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Average Weight Based Quality Control of Nigeria Bakery Industry: A Statistical Approach

O.O. Ajayi and D.O. Olawale
Department of Mechanical Engineering, Covenant University,
P.M.B. 1023, Ota, Ogun State, Nigeria

Abstract: This research looks at the average weight control of the Nigeria bakery industry. Visits were made to some bread factories and their statistical quality control measures were investigated, these were found to be substandard and samples taken insignificant at 95% confidence interval. One hundred percent batch weights of the whole production lot from factory site of a leading player in the industry were taken and analyzed using average weight per batch measure. Better approach to data analysis using the statistical hypothesis testing method was suggested, instead of those in operation within the industry. This proves to be time saving, eliminate error due to insignificant sample sizing, thus, quick decision can easily be reached with 95% confidence level.

Key words: Quality control, bread, hypothesis test, Nigeria

INTRODUCTION

Quality, according to Gryna (2001) is customer satisfaction. It is the totality of characteristics of an entity that bears on its ability to satisfy stated and implied needs (Aft, 1998). Control is the process employed to meet standards, thereby leading to a decision dependent on the observed performance (Gryna, 2001). Therefore, Quality Control (QC) is the action taken throughout the production of a product to prevent and detect product deficiencies and product safety hazards (Bentely, 1999; Gryna, 2001; Evans and Lindsay, 2005). In a narrower sense, it refers to the statistical techniques employed in sampling production and monitoring the variability of a product (Shewhart, 1986; Duncan, 1986; Sandholm, 2000).

In order to establish a QC policy for a part, there are four questions that must be answered. These include: what, how, when and where to inspect (Breyfogle, 1992; Kolarik, 1999; Montgomery, 2005). In the traditional QC system, inspectors makes rounds every hour, picks up few parts, carry them to the inspection site and takes decision (Breyfogle, 1992; Gryna, 2001; Montgomery, 2005). This practice is deficient in that, by the time the results are available, some of the bad parts will have made their way into the production stream or have been mixed with good ones. Thereby suggesting that, it will require a hundred percent inspection, in order to separate good parts from bad ones (Breyfogle, 1992; Montgomery, 2005). Thus, to achieve excellent results at shortest possible time, QC inspection would have to be an integral part of the manufacturing process.

Many researchers have reviewed the developments of QC from the Medieval Europe, when craftsmen began organizing into unions in the late 13th century up to the 20th century, when manufacturers began to include quality process in their practices (Shewhart, 1986; Evans and Lindsay, 2005; Montgomery, 2005). During the World War I, the high and complex manufacturing processes led to the employment of more workers for production purposes. The outcome of which was the production of below quality products (Gryna, 2001). To correct this, QC inspectors were engaged to

Corresponding Author: O.O. Ajayi, Department of Mechanical Engineering, Covenant University, P.M.B. 1023, Ota, Ogun State, Nigeria Tel: +234-803 620 8899

monitor the quality of products that were produced, marking the beginning of inspection QC and leading to large inspection organizations of the 1920s and 30s, respectively (Gryna, 2001; Evans and Lindsay, 2005). The need for the production of bullets that would be suitable for riffles produced elsewhere was the focus during the period of World War II. This resulted in the introduction of statistical QC where sampling techniques were used for inspection, aided by military specification standards, where sampling inspection system is provided, instead of a hundred percent inspection (Montgomery, 2005). Further developments went on after this period. By the 1980s, the concept of company quality had taken over and by the 21st century, attention have shifted from just total quality to include new systems such as quality service, quality governance etc (Melnyk and Denzler, 1996; Gryna, 2001).

