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Development of Integrated Lean Six Sigma-Baldrige Framework for Manufacturing Waste Minimization: A Case of NAS Foods Plc

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Abstract

The aim of this study objective is to develop an integrated constant quality improvement model so as to minimize unwanted biscuit processing industry wastes. The method used was lean- six- sigma elements to define measure and improve unwanted process company wastes. In other word, Baldrige with six-sigma were created to define, measure and improve management perspectives. The tasks were integrated using both quantitative and qualitative analyzing tools implementing mixed strategies. The result was improved by using FMEA analysis was carried out at each stage of the existing process used to determine the failure of the process and to analyses and improve the production quality. The SPSS software was also used. In the finding section, the correlation and regression analysis has shown that there is strong relationship between each variance. There are different wastes that identified in six sigma (DMAIC) on NAS food Plc as a result; the value of waste ratio indicated is 36.7%. This show non-lean of the food industry is practiced. The defect of the company also calculated and defect per million are 67,308. This shows that the biscuit production has a production capability with a failure of 67,308 every 1000,000 productions it high failure rate. The contribution of the paper has indicated that there are limited studies were conducted so far to implement waste minimization tools like six-sigma, lean and MBNQA framework approach integration for food processing industry.

Keywords: waste, lean, DAMIC, CQI, MBNQA

1. Introduction

Companies are more competitive in current globalization and every detail is important for the business that wants to improve its competitiveness. Since it is not a surprise, the best continuous improvement strategies that could be developed for manufacturing industries provide to improve efficiency and effectiveness of whole systems. Though, automating production and improving process efficiency are two major objectives of the food industry worldwide. Since, implementing advanced continues an improvement strategy in the modern manufacturing provides to

improve the performance of the process, reduce waste and ensure on time delivery of the sectors [1]. Because of the continuous improvement is a management philosophy that approaches to tackle the challenge of product and increase process improvement [2]. Thus, from numerous tools firms were invested to implement lean, six-sigma, TQM and JIT strategies in their business process so as to enhance performance and compete at global levels [3]. Though the lean principle provides to identifying and eliminating non value add (wastes) through continuous improvement tools, flowing the product at the pull of the customer in pursuit of perfection [4]. Since due to comprise on quality development, process focus, continuous improvement and value stream management and worker empowerment future several companies invest in the implementation lean principles [3]. While six sigma is a really effective tool for systematically attacking the highest priority production and support functional problems within an organization [4]. Hence, six sigma is statistical measure of defect rate within a system and the practice requires the knowledge of basic and advanced statistical tools so as to reduce defects and variations within a work process in firm. But the main limitations are six sigma not effective for every problem reduction in the firms [5]. Baldrige national quality award (MBNQA) for helping excellence ever, improving value to marketplace success, improvement of overall organizational effectiveness and capabilities, organizational and personal learning. Though from the above observe that a single improvement tools lacks to coherence to tackle the whole problems of the manufacturing firms. Single tools have good potential to tackle specific problems. Even though, an integrated continuous improvement strategies and methods have great power to improve the performance and the competitiveness of the firms [6]. As long as fewer studies were investigate to implements the integration of lean with six sigma, lean with TQM strategies in the firm so as to improve the performance and global Competitiveness [4]. Therefore integrating three or more continuous improvement strategies provides to enhance, quality of products, optimum product cost, timely delivery of products, the flexibility of their internal business process, reduction of wastes and customer satisfactions [3]. Thus, this study aims to develop an integrated frame work from lean, six sigma and the Malcolm Baldrige Criteria so as to improve the production performance, reduce waste and improve competitiveness of NAS Foods Plc.

