# Process Investigation and Exploration of Strategies to Minimize Waste in Biscuits Manufacturing Industry

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## ABSTRACT

**Aim of this research was to investigate the biscuit manufacturing process in order to find ways to minimize wastages in production process. Main factors considered in this research were Process Capability study, Waste analysis using Pareto charts and Labor detailing. The process was investigated by carrying out a process capability study. Root causes to the waste were identified using Pareto charts. Labor detailing was used to suggest suitable improvements related to labor force. Views of the employees were analyzed through face to face discussions.**

**Capability study revealed that $P^H$ Level, Moisture Content of biscuit, and Gluten Content of dough are the capable processes. Raw weight of biscuits has a reasonable level of capability. The word capability here means the ability of the mentioned process to meet prescribed specifications. Bake weight, Bake height, and all Packet weights fail to meet specifications.**

**Major cause of wrapper waste is double packets. Number of double packets reduces at higher machine speeds. Start up waste is unavoidable. Skilled labor is important to improve the capability. The findings show that high amount of automation also is responsible for higher amount of waste.**

**KEYWORDS: Biscuits Manufacturing Industry, Process Capability, Statistical Process Control, Waste Minimization**

## INTRODUCTION

When the recent developments in the SriLankan industrial sector are considered, it is evident that food processing is a key player in SriLankan industry. Following statement published in www.theodora.com confirms that "Sri Lanka's most dynamic sectors are now food processing, textiles and apparel, food and beverages, port construction, telecommunications, and insurance and banking." Other than that Annual Report of central bank of Sri Lanka for year 2008 suggests that "The growth of food, beverages and tobacco products category decelerated to 5.2 per cent in 2008".

In the mean time it goes on to say "Among export oriented industries, the textile, wearing apparel and leather products category recorded a slower growth of 3.1 percent in 2008". "Textile and apparel industry was the key contributor in SriLankan industrial sector after 1990's." (Kelegama, 2005).

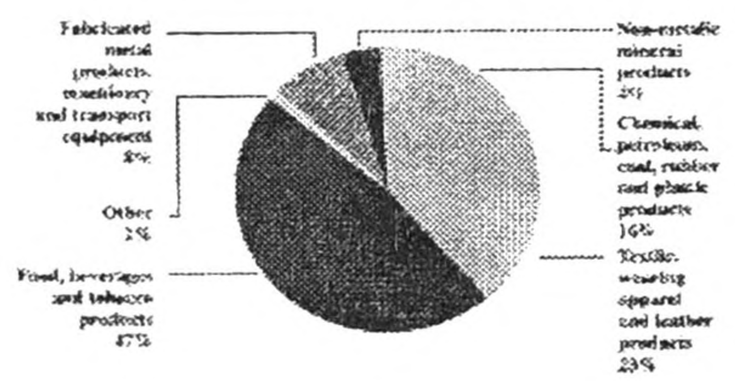


**Figure 1. Comparison of value added in industry -2008**

Figure.1 shows that the value added from food and beverages to the industry in year 2008 is 47%. It is more than double the contribution from textile and apparel which records only a 23%.

From the above facts it's clear that food processing is taking over the leadership among Sri Lankan industries. Therefore

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carrying out this research in Biscuit manufacturing industry which is a part of food processing seems to be a timely need.

The organization where this research was carried out is one company which belongs to a group of companies engaged in food processing industry in Sri Lanka. This group consists of seven subsidiary companies engaged in manufacturing various food products. Their product range include biscuits, wafers, chocolates, cakes, natural fruit juices, dehydrated fruits, flavored soya meat products, energy foods, herbal foods and so on.

This particular organization has been engaging in biscuit manufacturing for over 40 years. The beginnings roots back to 1968. By now they are the market leader with a total market share of more than sixty percent, by out-competing the closest rival by a good margin of forty percent where the closest rival is only capable of twenty percent market share.

The manufacturing process consists of the following steps.

- •Mixing
- •Dough Piece Forming
- •Laminating
- •Gauging
- •Cutting
- •Baking
- •Cooling
- •Packeting

### Background and Rational For the Research

Due to the deficiencies in processes company roughly losses 45000 rupees per working day while the value of total production stands at around 12million rupees (loss is 0.375% of value of total production). That was the main reason to select this research. Actually the percentage value stands small but when the money value is concerned 45000 rupees seems reasonably large.

