*International Journal of Engineering Science Invention (IJESI)*
*ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726*
*www.ijesi.org ||Volume 7 Issue 12 Ver. IV || Dec 2018 || PP 35-42*

# Productivity Improvement through Quality Control in Nigerian Manufacturing Industry: A Case Study

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***Abstract:*** *This study seeks to examine the various methods used by Nigerian Manufacturing Industries to improve productivity through quality control. To achieve this, a survey of Dufil Prima Foods (Indomie), one of the manufacturing organizations in Port Harcourt was undertaken. A sample survey technique on quality control variables was developed and administered to the various departments. Statistical quality control charts for variables (Upper Control Limit and Lower Control Limit) were used to analyse the data collected and interpreted with the aid of Excel software. The study reveals 40% significant improvement in productivity and that some of Dufil Prima Foods quality control processes were not in full control. Results found that 40% of the production processes are out of control and 60% is in control. An adjustment in her processes is necessary especially in reduction of scrap/waste, inspection, rewards based on performance and finally, according to the percent defective graph 18.78% of both the raw materials and the finished products were defected. Based on these findings, it recommends that reduction of waste/scrap and proper inspections on both raw and finished products should be encouraged by the management of every department and not allowing the machines to go bad before maintenance can be checked.*

***Keywords:*** *Manufacturing Industry, Productivity Improvement, Quality Control,*

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Date of Submission: 13-12-2018 Date of acceptance: 28-12-2018

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## I. Introduction

The success of every manufacturing organization depend greatly on the degree of its reputation for supplying quality products that will give customers satisfaction in the price range offered yet the realization of quality standard and improved productivity has been the search for a solution, which has led to a research of this nature andfactors responsible for this problem and action to be taken to reduce their negative impact on the manufacturing industry in Nigeria.The study lets out to investigate the application of quality control measures by Dufil Prima Foods, makers of indomie noodles. It is the believe of the researcher that theory and postulations are but ideas in the head with no value except it is applied to human daily living. This has informed this study.

Several studies have been carried out on how best to improve productivity and indeed preserve the quality of products with its explicit implications on both the company and the product life. Nworah (1991), notes that primitive man was concerned with quality. He believes that quality is a one man's affair and man is the best manufacturer that manufactures what he uses. He was responsible for carrying out his technological and managerial activities and was able to co-ordinate all these activities, ensuring that he produced item that was of a quality acceptable to him and by him.Eccles (2004) insisted that quality is all about business performance and its being determined by the customer. Also, Ezirim (2005) discussed quality as a means of to achieve true reliability and quality control as a system of inspection analysis and action applied to a manufacturing operation so that by inspecting a small portion of the product currently produced, an estimate of the overall quality of the product can be made to determine what changes must be made in the operation in order to achieve or maintain the required level of quality control of manufacturing operations.

Juran (1979) insisted on a long period of training for apprentices and required that these constitute the evidence of their ability. Such rules were in part, aimed at the maintenance of quality. In recent times, training of factory personnel and managers have all aimed at ensuring the quality output and also introduced quality control variables. Quality Planning consists of developing the products required to meet customer's needs and without a standard there is no logical basis for making or taking action.Demining(2000) popularly known as father of quality control developed 14 points quality control and insisted that everybody in the company to work will work hard at accomplishing the transformation sought by its management. He further charged managers to institute training on the job, create constancy of purpose for improving products and services as part of his 14 points of quality control. He noted that by adopting appropriate principles of management, organizations can increase quality and simultaneously increase productivity by increasing labour (staff) and staff training.

This research has contributed to knowledge by identifying reduction of waste or scrap, inspection and ensuring rightful machine or tools are used to increase productivity rather than increase in staff (labour) as were emphasized in the previous studies.

## II. Methodology

### 2.1Analytical Model

The information for the analysis was drawn from notice board, hand bills and administered questionnaires from the departments of Dufil Prima Foods Plc in Port Harcourt and was analysed using the statistical quality control charts for variables.