2. Problem statements

Nowadays food industry makes a significant contribution to national economy in many developing countries. Here in Ethiopia the economy depend on agricultural and which accounts 43.2% of gross domestic product (GDP) [7]. Also there is less contribution in an improvement of biscuit industry analyzed and waste minimization. There is different waste that are identified in six sigma (DMAIC) on NAS food Plc. Currently the company only uses 30% of its capacity and produce 3000 carton per day via 349 workers but it can produce 10,000 cartons with 1000 workers. As a result the value of waste ratio is 36.7%, this show non lean and can be categorized as a traditional company [8]. The defect of the company also calculated and defect per million are 67,308. This shows that the biscuit production of has a production capability with a failure of 67,308 every 1000,000 productions or equivalent to 6.73% loss and this indicates the production process still has a high failure rate. The other problem here is there are limited studies were conducted so far to implement waste minimization tools like six sigma, lean and MBNQA approach on Ethiopian food processing industries [9].

3. Objective

The main objective of this study is to develop an integrated continuous quality improvement model so as to minimize waste of biscuit manufacturing.

- To identify the gaps and strength of previous researches on related to continuous improvement strategies to minimize waste.
- To investigate the challenges and potentials of integrating continuous improvement strategies in the context of biscuit manufacturing.
- To develop an integrated continuous quality improvement models to reducing waste and enhancing competitiveness of NAS food Plc.

4. Literature review

The purpose of this literature review is to provide a background on challenges of waste, waste controlling mechanism and applicability of waste controlling strategies across a variety of industries. Since this understanding will help determine which waste controlling strategies and principles are appropriate for implementation within the food manufacturing industry, and detail topics discuss in this section are for history of waste minimization in manufacturing industry, lean manufacturing philosophy, six sigma and Malcolm Baldrige National Quality Award (MBNQA) principle, tools and technique in manufacturing industries as whole as well as a detailed summary of the literature concerning improvement and competitiveness problem of Ethiopian food processing industry. Though the principal sources of this information included company reports, published literature in textbooks and journals were incorporated.

4.1 Wastes in the food processing sector

Food loss should mean the decrease in edible food mass throughout the food chain. Food losses take place in production, postharvest and processing stages in the food supply chains. Since a division is to be made whether the loss of resources happens in the early stages of the food supply chains (FSC) or the resource was wasted by the action of the retail sector or consumers. Though in the first case, the problems can call about food losses, while in the latter case about food waste. The food losses can be avoided by a correct action, e.g. by maintaining the cold supply chain or ensuring correct storage conditions for products. Since the food loss also occurs if the product that was originally intended for human consumption is recovered in the form of feed, fertilizer or energy [10, 11]. Besides the waste and food waste is more comprehensive and it includes all resources that are lost in the different sectors of the food supply chain, and will include also those parts that were originally not intended for human consumption.

4.2 Waste minimization strategies and mechanisms

The waste is an important issue that should be treated in such a way that the benefits achieved from that will be in both environmental and social aspects. As in manufacturing industries, waste management is key issues to greater opportunities for waste recovery and diversion of waste from landfill, and services suitable to

businesses. Though according to [10] shows that waste management is favoring reuse and recycling before land filling, with the main idea of environmental sustainable society.

4.3 Continuous improvement strategies

Quality is becoming an increasingly important subject in organizations. It is central matter to develop a sustained resource management technique. Therefore, logistics emerges as an activity that allows the achievement of a prodigious efficiency and economic welfares and in long term it is to obtain competitive advantages of the country. However, organizations have improvement choices with time depending up on the way they track to meet their strategic and operational objectives, they can watch to its economic welfares. Science raises continuous improvement as the competence of frequent processes and schemes and is closely integrated with means of waste elimination. The customers focus programs such as total quality management, supply chain management, just-in-time and kaizen also need to be understood how to assess quality of products and systems through use of a variety of quality control tools. It is also important to understand how to interpret findings and how to correct problems. There are countless specific tools and techniques that help the industry process improvement and enhancement. Any organization needs to focus on quality of products, optimum product cost, timely delivery of products and the flexibility of their internal business process to adjust to quick fluctuations. Consequently, continuous and constant improvement tools like Kaizen, Six Sigma, ISO-9000, Lean thinking, TQM, SCM and JIT system are not new to the present situation of industrialization for achieving the above concepts. This method is not only limited to any particular industry but also to large potential benefit. It has a widespread application throughout the whole industries. Many industries have adopted it and others are going to implement for their endurance in the fast competition at each stage in each area.