When the generated waste from the production process is concerned, it was evident that the waste cannot be fully recyclable (Total value cannot be earned through recycling). Therefore only way to save the money is through improving the process so that reduce amount of waste generated.

Srikaeo, Furst, and Ashton (2004) mentioned that in biscuits manufacturing Variables other than wheat moisture content was not capable. Thus the researcher going on to see whether the above research finding could be validated in Sri Lankan context.

## RESEARCH OBJECTIVES

Objective of this particular research is to get an idea about the biscuits manufacturing process by investigating and to see whether the findings of previous research studies in similar industries worldwide could be applicable in the Sri Lankan context.

Other than that, this research focused on finding the root causes of waste generation in biscuits manufacturing process and thereafter it suggest ways to minimize the adverse effects of identified root causes.

## LITERATURE REVIEW

The word biscuit derives from Latin word "panis biscoctus", which means "Twice cooked bread" and refers to bread rusks that were made for mariners (ship biscuits) from as long ago as the Middle Ages. (Manley, 2000)

Biscuits manufacturing first started as an industry in Britain. It was the Industrial revolution, which gave the boost to the biscuits manufacturing. The story of biscuits roots back centuries. Following statements prove that. 'Biscuits are a kind of hard dry bread made to be carried to sea." William Shakespeare also refers to biscuits in his play "As You like It" in 1600. (Manley, 2000).

First type of biscuits, In terms of mass production was of an unsweetened type relating more to crackers in modern

world. Nevertheless, wafers might be the oldest form of biscuits. Evidence that it was introduced to England by Normans from France way back in 1100. Those were mostly used in religious rituals. However, they were not like the wafers that can be seen today. They were more cake like things.As it was mentioned above the beginnings of biscuits, manufacturing roots back to the beginnings of industrial revolution. At the beginning, all the manufacturing works carried out manually as an example at the end of the 18th century the dough mixing was done by hand and at the end mixer man jumps in to the trough and treating it with his bare foot. Later the dough piece forming has been mechanized but cutting has to be done manually.

Modern form of traveling oven introduced in 1810. However, not succeed. Later in 1849 -51 periods it was introduced to England. At the beginning, the ovens were powered using coal. Later gas and electrically powered ovens were introduced. Mixing machines were developed in 1849. Most of them were of vertical type. First rotary cutter was introduced in 1890. First continuous running biscuits factory started in 1846 at Reading, west of London. Gauge rollers and laminators were synchronized to form one machine in USA and continuous oven bands were introduced during 1930s. Direct gas fired oven came in to use in1968. Baking time for cream cracker in that was 2.5mins.

At the beginning, the biscuits were packed in barrels or in tin boxes. They were dispensed to paper bags when sold.The British were the first to export biscuits. In the early days, most of biscuits were various types of crackers.

Cream Cracker biscuits were first introduced in about 1885 by the Irish firm of Jacobs. Since then they have maintained a significant place in sales of biscuits in Britain and have become popular in many other countries. In most cases, they owe their introduction to British influence and transfer of technology. In contrast to most other biscuits, cream crackers are distinguished by being made from fermented dough. They should not be confused with soda crackers, which are another type of traditional cracker with an American origin.

The name Cream Cracker is traditional and does not indicate that cram or even milk is now to be found in the recipe. Cream Crackers have a simple unsweetened basic recipe of flour, fat and salt. The dough is always fermented with yeast and is then laminated prior to cutting and baking. The combination of flour protein modification achieved during fermentation and lamination gives rise to characteristic flaky and variously blistered biscuit.

## Statistical Process Control

Statistical process control (SPC) is a mathematical method for determining whether a given operation is in control. If an operation is in control, the results of that operation will be predictable. For example, in a machine shop, as parts are made measurements of a critical dimension are taken and analyzed. After the first few parts are evaluated, the operator can statistically predict that future parts will be in tolerance. Evaluation of a few of these future parts documents the continuing quality of machined parts.