### 2.2Control Charts for Variables

The study relied on the sampling theory and the central limit theoremto develop the control charts for variables. Five departments were administered questionnaires bordering on nine quality control factors affecting the production processes and the mean of each quality control factors on the departments were computed.The sample means are$\overline{\overline{x_1}}$,$\overline{\overline{x_2}}$,$\overline{\overline{x_3}}$, and so on. The mean of these quality control factors on each of the departments is denoted as $\bar{\bar{x}}$ . k is used to indicate the number of quality control factors. The overall or grand mean is found by:

Grand mean $\bar{\bar{x}} = \frac{\sum \text{of the means ofquality control factors on each department}}{\text{Number of quality control factors}} = \frac{\sum \bar{x}}{k}$ (1)

The standard error of the distribution of the sample mean is designated by $s_{\bar{x}}$. It is found by:

standard error of the mean $s_{\bar{x}} = \frac{s}{\sqrt{n}}$ (2)

where $s_{\bar{x}}$ is the standard error of the distribution; s is an estimate of the standard deviation;n is the total number of item sampled. These relationships allow limits to be set up around the sample means to show how much variation can be expected for a given sample size. These expected limits are called the upper control limit (UCL) and the lower control limit (LCL). A mean chart has two limits, an upper control limit (UCL) and a lower control limit (LCL). These upper and lower control limits are computed by:

Control limits for the mean UCL = $\bar{\bar{x}} + 3\frac{S}{\sqrt{n}}$ and LCL = $\bar{\bar{x}} - 3\frac{S}{\sqrt{n}}$ (3)

Notice that in the calculation of the upper and lower control limits the number 3 appears. It represents the 99.74 percent confidence limits. The limits are often called the 3-sigma limits. It can be demonstrated that the term $3\left(\sqrt[s]{n}\right)$from equation (3)is equivalent to $A_2\bar{R}$ in the following formula.

Control Limits for the Mean UCL = $\bar{\bar{x}} + A_2\bar{R}$, LCL = $\bar{\bar{x}} - A_2\bar{R}$ (4)

where $A_2$ is a constant used in computing the upper and the lower control limits. It is based on the average range; R.$\bar{\bar{X}}$ is the mean of the sample means, computed by $\sum\frac{\bar{x}}{k}$, where k is the number of samples selected.$\bar{R}$ is the mean of the ranges of the sample. It is $\sum\frac{R}{k}$. Remember the range is the difference between the largest and the smallest value in each sample. It describes the variability occurring in that particular sample.

### 2.2 Range Chart

A range chart shows the variation of quality control factors in the departments. If the points representing the ranges fall between the upper and the lower limits, it will be concluded that the operation was in control. Presumably, in a range of 1000 sample, 997 fall within the limits within the range. When the range falls above the limits, we will conclude that an assignable cause affected the operation and an adjustment to the process will be needed. The upper and lower control limits of the range chart were determined from the following equations.

Control chart for Ranges UCL =$D_4\bar{R}$, LCL = $D_3\bar{R}$ (5)

The values for $D_3$ and $D_4$, which reflect the usual three Ω(sigma) limits for various sample sizes.

### 2.3Percent Defective Chart

In inspecting the different pack sizes of Indomie for proper quality control measures, the percentage defective control chart was used and adopted. Starting the P defective chart mathematically;

- Average P is calculated

  where P = average of all values of P.

  $$P = \frac{P_1 + P_2 + ------ P_y}{Y} \quad (6)$$

- The Center Line (CL) becomes P
- Then find the standard deviation of the process to be

$$D = \sqrt{\frac{P(1-p)}{n}} \quad (7)$$

where n is the size of each sample.

- Usually, the upper and lower control limits become

UCL = P + 3D; LCL = P - 3D

where D is the standard deviation

Decision are now taken

- The shaded part forms the control limits
- If the sampled percentage falls within the control limits, the production process was under control and no action is to be taken
- If otherwise (say within the region A or B in Figure 1) the production process is out–of–control. The process was stopped and a research into the assignable cause (material, operator a machine) will be carried out. The cause will be corrected. Then the process will be restored to functional operating condition and production.