Over the years, bread has become a staple food for many Nigerians. A day does no go without several hundreds of thousands consuming it. This high rate of consumption has made the business very lucrative, both for manufacturers and sellers. However, in an industry as precise as that of baking, the margin for error should always be minimal, suggestive of a 95% confidence interval. Therefore, standard QC measures must be in place to track variability and determine conformity to acceptable standard sizes. In Nigeria bakery industry, there are three types of bread loaves with accompanying weight standards. These are: Agege bread (in 3- sizes of 300, 400 and 600 g, respectively) and the ordinary and special sliced (between 900 and 950 g). The shape standard of the loaves is pan baked, flat surfaced and rectangular. This research used the special sliced to carry out the work. Loaves are to be rejected if the weight falls outside their weight standards. Unfortunately, the Nigeria bakery industry does not have adopted standard QC technique for checking product variability and conformity. Visits to some bakery sites prove this. Each industry adopted its own style. Whereas this is acceptable, the statistical steps taken to determine product conformity to standard are inadequate. The sample sizes are not uniform and not statistically significant at 95% in almost all the factories. Some don't take sample measurement after baking while some analyze between 4 and 10 samples out of a batch of 170-176 loaves (representing 2-bags of 50 kg flour), some others only occasionally take few samples for weight measurement without making statistical extrapolation. Therefore, researchers must come to the rescue, by developing simple statistical model which can be adapted to the Nigeria bakery industry. This research looks into this, with the aim of adapting standard statistical technique to the operational QC measures of the Nigeria bakery industry.

MATERIALS AND METHODS

The head quarter factory of a major bread producer, located in Lagos State, having branches and distribution around two states of the federation was visited, between April and June, 2006. The production process was observed and a hundred percent inspection was carried out in order to generate data. Depending on the volume of demand, between 10 and 30 batches of flour (containing 2-bags of 50 kg per batch) were being produced per day. The data presented in Table 1 are the average weights per batch for all batches for a particular day when demand is lowest, while Table 2 presents 100% weight measurement for batch 1 of the 10-batches produced on the day.

Table 1: The average values of all loaves per batch

Batch	Mean weight (g)
1	919.12
2	913.38
3	922.38
4	915.04
5	911.29
6	921.75
7	922.71
8	924.98
9	922.52
10	921.48

Table 2: Table showing weight values of all loaves produced in batch 1

880	915	945	940	950	920	920	915	900
940	945	950	940	950	930	900	900	920
920	950	910	920	900	920	900	920	930
950	940	936	900	940	900	900	900	900
930	940	920	905	950	940	900	900	900
950	960	915	915	950	950	900	920	910
970	915	900	920	900	930	920	900	940
915	900	900	885	900	940	900	930	930
920	900	920	890	900	930	900	900	
910	915	920	800	900	935	900	940	
930	900	930	820	910	980	900	900	
925	950	940	850	920	960	905	900	
900	940	920	860	940	950	910	920	
940	940	900	850	940	940	900	920	
940	920	940	905	950	920	900	920	
940	900	950	900	900	935	900	940	
920	940	950	945	920	945	900	900	
920	930	950	943	930	920	900	900	
920	900	900	942	940	925	900	900	
945	940	900	940	930	925	900	920	
900	930	950	940	915	920	900	920	

RESULTS AND DISCUSSION

Table 1 indicates that the mean values of individual batch measurement falls between the upper control limit (950 g) and the lower control limit (900 g). However what happens when most of the loaves produced in a batch fall outside the control limits. The practice of not taking sample measurement after production or taking between 4 and 10 sample measurements may not produce statistically significant result; more so, it may be difficult to place confidence limit on results obtained from such practices. Hence, a better method of statistical analysis which will aid in making adequate decision will be most needed. This can be achieved by employing a statistical comparison test, the Hypothesis test, detailed in (Lipson and Sheth, 1973; Nelson *et al*., 2003; Gryna, 2005).

Sample Analysis Using the Hypothesis Testing Method

The accepted industry standard was that weight outside 900-950 g should be avoided as much as possible. Thus the average weight of 925 g should be adequate and a two sided test was employed with a confidence level of 95% and $\beta = 0.05$. The procedure adopted for testing was as follows:

H_o: ($\mu_o = 925$ g); H_A: ($\mu \neq 925$ g); H_D: ($/\mu - \mu_o/ = 25$ g); $\mu_1 = 900$ g; $\mu_2 = 950$ g; $\alpha = \beta = 0.05$.