## Process

Process is defined as to treat raw material or food in order to change it or preserve it (Oxford Advance Learners 2003)

## Process Capability

Process capability refers to the normal behavior of a process when operating in a state of statistical control. It refers to the inherent ability of the process to produce similar parts for a sustained period under a given set of conditions. (Winton 1999)

## Process Capability Indices

Process capability can be expressed as percent non – conforming or in terms of

natural spread related to the specification spread.

**$C_p$:** This process capability index indicates process potential performance by relating the natural process spread to specification (tolerance) spread. It is often used during the pilot production phase and routine production phase. (Winton 1999)

**$C_{pk}$:** This process capability index indicates the process actual performance by accounting for a shift in the mean of the process toward either the upper or lower specification limit. It is often used during the pilot production phase and during routine production phase. (Winton 1999)

**$C_{pm}$:** This is a process capability index that indicates the Capability of a process to meet a given target value.

## Control Charts

According to Winton (1999), control charts are used to monitor the process after the initial process capability evaluation. How ever, periodic reevaluation of process capability is recommended to assure that the process mean has not shifted and that the process variation has not increased. The control chart may be used to obtain an estimate of the standard deviation and the process mean for use in the process capability formulas.

## Pareto Charts

Pareto charts are used to find the significant causes among a given set of causes. This analysis has done based on Eighty – Twenty Theory. In the theory it says eighty percent of outcomes originate from twenty percent of causes.

## RESEARCH METHODOLOGY

The purpose of the study is to investigate manufacturing process and minimize waste in biscuits manufacturing industry. Here it was possible to identify the Characteristics of the variables need to be analyzed. So the method of study to be followed can be classified under descriptive study according to Uma Sekaran (2009)

Research was broken in to three steps. That was done based on the points to be analyzed. First Characterization of Process done through analyzing the process variables in order to analyze the capability of each process. Gluten Content of Dough, $p^H$ Level of Dough, Moisture Content of Dough, Raw Weight of Biscuits, Baked Weight of Biscuits, Baked Height of Biscuits, and the Pack Weights of Biscuits were the variables analyzed.

The Waste generated was analyzed in the next step. Waste was analyzed in three different categories Wrapper Waste, Grinding Waste and Sweeping Waste. Finally Labor Detailing was done.

Data collection strategy was design in order to meet the requirements stated in the research design. In the first phase of the research, primary data was mostly used except for Gluten Content of Dough, $P^H$ Level of Dough, and Moisture Content of Dough. For those secondary data was used.

Data gathered for research from the actual site of occurrence of events are called primary data. Data gathered through existing sources are called secondary data. These two definitions were found from Uma Sekaran (2009).

In the second phase for wrapper wastes, Primary data was gathered and for grinding and sweeping wastes, secondary data was used. In observing the labor allocations, it used the primary type of data.

The data collection strategy mainly based on observations. Nevertheless, secondary sources were used when required.

In observation, there are two types, one is Participant observation, where the researcher may play the role of the participant observer. Here the researcher enters the organization or the research setting and become a part of the research setting says Uma Sekaran (2009). This was widely used in the first phase of the research. According to the same author mentioned above the non-participant

observation is the researcher collecting the needed data in that capacity without becoming an integral part of the organization system. This was applied in observing the labor allocations.

Secondary sources of data include company data sheets and work instructions. They are mostly used during grinding and sweeping waste analysis.

## DATA COLLECTION & ANALYSIS

Data were collected on, Process Characterization and Capability Analysis, Waste Monitoring. Labor detailing was done using the feedbacks received during discussions taken place in the production floor.

Process Characterization includes Weight and Height Monitoring, Monitoring of Dough gluten content, $P^H$ level of biscuits and moisture content of biscuits. Raw weight, baked weight, and baked Height refer to Weight and Height for 10 biscuits taken at once. Those ten biscuits are taken along a cross line where the conveyer belt consists of twenty separate lines of biscuits. Packet weight was analyzed for three types of packs 130g, 190g, and 500g. For $P^H$ Moisture and Gluten Company records were referred.

In waste monitoring Wrapper waste for two packs of size 130g and 190g was monitored. Other than that Grinding and sweeping waste was monitored. Sweeping and grinding waste data were obtained through company records.

In collecting data various sample sizes were used and they are shown in Table. 1. Data collection for each category was done in two months periods each. Number of data points obtain under each variable is shown in Table. 2.Data analysis was carried out using Minitab statistical software release fifteen-trial version.