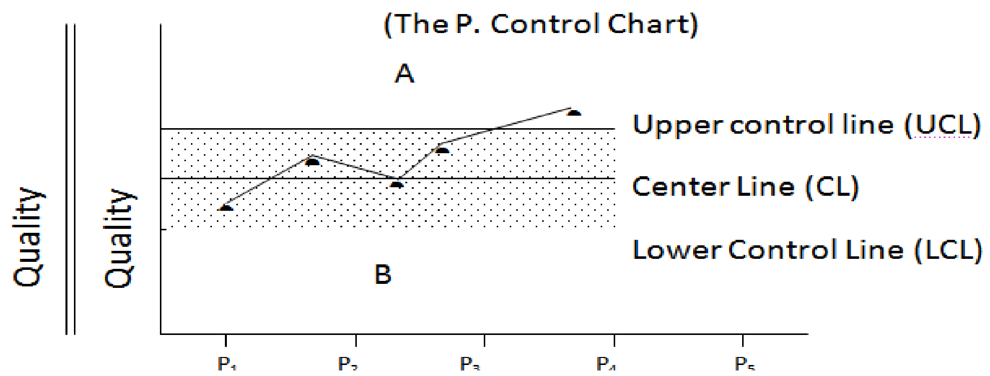


**Figure 1: The P. Control Chart**

**Also** stating the construction of member defective control chart:

- With the appropriate sample size n, find the proportion of defective P and compute number defective (initial process defective) = np
- Compute the control limits from the formula:

  Control limits = $np\ q\sqrt{X\,Z}$ (8)

  where Z is the appropriate normal value for the required confidence level.
- Construct the number defective chart with time on the horizontal axis and the number of defectives on the vertical axes.
- Insert horizontal lines indicating 'np' value and the control limits.
- Finally, take subsequent samples, each of size 'n' at regular intervals and plot the number defectives in each sample against the time the sample was taken.

## III. Results and Discussion

### 3.1 Results

Table 1 shows the number of Dufil Prima Foods products that were inspected, numbers that were defected and the departments that participated in the study, while Table2 shows the number of issued and returned questionnaires in percentage.Most of the population members were from departments such as the Production, Warehouse, Engineering and Administration.

**Table 1: Types of Department surveyed**

| Types of Department | Number inspected | Number of defection |
|---|---|---|
| Production | 1500 | 354 |
| Warehouse | 1500 | 253 |
| Marketing | 1500 | 274 |
| Store | 1500 | 246 |

**Table 2: Questionnaire Administration & Retrieval**

| Departments | Number Issued | Number Returned | Percentage |
|---|---|---|---|
| Engineering | 20 | 18 | 90 |
| Warehouse | 20 | 19 | 95 |
| Production | 20 | 17 | 85 |
| Administration | 20 | 18 | 90 |
| Product Pricing & inventory Control (PPIC) | 20 | 18 | 90 |
| **Total** | 100 | 90 | |

**Table 3:Quality Control factors on Productivity in Percentage (%)**

| QC/DEPT | Engineering | Warehouse | Production | PPIC | Admin | Mean | Range |
|---|---|---|---|---|---|---|---|
| Reduction of scrap/waste | 67 | 74 | 88 | 94 | 89 | 82 | 22 |
| Selection/proper/Adequate Raw Materials | 38 | 52 | 41 | 33 | 44 | 42 | 19 |
| Improve Training/Invest in Training | 62 | 63 | 59 | 50 | 56 | 58 | 13 |
| Inspection | 67 | 84 | 82 | 89 | 67 | 78 | 22 |
| Ensure right machines or tools are used | 39 | 37 | 59 | 22 | 61 | 63 | 39 |
| Report Machine failures | 56 | 37 | 24 | 56 | 56 | 46 | 32 |
| Eliminate valueless processes | 44 | 58 | 47 | 77 | 67 | 59 | 23 |
| Rewards based on performance | 50 | 47 | 24 | 22 | 61 | 41 | 39 |
| Tracking of mistakes/Review | 67 | 47 | 70 | 94 | 61 | 68 | 23 |
| **Total** | | | | | | **517** | **232** |

Table 3 presents the general performance of quality control on Productivity and the nine quality control variables used in analysing the productivity of Dufil Prima Foods. The first quality control variable was "reduction in waste or scrap" and about 82% of staff mentioned that Reduction of Scrap/Waste influenced productivity. The 2nd quality control variable was "selection or proper or adequate raw materials" and about 42% said selection/adequate raw materials influenced productivity while the 3rd quality control variable was "improve or invest in training" and 58% agreed to Improved Training as a factor that influenced productivity. The 4th quality control variable was "inspection" and about 78% affirmed that Inspection affects productivity. The 5th quality control variable was "ensuring that the right machine or tools were used in production process" about 63% pointed to adequate or right use of machine or tools as a major factor that influences productivity. The 6th quality control variable was Report of machine failures" and 46% revealed that Report Machine of failures greatly affect productivity of the organisation. The 7th quality control variable was "Eliminating valueless processes" and 59% of the respondents chose to eliminate valueless processes to boost productivity. The 8th quality control variable was "Rewards based on performance" and 41% said that Rewards based on performance influences productivity. The 9th quality control variable was "Tracking or reviewing of mistakes" and 68% ticked tracking or reviewing of mistakes as a factor that boosts productivity.