4.4 The concepts of lean manufacturing

Historically the lean production system is the world famous production system developed and practiced by Toyota Company for a long time [12, 13]. Though the basic ideas behind the lean manufacturing system are waste elimination, cost reduction and employee empowerment. Since this concepts leads to maximize customer value while minimizing all the wastes that come with that significance. Nevertheless, lean processes can make jobs highly repetitive while eliminating critical rest time for employees [14]. Lean is a philosophy that aims to maintain smooth production flow by continuously identifying and eliminating waste resulting in increasing value of activities in the production process [15].

4.5 Waste reduction and waste removal

Through Lean Main goal of lean thinking is to reduce and remove waste. Since lean strategy is a potential tool to minimize and then remove waste so as to achieve sustainable development of manufacturing firms. Even though, the lean strategy reduction is one of the main functions of Lean Manufacturing implementation plan [15]. Since all the form of waste i.e. overproduction, defect, transportation, work in progress inventory, over processing, waiting and motion are reduced with Lean manufacturing implementation (**Figure 1**).

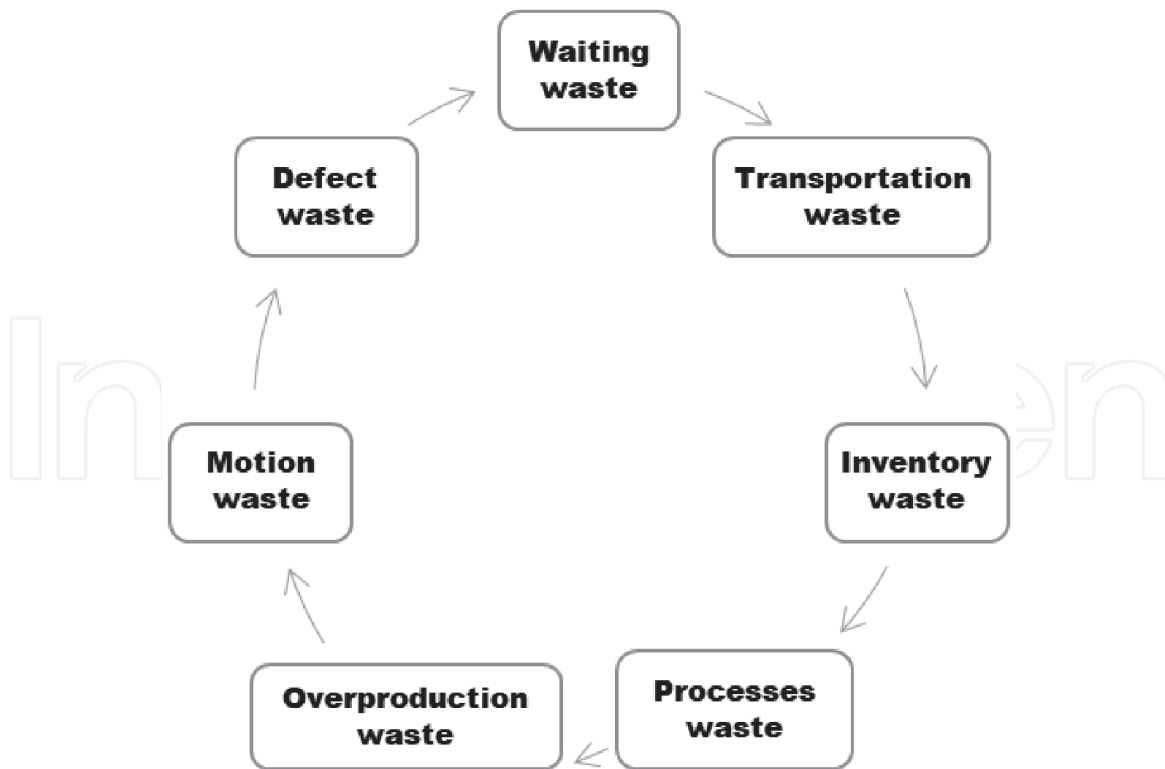


Figure 1.
 The seven wastes that controlled quality.

