a product. For an automobile, these would be traits like acceleration, handling, cruising speed, and comfort; for a television set, they would include sound and picture clarity, color, and ability to receive distant stations. For food these will include satisfaction, palatability, tenderization, flavor, etc.

This dimension of quality combines elements of both the product and user-based approaches. Measurable product variables are involved, and brands can usually be ranked objectively on at least one dimension of performance. The connection between performance and quality, however, is more ambiguous. Whether performance differences are perceived as quality differences normally depends on individual preferences. Users typically have a wide range of interests and needs; each is likely to equate quality with high performance in his or her area of immediate interest. The connection between performance and quality is also affected by semantics. Among the words that describe product performance are terms that are frequently associated with quality as well as terms that fail to carry the association. For example, a 100-watt light bulb provides greater candlepower (performance) than a 50-watt bulb, yet few consumers would regard this difference as a measure of quality. The products simply belong to different performance classes. The smoothness and quietness of an automobile's ride, however, is typically viewed as a direct reflection of its quality. Quietness is therefore a performance dimension that readily translates into quality, while candlepower is not.

Features

The same approach can be applied to product features, a second dimension of quality. Features are the “bells and whistles” of products, those secondary characteristics

that supplement the product's basic functioning. Examples include free drinks on a plane flight, permanent press as well as cotton cycles on a washing machine, and automatic tuners on a color television set. In many cases, the line separating primary product characteristics (performance) from secondary characteristics (features) is difficult to draw. Features, like product performance, involve objective and measurable attributes; their translation into quality differences is equally affected by individual preferences. The distinction between the two is primarily one of centrality or degree of importance to the user.

Reliability

Reliability is a third dimension of quality. It reflects the probability of a product's failing within a specified period of time. Among the most common measures of reliability are the mean time to first failure (MTFF), the mean time between failures (MTBF), and the failure rate per unit time. Because these measures require a product to be in use for some period, they are more relevant to durable goods than they are to products and services that are consumed instantly. Japanese manufacturers typically pay great attention to this dimension of quality, and have used it to gain a competitive edge in the automotive, consumer electronics, semiconductor, and copying machine industries.

Conformance

A related dimension of quality is conformance, or the degree to which a product's design and operating characteristics match pre-established standards. Both internal and external elements are involved. Within the factory, conformance is commonly measured by the incidence of defects: the proportion of all units that fail to meet specifications, and so require rework or repair. In the field, data on conformance are often difficult to obtain, and proxies are frequently used. Two common measures are the incidence of service calls for a product and the frequency of repairs under warranty. Both reliability and conformance are closely tied to the manufacturing-based approach to quality. Improvements in both measures are normally viewed as translating directly into quality gains because defects and field failures are regarded as undesirables by virtually all consumers. They are, therefore, relatively objective measures of quality, and are less likely to reflect individual preferences than are rankings based on performance or features.

Durability

Durability, a measure of product life, has both economic and technical dimensions. Technically, durability can be defined as the amount of use one gets from a product before it physically deteriorates. A light bulb provides the perfect example: after so many hours of use, the filament burns up and the bulb must be replaced. Repair is impossible. Economists call such products “one-hoss shays,” and have used them extensively in modeling the production and consumption of capital goods (Bliss, 1975).

Durability becomes more difficult to interpret when repair is possible. Then the concept takes on an added dimension, for product life will vary with changing economic

conditions. Durability becomes the amount of use one gets from a product before it breaks down and replacement is regarded as preferable to continued repair. Consumers are faced with a series of choices: each time a product fails; they must weigh the expected cost, in both naira and personal inconvenience, of future repairs against the investment and operating expenses of a newer, more reliable model. In these circumstances, a product's life is determined by repair costs, personal valuations of time and inconvenience, losses due to downtime, relative prices, and other economic variables, as much as it is by the quality of components or materials.

This approach to durability has two important implications. First, it suggests that durability and reliability are closely linked. A product that fails frequently is likely to be scrapped earlier than one that is more reliable; repair costs will be correspondingly higher, and the purchase of a new model will look that much more desirable. Second, this approach suggests that durability figures should be interpreted with care. An increase in product life may not be due to technical improvements or to the use of longer-lived materials; the underlying economic environment may simply have changed. For example, the expected life of an automobile has risen steadily over the last decade, and now averages fourteen years. Older automobiles are held for longer periods and have become a greater percentage of all cars in use (Burch and Stekler, 1969).