### 3.1.2 The Mean $\bar{\bar{X}}$Graph

From "Table 3" the center line for the mean graph is ( $\bar{\bar{X}}$ = 57.444%,) found by 517/9 and the Mean of Range $\bar{\bar{R}}$ is 25.778% found by 232/9, both is found by applying equation (1) respectively. Thus the Upper Control Limit (UCL) of the mean graph is 72.314% and the Lower Control Limit (LCL) is 42.566% and it is found by using "equation 4" respectively. Mathematically, UCL = $\bar{\bar{x}} + A_2\bar{R}$ = 57.444 + 0.577 (25.778) = 72.314
LCL = $\bar{\bar{x}} - A_2\bar{R}$ = 57.444 – 0.577 (25.778) = 42.566

The mean graph in Fig 2 shows that the process is not in full control, some of the quality control variables are out of control. Note that the quality control variables are not clustered around the center line; some are above, below and out of the control limit lines which indicates that the processes are quite unstable. The 1st quality control variable (Reduction of scrap or waste) and the 4th quality control variable (Inspection) are above the upper control limit line.

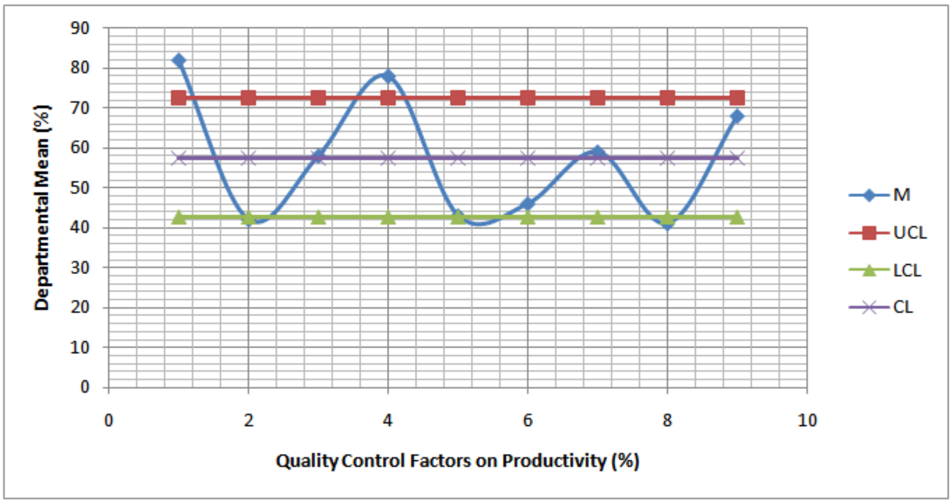


**Figure 2: The Mean Graph**

The 8th quality control variable (Rewards based on Performance) is below the lower control limit line, which indicates that there is a considerable variation in the process and an adjustment in the process is necessary. The 9th quality control variable (Tracking or Reviewing mistakes), the 7th quality control variable (Elimination of valueless processes), the 6th quality control variable (Report machine failures), the 5th quality control variable (Ensure rightful use of machines or tools), the 3rd quality control variable (Improved training or invest in training) and the 2nd quality control variable (Selection or proper or adequate raw material) are in control. But there is a need for the 5th and 2nd quality control variable to be looked into because they are directly on the lower control variable line. Also the 9th quality control variable is very close to the upper control limits line and if there are any lapses it can go out of the control.

### 3.1.3 The Range $\bar{R}$ Graph

From "Table 3" the total Range is 232, so the average range is 25.777 and is found by 232/9. Table of factors for control charts is attached as Appendix 1, the values for $D_3$ and $D_4$ are 0 and 2.115 respectively. Applying "equation 5", the Lower Control Limit (LCL) and Upper Control Limit (UCL) are 54.520 and 0 respectively. See "Fig 3".