4.6 Roles of six- sigma on improvement

Numerous companies use Six Sigma practice to achieve competitiveness of their business. Six sigma methodologies are cast-off to improve the excellence of the product and process dramatically. Sigma, σ , is a letter employed from the Greek alphabet to measure the process variability and the sigma level measured to determine the performance of the business processes [15]. The six sigma methodology was introduced by Womack et al. [16] and resulted in the accomplishment of business quality in Motorola. According to the study by Snee [17] states that six sigma concept was constructed by Bill Smith, then an engineer at Motorola who wins the 1988 Baldrige National Quality Award. The deployment of six sigma concept is led by Allied-Signal and General Electric (GE). Six-sigma is described as an improvement programmer for reducing variation. It focuses on continuous and breakthrough improvements. In research the two major improvement methodologies in six- sigma has been considered. These are already existing processes and new processes. The first methodology used to improve an existing process and can be divided into five phases [15]. These are:

- **Define:** which process that needs improvement. Define the most suitable team members to work with the improvement. Define the customers of the process, their needs and requirements, and create a map of the process that should be improved.
- **Measure:** Identify the key factors that have the most influence on the process, and decide upon how to measure them.
- **Analyze:** Analyze the factors that need improvements.

- **Improve:** Design and implement the most effective solution. Cost–benefit analyses should be used to identify the best solution.
- **Control:** Verify if the implementation was successful and ensure that the improvement sustains over time. As well the second methodology is often used when the existing processes do not satisfy the customers or are not able to achieve strategic business objectives, see [18]. This methodology can also be divided into five phases; define measure, analyze, design, verify, according to [15]. In summary, the two different methodologies have obvious similarities [19]. **Table 1** indicates the integration of the tools.

	Define	Measure	Analyze	Improve	Control
Lean tools	Value Mapping Project Charter	Process Mapping Cause and Effect Matrix	FMEA Bottleneck Analysis	Production Smoothing Kaizen Events	Standard Work 5S Poka-Yoke

Table 1.
Integration of lean tools in the DMAIC framework [3].

Program	Six Sigma	Lean thinking	MBNQA
Theory	Reduce variation	Remove waste	Quality awareness
Application and Principles	<ul style="list-style-type: none">• Define• Measure• Analyze• Improve.• Control	<ul style="list-style-type: none">• Identify value• Identify value stream.• Flow.• Pull, Perfection.	Visionary Leadership, Customer-Driven, Excellence, Organizational and Personal Learning, Valuing Employees & Partners, Agility, Focus on the Future, and analysis and knowledge transfer and organization performance
Focus	Problem focused	Flow focused	Quality focused
Criticisms	System interaction not considered. Processes improved independently.	Statistical or system analysis not valued	Unfairness, superficiality and publicity the inherent value of the continuously improving award program far outweighs its limitations.
Tools	Flow chart, control chart, graphical chart	5S,VSM	Questioner, ABC
Type of Continuous Quality Improvement (CQI) Initiative	<ul style="list-style-type: none">• Emphasis processes & outcomes• Greatest for processes plagued by wide variability —logging of pharmaceuticals, standardizing referral processes, etc.• a heavily quantitative approach to CQI	<ul style="list-style-type: none">• Emphasis on process.• Simplifies overcomplicated processes and considers interdependencies.• Best for known problems with known system change solution.• Integrated throughout the organization.• Ideal for large complex health care	<ul style="list-style-type: none">• Emphasis on structure and outcomes.• Best for practice-wide problem assessment and goal setting.• A broad, holistic approach to CQI initiated at strategic times.• Ideal for practices that want to establish a new