Serviceability

A sixth dimension of quality is serviceability, or the speed, courtesy, and competence of repair. Consumers are concerned not only about a product breaking down, but also about the elapsed time before service is restored, the timeliness with which service appointments are kept, the nature of their dealings with service personnel, and the frequency with which service calls or repairs fail to resolve outstanding problems. Some of these variables can be measured quite objectively; others reflect differing personal standards of what constitutes acceptable service. For example, in a study by Quelch (1981) on consumer satisfaction with professional services found the major complaints to be that “the service was provided in a careless, unprofessional manner” and that “I feel I was treated as an object rather than as an individual.” These comments clearly reflect subjective views of what constitutes acceptable professional behavior. Other aspects of service can be assessed more objectively. Responsiveness is typically measured by the mean time to repair (MTTR), while technical competence is reflected in the incidence of multiple service calls required to correct a single problem. Because most consumers equate more rapid repair and reduced downtime with higher quality, these elements of serviceability are less subject to personal interpretation than are those involving evaluations of courtesy or standards of professional behavior. A number of companies have begun emphasizing this dimension of quality. Caterpillar Tractor's promise that it will deliver repair parts anywhere in the world within forty-eight hours and Mercedes' guarantee of twenty-four-hour (overnight) service in California and Arizona show that even top-of-the-line producers believe that this approach has value.

Aesthetics

The final two dimensions of quality are the most subjective. Both aesthetics and perceived quality are closely related to the user-based approach. Aesthetics — how a product looks, feels, sounds, tastes, or smells — is clearly matters of personal judgment, and reflections of individual preferences. In fact, the marketing concept of "ideal points" — those combinations of product attributes that best match the preferences of a specified consumer — was originally developed to capture just this dimension of quality.

Perceived Quality

Perceptions of quality can be as subjective as assessments of aesthetics. Because consumers do not always possess complete information about a product's attributes, they must frequently rely on indirect measures when comparing brands. In these circumstances, products will be evaluated less on their objective characteristics than on their images, advertising, or brand names. These forces even affect scholarly judgments. When professors around the country were asked to rank the departments in their fields by quality, their rankings were only partially explained by such objective measures as the number of articles published in leading journals by members of the department. Both reputation — the historical strength of the department — and affiliation — the quality of the university to which a department was attached — were equally important in explaining the rankings.

Together, the eight major dimensions of quality cover a broad range of concepts. Several of the dimensions involve measurable product attributes; others reflect individual preferences. Some are objective and timeless, while others shift with changing fashions. Some are inherent characteristics of goods, while others are ascribed characteristics.

The diversity of these concepts helps to explain the differences among the five traditional approaches to quality. Each of the approaches focuses implicitly on a different dimension of quality: the product-based approach focuses on performance, features, and durability; the user-based approach focuses on aesthetics and perceived quality; and the manufacturing-based approach focuses on conformance and reliability. Conflicts among the five approaches are inevitable because each defines quality from a different point of view. Once the concept is unbundled, however, and each dimension is considered separately, the sources of disagreement become clear.

Statistical Process Control (SPC) in the Food Industries: It is expected that companies utilize gain in their ability to control input variables in which product quality variations can easily be identified. The statistical process control (SPC) charting includes several methods to assess visually and statistically the quality and consistency of process Key Output Variables (KOVs) and identifying unusual occurrences. The SPC is therefore useful in establishing the value and accuracy of current settings and confirming whether recommended changes will consistently improve quality.X –Food industry produces yoghurt by the control of fermentation of milk by two species of

bacteria (Lactobacillus sp. and Streptococcus sp.).The sugar in milk (called lactose) is fermented to acid (lactic acid) and it is this that causes the characteristic curd to form. Major parameter of assessing the quality is the taste/colour and any that falls short is withdrawn from circulation/distribution in order to keep the company's reputation, have a fair share of the market and achieve overall customer satisfaction while producing to specified industrial standards. The product attribute characteristics of taste/colour was used to select number of defects from which p-chart was plotted using the Minitab statistical software to show whether the production process was in a state of control or out of control.

Manufacturing Process

The procedure is as follows:

• Collect the milk in carefully cleaned, covered vessels.

• Pasteurize the milk at 80-85°C for 15-20 minutes. This is especially important if tuberculosis bacteria are thought to infect animals locally.

• Cool the milk to 40-45°C as quickly as possible and add a starter culture of the yoghurt bacteria. Keep the milk at this temperature for 3-4 hours while the fermentation takes place. If possible, then cool the yoghurt in a refrigerator until it is eaten or sold.

The key potential problem in yoghurt making is spoilage by bacteria or moulds. This is due to:

•Unclean equipment,

•contaminated milk or

•Poor hygiene of the production staff.

Methodology

The Magnesium Department of Dow's Texas Operations was the first to train its technical staff and managers in the use of statistical quality control. Some of the earliest successful applications of statistical quality control were in chemical processing. In one application involving the operation of a drier, samples of the output were taken at periodic intervals; the average value for each sample was computed and recorded on a chart called an X chart (X-bar chart).Such a chart enabled Dow analysts to monitor trends in the output that might indicate the process was not operating correctly. In one instance, analyst began to observe values for the sample mean that were not indicative of a process operating within its design limits. On further examination of the control chart and the operation itself, the analysts found that the variation could be traced after that operator was retrained showed a significant improvement in the process quality. Quality improvement has been achieved by Dow's Chemicals everywhere statistical quality control is applied and record shows that several hundreds of thousand dollars per year have been realized and new applications are continually being discovered.