**Table. 1 Sample Sizes for Variables**

| Data Type | Sample Size |
|---|---|
| Raw Weight Of 10 Biscuits | 03 |
| Bake Weight Of 10 Biscuits | 01 |
| Bake Height Of 10 Biscuits | 01 |
| 130g PACKETS | 40 |
| 190g PACKETS | 40 |
| 500g PACKETS | 20 |
| Dough Gluten Content | 01 |
| Biscuit Moisture Content | 10 |
| Biscuit $P^H$ Level | 10 |

**Table. 2 Details of Responses**

| Data Type | Number of Data |
|---|---|
| Raw Weight Of 10 Biscuits | 363 |
| Bake Weight Of 10 Biscuits | 334 |
| Bake Height Of 10 Biscuits | 338 |
| 130g Packets | 5040 |
| 190g Packets | 2420 |
| 500g Packets | 2160 |
| Dough Gluten Content | 98 |
| Biscuit Moisture Content | 440 |
| Biscuit $P^H$ Level | 190 |
| Wrapper Waste | 100 |
| Grinding Waste | 136 |
| Sweeping Waste | 136 |

In data analyses following results were obtained for the process capability study. The relevant $C_p$ values for each process that have been studied are given in Table. 3

**Table. 3 $C_p$ Values Obtain in Study**

| Process | $C_p$ Value |
|---|---|
| Raw Weight Of 10 Biscuits | 0.45 |
| Bake Weight Of 10 Biscuits | 0.29 |
| Bake Height Of 10 Biscuits | 0.27 |
| 130g Packets | 0.27 |
| 190g Packets | 0.36 |
| 500g Packets | 0.34 |
| Dough Gluten Content | 1.15 |
| Biscuit Moisture Content | 1.02 |
| Biscuit $P^H$ Level | 0.90 |

Pareto charts obtained in wrapper waste analysis for 130g pack is shown in Figure. 2 It shows that double packets are

the major contributor; this is same for 190g packs. It is shown in Figure. 3

Significant contribution to grinding waste occurs at oven end. While sweeping waste is significant at Packeting table end.

Total wrapper waste percentage for 130g pack is 6.25%. While 53.1% of total wrapper waste is due to double packs.

Total wrapper waste percentage for 190g packs is 10.41%. Out of that 65.9% occur due to double packs