Mathematically, UCL $= D_4\bar{R}$ = 2.115 (25.778) = 54.520

LCL = $D_3\bar{R}$ = 0 (25.778) = 0

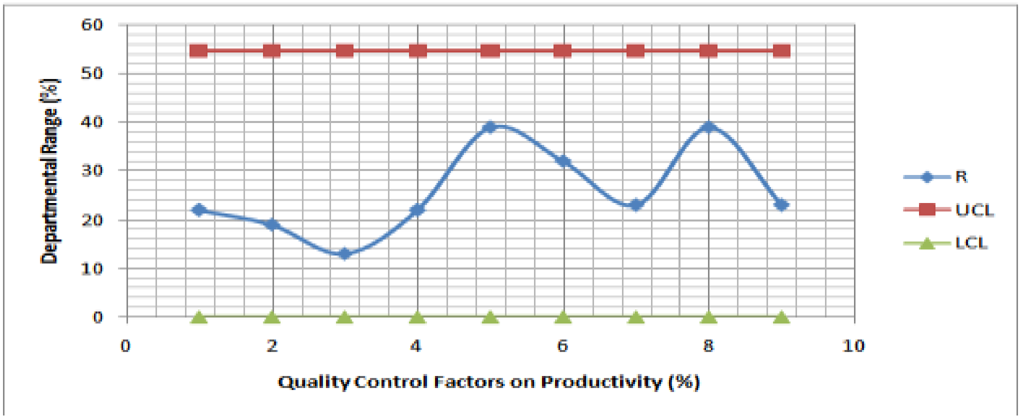


**Figure 3: The Range Graph**

The range graph in "Fig 3" indicates that the range of the quality control process is in control as all the nine quality control variables falls within the control limits. See "Table 3" and "Fig 3"

### 3.1.4 Percent Defective Graph

According to "Table 4" four departments were involved in an inspection and as a result some of the products were mismatched and the departments are Store, Warehouse, Production and Marketing. To enable us know how much of the product were bad and to improve on it, we constructed the percent defective graph of quality control.

**Table 4: Proportion Defective Table**

| Departments | Number Inspected | Number Mismatched | Proportion Defective |
|---|---|---|---|
| Store | 1500 | 246 | 0.16400 |
| Warehouse | 1500 | 253 | 0.16867 |
| Production | 1500 | 354 | 0.23600 |
| Marketing | 1500 | 274 | 0.18267 |
| **Total** | **6000** | **1127** | |

The upper and lower control limits were computed using equations (6) and (8) respectively.

Mean proportion defective $P = \frac{Total\ number\ defective}{Total\ number\ of\ item\ sampled} = \frac{1127}{6000} = 0.187833$

**Control limits for proportions LCL, UCL = P $\pm$ 3** $\sqrt{\frac{P(1-p)}{n}}$

$$UCL = 0.187833 + 3\sqrt{\frac{0.187833\ (1-0.187833)}{1500}}$$

UCL = 0.187833 + 0.0302541039 = 0.2180874039

$$LCL = 0.187833 - 3\sqrt{\frac{0.187833\ (1-0.187833)}{1500}}$$

LCL = 0.187833 – 0.0302541039 = 0.1575792261

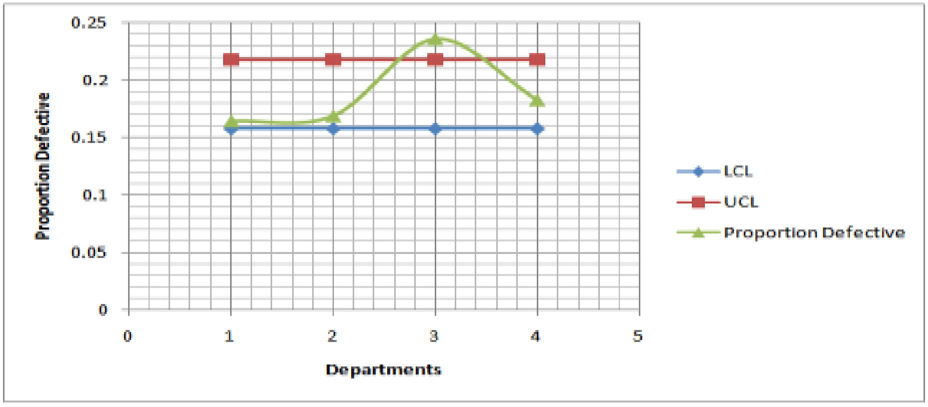


**Figure 4: Percent Defective graph**

The percent defective graph shows that the number of products mismatched in the production department is out of control and needs an adjustment to enable the productivity to improve.