Program	Six Sigma	Lean thinking	MBNQA
	<ul style="list-style-type: none">Adapted for targeted changes to specific processes.Combined with Lean when the focus is on efficiency and quality.Ideal for practices that want to rigorously quantify improvements in safety, quality, and cost effectiveness	organizations and practice networks that want to standardize operations across multiple units	CQI system or overhaul an existing one.

Table 2.
Comparison of improvement programs [22, 23].

4.7 Malcolm Baldrige national quality award

The initiative taken to improve quality management practices and the competitiveness of U.S. firms was signed by President Ronald Reagan on Malcolm Baldrige National Quality Improvement Act in 1987. The Malcolm Baldrige National Quality Award (MBNQA) was created to promote quality awareness, identify the requirements for quality excellence and share information about successful quality strategies and benefits [20]. The Baldrige core values and concepts includes visionary leadership management for innovation, customer-driven, excellence, management by fact, organizational and personal learning, social responsibility, valuing employees and partners, focus on results and creating value, agility systems perspective and focus on the future are the common values [21].

Table 2 indicates the comparison of the different programs and tools. It indicates the difference and similarities the tools have so that they lead to develop the ingrate once. **Figure 2** indicates the summery of literature review with the major areas considered during the study.

4.8 Literature gap

To get enough information about the topic raised so many literatures are reviewed from different sources, among these journal articles, reports, and unpublished master thesis is the main one. During literature survey recent

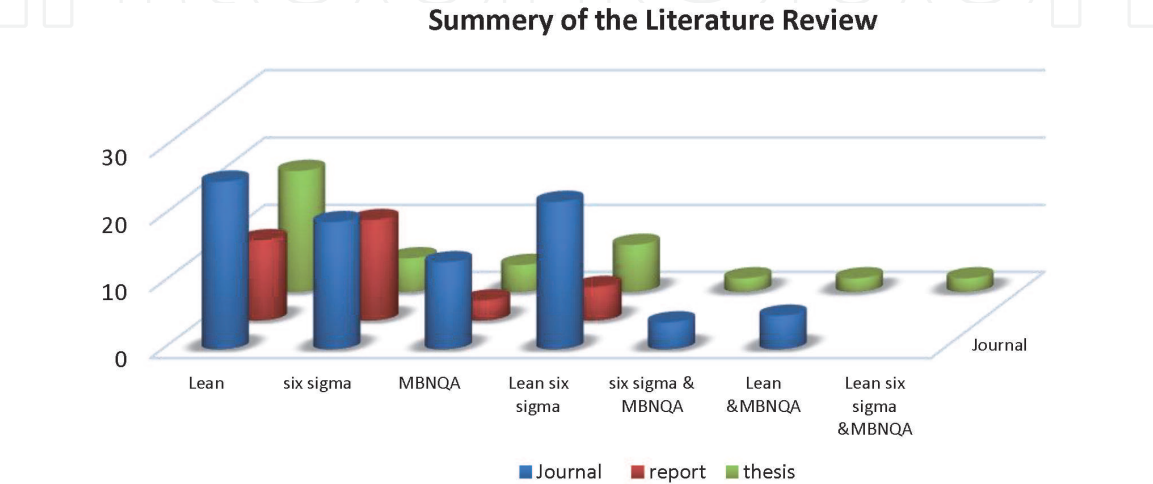


Figure 2.
Summary of the literature review (authors).

documents concerning waste minimization tool lean, six sigma and Malcolm baldrige quality award are collected from different sources then each document critically examined in order to filter gaps below.