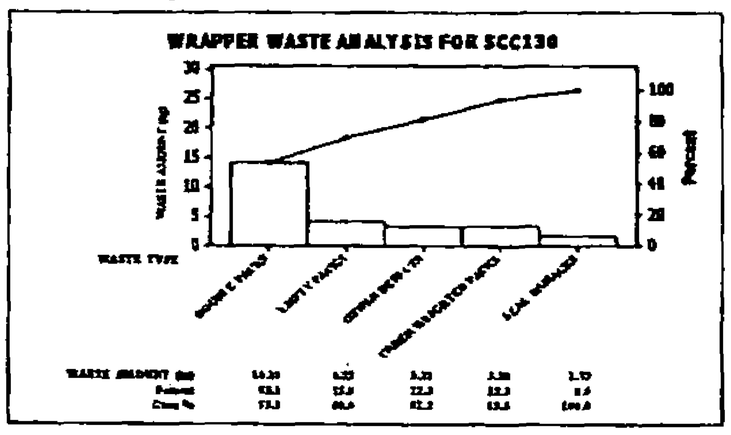


**Figure2. Wrapper Waste Analysis for 130g Pack**

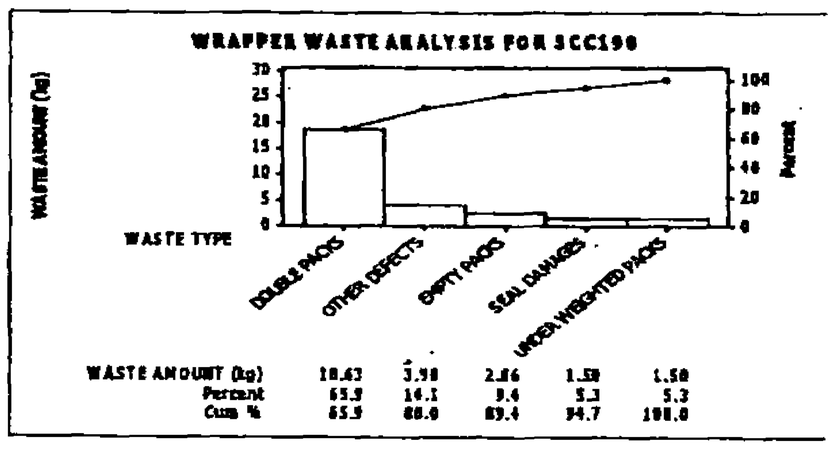


**Figure3. Wrapper Waste Analysis for 190g Pack**

Company Standard for wrapper waste is 3.0%.Grinding waste and sweeping waste record 5.38% and 0.39% of total production respectively. Company Standard for Grinding & Sweeping waste is 3.0%.

## RESULTS AND DISCUSSION

In analyzing capability following variables were analyzed raw weight, baked weight, Baked Height, Packet weights for 130g, 190g and 500g, Moisture Content, $P^H$ level and Gluten Content. Out of these $P^H$, Moisture and Gluten seems Capable because $C_p$ values are above and around 1. (Table3.) Raw weight is somewhat satisfactory with 0.49. (Table3.) Because Raw weight is about 85% capable. ($C_p$ Value of 0.5 corresponds to 86.64% capability (Winton1999).) Rest is incapable($C_p$ less than 0.5(Table. 3)). Major contribution to wrapper waste is Double Packs irrespective of the packet type. High amount of grinding waste was generated at Oven End and sweeping waste mostly Occur at Packeting table end.

According to the results given in the previous section, it can be seen that most of the processes are incapable,(Not according to specifications) as the research focus on find ways to maximize the process capability through minimizing waste it is really remorseful to obtain such a result. However, it is better to look in to this kind of matter in comparison to the past experience in the field. As Khongsak Srikaeo, John E. Furst and John Ashton (2004) mentioned in their research only variable seem capable was Moisture content of Wheat. In that sense, this research have some favorable results, because more number of process variables ($P^H$, Moisture and Gluten) seems Capable. Still the processes need improvements.

The studied process produces cream crackers. Cream crackers are a type of biscuit with Bubbles and thus the specifications of biscuits tend to vary. Therefore, in production process when going for the taste and Quality of the biscuits (As the quality of cream crackers is judged by the amount of bubbles exists on the biscuits) specifications have to be given up. It is very hard to concentrate both on specs and on the product quality. Lack of close monitoring of the process is also contributor to process incapability. Here the employees are advice to monitor the process once in every fifteen minutes. But they do not follow that. Even data were gathered by Quality checkers have not analyzed, they are taken and store as hard copies so no analysis was possible with this data.Next is lack of communication with each section of production floor. As the variations are an inherent characteristic of

this biscuit. Smaller variations in the raw material cause high variability in end product, as the production volume was so large. Through proper communication, those can be avoided.

Packeting machines do not permit adjustments, as the biscuit type, Cream crackers have variations in height due to the bubbles. Therefore, the biscuit height varies according to the amount of bubbles but it cannot be controlled, because of that, variation of height is unpredictable before baking. As the packet, weight was taken in proportion to the height the packet weight varies. However, the machine is not capable of adjusting to such situations. Actually, the allowable range is not enough.In waste analysis, double packets (Packets jointed from cutter seal) are the significant category in wrapper waste, which accounts for about 60% of total waste. These double packets generated when the biscuits fall over in the pack this fall over occur when biscuits differ in height.So,there may be some mechanical issues affecting that. It was found that at higher speeds of the machine double packs generation tend to reduce. (At higher machine speeds 90 to110packets/minitue the number of double packs per minute tend to reduce from 50%)Grinding waste is higher at oven end because of the startup waste occur; in each time oven starts. This is unavoidable.Sweeping waste is negligible compared to production volume.

## CONCLUSION

By considering the results of the study, it can be conclude that the incapability in Process variables is a common characteristic of the Biscuits Manufacturing industry. This is highly effective for the Cracker types. High automation sometime becomes a cause of process inefficiencies. However,this has to be tackled in order to achieve higher production volumes by continuously monitoring the process through a well established statistical process control (SPC) system

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