Where H_o = null hypothesis,
H_A = alternate hypothesis,
H_D = design hypothesis,
μ_1 and μ_2 are the lower and upper standard weight's cut-off points,
α and β are the type I and II errors, respectively (Lipson and Sheth, 1973).
The statistical equations (Lipson and Sheth, 1973) employed were as indicated below.

$$n_1 = \frac{\left(t_{\alpha/2;v} + t_{\beta;v}\right)^2}{\left(\mu_o - \mu_1\right)^2} S^2 \tag{1}$$

$$\bar{X}_{c1} = \frac{\left(\mu_o + \mu_1\right)}{2} + \frac{1}{2}\left(t_{\beta;v} - t_{\alpha/2;v}\right)\sqrt{\left(\frac{S^2}{n}\right)} \tag{2}$$

$$\bar{X}_{c2} = 2\mu_o - \bar{X}_{c1} \tag{3}$$

Where n_1 = minimum sample size for statistical significance,
$\bar{X}_{c2}$ and $\bar{X}_{c1}$ = upper and lower boundary values of the population mean,
$t_{\alpha/2, v}$ and $t_{\beta, v}$ are the statistical t-values required for significance at the degree of freedom,
and S is the sample standard deviation.
The statistical test employed tested if $n_1<n$. Moreover, a sample was considered statistically significant (CI %) if $n_1<n$, else more samples were picked for the analysis. Also if $\bar{X}_{c1} < \bar{X} < \bar{X}_{c2}$, the null hypothesis is accepted and the batch in question is declared controlled else, it is out of control.
Choosing weights 20 samples (randomly) from Table 2 as: 920, 885, 860, 905, 945, 940, 940, 900, 950, 940, 900, 920, 915, 920, 900, 970, 936, 935, 960 and 945 g gave sample average $\bar{X}$ as 924.3 g and sample standard deviation S as 26.98 g. However, using Eq. 1- 3 above gave n_1 = 19.53
Where $t_{\alpha/2, v}$ and $t_{\beta, v}$ are 2.262 and 1.833, respectively (Lipson and Sheth, 1973).
$\bar{X}_{c1}$ = 910.71 g and $\bar{X}_{c2}$ = 939.29 g.
Hence, since $\bar{X}_{c1} < \bar{X} < \bar{X}_{c2}$, the batch so analyzed (Table 2) was accepted as being controlled. Thus, based on these data obtained from the company and analyzed, the product arising from this batch is well within quality control standard. This statistical testing method using the hypothesis system of testing is accurate and can be employed in carrying out quality control measures based on average weight, rather than the 100%, zero, between 4 and 10 sample testing of production lot. This method, if adopted could save enormous time consumed in quality assurance, reduce errors in sample sizing and decision on quality would easily and quickly be reached with confidence, also whatever rough present would be identified with little errors by weighing only those suspected to be under or over weight during bagging of each loaf. Moreover, equations 1-3 can be re-modified to 4-6 by substituting the constant values of $t_{\alpha/2, v}$ and $t_{\beta, v}$, based on the assumption that the sample size is 20 and type I and II errors are 0.05, respectively.

$$n_1 = 0.026683S^2 \tag{4}$$

$$\bar{X}_{c1} = 912.5 - 0.048S \tag{5}$$

$$\bar{X}_{c2} = 937.5 + 0.048S \tag{6}$$

CONCLUSIONS

The average weight statistical quality control analysis employed by the Nigeria bakery industry has been observed and data obtained from factory site on the special sliced bread were analyzed. A better and faster approach to data analysis using the statistical hypothesis testing method was employed and found to be adequate and time saving. More work can still be done to adapt the equations 4-6 to the computer, so that quick decision can be reached and as a result the production process enhanced. Also, other statistical testing method can be developed and compared with this to obtain optimum result.

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