In this work, we show how variable control charts and attributes control charts such as the ones used by Dow's Chemicals were developed for X-Food, Nigeria. We also demonstrate whether the processes were within control or out of control.

- Statistical process control is a collection of tools that when used together can result in process stability and variance reduction

Basic Principles

- A process that is operating with only **chance causes of variation** present is said to be in statistical control.
- A process that is operating in the presence of **assignable causes** is said to be out of control.
- The eventual goal of SPC is the **elimination of variability** in the process and saves cost.

Types of Control Charts

Variables Control Charts-These charts are applied to data that follow a continuous distribution.

Attributes Control Charts -These charts are applied to data that follow a discrete distribution.

Popularity of Control Charts

1) Control charts are a proven technique for improving productivity.
2) Control charts are effective in defect prevention.
3) Control charts prevent unnecessary process adjustment.
4) Control charts provide diagnostic information.
5) Control charts provide information about process capability.

Data Collection

Random samples size 200 yoghurt already processed were selected for examination periodically and the numbers of defects were recorded correspondingly in table 1.

Table 1: Number of observations and defective items (X-Foods)

S/N	C1	C2	C3
	Sample number	Number of observations	Number of defective items
1	1	200	12
2	2	200	13
3	3	200	15
4	4	200	17
5	5	200	16
6	6	200	21
7	7	200	20
8	8	200	14
9	9	200	17
10	10	200	17
11	11	200	13
12	12	200	12
13	13	200	13
14	14	200	14
15	15	200	15
16	16	200	13
17	17	200	11
18	18	200	15
19	19	200	12
20	20	200	23

Data analysis

The Minitab's statistical software (Minitab 17®) was used to construct the control chart.

Steps for constructing the P-chart

The sample numbers appear in column C1. The number of observations (same for all samples) is in column C2, the number of defective items counted is in column C3. The following steps describe how theP-chart was produced.

Step1: Select the Stat pull-down menu.
Step2: Choose control Charts.
Step3: In the control chart dialog box, select attribute charts for subgroups.
Step4: In the variables charts for subgroups drop down menu select P – charts.
Step5: In the P– charts dialog box,Enter C3 is the column of number of defectives
And enter C2 for subgroup sizes.
Step6: Click on P-chart options, and click tests.
Step7: When tests dialog box appears,

choose one point >Standard deviations from centre line (k =3.0)

Step8: Click ok on the P-chart dialog box to display the chart

Step9: Save your graph and current worksheet.

The result is illustrated in figure 1.

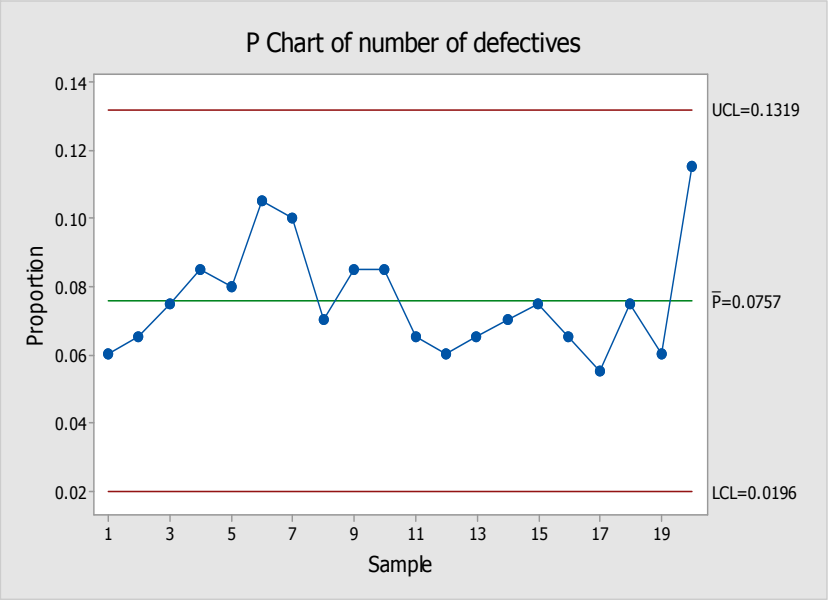

Figure 1: P-chart for X-Food, Nigeria (Track processes in real-time and provides automatic notification of non-conformances)

Results and Discussion of results

To check product quality, 200 samples were periodically selected 20 times in all in order to regulate product quality. The process was believed to be in control when the samples were selected. The Company is interested in using control charts to monitor the number of defectives of its manufacturing process – manufacturing conformance approach to quality to reduce cost.

The implications of this chart plotted is that the process is in a state of control as all points plotted lies between the upper control limit (UCL) and the lower control limit (LCL) and the data points rally round the P-bar.

Conclusion

We were able to monitor the product consistency to manufacturing conformance to reduce cost and wastage. If deviations are noticed in time the quality control team would stop operations temporarily, production will only resume after assignable causes have been corrected.

Recommendation

We recommend this process and other statistical process control techniques for all sectors of the economy of Nigeria for improve industrialization and developmental growth.

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