### 3.2 Discussion of Results

According to "Table 3" and "Fig 2" the 1st quality control variable (reduction of waste or scrap) constituted about 15.9% of the production process and it is obtained by

Reduction of waste or scrap = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean} = \frac{82}{517}$ X 100 = 15.9%

The 2nd quality control variable (selection or proper or adequate raw materials) constituted 8.1% of the production process and it is obtained by

Selection or proper or adequate raw material = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean}$ X 100 = $\frac{42}{517}$ X 100 = 8.1%

The 3rd quality control variable (Improved training or investment on training) constituted 11.2% of the production process and it is obtained by

Improved training or investment on training = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean}$

$= \frac{58}{517}$ X 100 = 11.2%

The 4th quality control variable (Inspection) constituted 15.1% of the production process and it is obtained by

Inspection = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean} = \frac{78}{517}$ X 100 = 15.1%

The 5th quality control variable (Ensure rightful use of machine or tools) constituted 12.2% of the production process and it is obtained by

Ensure rightful machine or tools are used = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean}$

$= \frac{63}{517}$ X 100 = 12.2%

The 6th quality control variable (Report machine failures) constituted 8.9% of the production process and it is obtained by

Report machine failures = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean} = \frac{46}{517}$ X 100 = 8.9%

The 7th quality control variable (Eliminating valueless processes) constituted 11.4% of the production process and it is obtained by

Eliminate valueless processes = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean} = \frac{59}{517}$ X 100 = 11.4%

The 8th quality control variable (Rewards based on performance) constituted 7.9% of the production process and it is obtained by

Rewards based on performance = $\frac{mean\ total\ of\ all\ the\ department}{mean\ of\ mean} = \frac{41}{517}$ X 100 = 7.9%

The 9th quality control variable (Tracking or Reviewing mistakes) constituted 13.2% of the production process and it is obtained by

Tracking or reviewing of mistakes = $\frac{\text{mean total of all the department}}{\text{mean of mean}} = \frac{68}{517}$ X 100 = 13.2%

"Fig 2" shows that the 1st and 2nd quality control variables are above the upper control limit and affected the production process by 30.8% and was obtained by

Variables above the UCL = $\frac{\text{mean total of all the department}}{\text{mean of mean}}$X 100 = $\frac{82+78}{517}$ X 100 =30.8%

The 8th quality control variable is below the control limit and affected the production processes by 7.2% and was obtained by

Variables below the LCL = $\frac{\text{mean total of all the department}}{\text{mean of mean}}$ X 100 = $\frac{41}{517}$ X 100 = 7.2%

The 2nd, 3rd, 5th, 6th, 7th and 9th quality control variables were within the control limit and influenced the production processes by 60% and was obtained by

Variables in control = $\frac{\text{mean total of all the department}}{\text{mean of mean}} = \frac{42+58+63+46+59+68}{517}$ X100 = $\frac{336}{517}$ X100 = 60%

The research has also shown that 40% of the production process went of control and it is obtained by

Total variables (out of control) = $\frac{\text{mean total of all the departmental mean}}{\text{mean of mean}}$ X 100 = $\frac{82+78+41}{517} = \frac{201}{517}$ X100 = 39.9%

According to Table 4.4 and Figure 4.3 the Production department went of the control limit which represents 31.4% of the total number of mismatched products and it can be obtained by

Production department = $\frac{\text{number mismatched}}{\text{Total number of mismatched}} = \frac{354}{1127}$ X 100 = 31.4%

Also, 68.6% of the mismatched products were in control and it is obtained by

Mismatched products in control = $\frac{\text{number mismatched}}{\text{Total number of mismatched}}$ X 100 = $\frac{246+253+274}{1127}$ X 100 = 68.6%

According to the research, about 18.78% of both the raw materials and the finished products were defected and it is obtained by

P = $\frac{\text{Total number defective}}{\text{Total number of item sampled}}$ X 100 = $\frac{1127}{6000}$ X 100 = 18.78%

**3.6 To check for substantial improvement in productivity**

Information on the notice board of Dufil Prima Foods showed that the company had a target of 3.5 million cartons of indomie produced monthly but produces a range of 2.7 to 3 million cartons monthly. According to the research, 40% of the quality control variables affected the production process and when considered, the company's productivity has increased. Therefore, we conclude that there is a substantial improvement in productivity.

## IV. Conclusions and Recommendation

The study concludes that quality control can be used as a control mechanism to improve productivity in Nigerian manufacturing industries and also that the construction of statistical quality control chart for the industry has thrown more light in resolving production challenges in the industry. This research was empirically carried out and the findings have helped in solving the research problem. From the result, it was found that Dufil Prima Foods as a product is under control but needs to improve on training to minimize scrap in their production department or through their production processes. Also it was found that the process needs not to be readjusted for any assignable cause but needs to improve on some of the quality control standards. Also no production process should be carried out within the industry without properly spelt – out quality control measures by the managers of the process. This will ensure uniform of quality product and significant control of the entire production process.

Since the study was to investigate how to improve productivity of manufacturing industries in Dufil Prima Foods product. The following recommendation should be taken.There should be an intensive training and retraining of staff. It should be management led and involve all employees of the company and not a unit or a group of workers. This will enhance the skill and competence of the employees for better productivity and motivate them to achieve set organizational goals.For the company to achieve high productivity, Reviewing/tracking of mistakes should be encouraged as this enhances oneness, minimize scrap in production and increases productivity.The maintenance of the machine should be encouraged by management as the culture of every department in the organisation rather than allowing the machine to go bad before maintenance can be effected.

It is very necessary to inspect the incoming products (raw materials) before they are passed on for production. If the raw materials are of poor quality the final product will never come out as expected. Unless extra work is done on the raw materials which may have not been bargained for by the production department and may carry extra cost on the part of management and affect productivity.It is good to embrace new technology but though research should be made before accepting the new technology and also ensure that the rightful machines and equipment or tools are used. This is to eliminate valueless processes and enhance or improve productivity.Finally, appropriate quality management technique for the industry is the statistical quality control chart.

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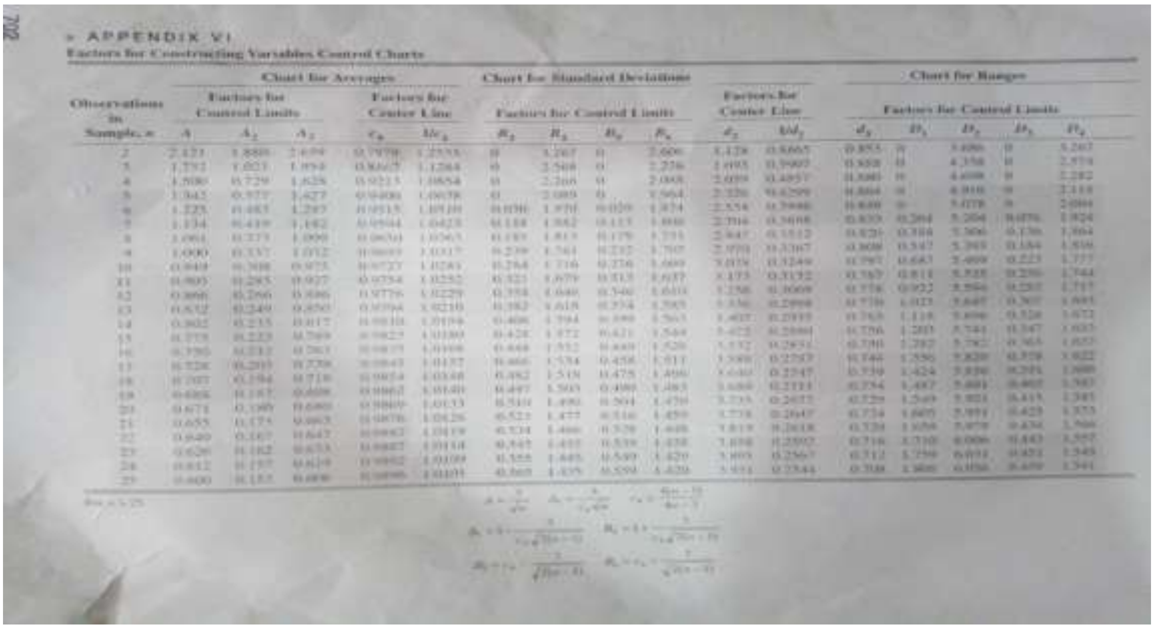
**APPENDIX 1**



APPENDIX VI

Factors for Constructing Variables Control Charts

| Observations in Sample, n | Chart for Averages | | | | | Chart for Standard Deviations | | | | | | Chart for Ranges | | | | | | |
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Des-Wosu A. G." Productivity Improvement through Quality Control in Nigerian Manufacturing Industry: A Case Study" International Journal of Engineering Science Invention (IJESI), vol. 07, no. 12, 2018, pp 35-42