- [9, 19, 23–29] this papers integration lean six sigma with different tools but not integration awards or quality perspective.
- [21, 30] these papers see the alignment and reviewed of Lean Six sigma and Baldrige but not integrate all and not much has been found in Ethiopian context.
- The organizations are not able to reap out the benefits of Lean Six sigma, Baldrige and other advance tools practices due to lack of awareness.
- Integrated Lean, Six sigma and Baldrige approach in Ethiopia Industries is not explored and not much has been found in food industry.

5. Research methodology

This study was conducted based on both secondary and primary data collected from the primary sources and ordinary data. Preliminary literature review and existing company condition was scanned to formulate the problems and objectives of the study. The data collection process considered defines measure and analyses the data sources. The process set improvement model and then control the research process. The research draws the conclusion of the resulting analysis with.

As shown in **Figure 3**, the research process start at problem formulation and arrives at conclusion and recommendation. The study has been conducted by considering preliminary literature review to develop objectives and problem statement. The study was conducted by considering literature review from different know sources and databases. The literature was reviewed from databases like Scopus

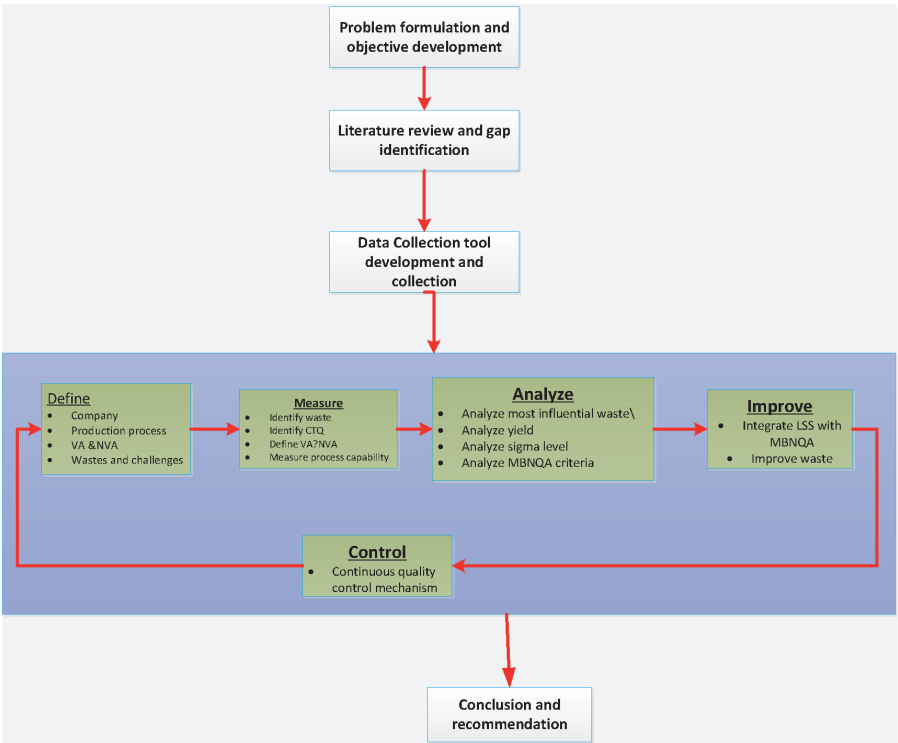


Figure 3.
A methodology framework.

indexed, web of science listed journals, PUBMED, MEDIN, research gates and DOJ indexed journals. After analyzing and screening literatures, the study found gaps from literature that helped to know the research focus area. Based on the literature review method of data collection and sources were identified. The data was collected through questionnaires, interviews, and field observation. Data sources were used from primary data which was collected by physical field observation, interviews, questioners and company reports from NAS Foods Plc. Responsible and targeted groups were considered under survey on this study. Interview of top managers were made containing 14 interview questions and answer by 1 management and 2 supervisor of the NAS Foods Plc. during the field visiting.

Questioners for employees also conducted to collect data from employees by using questioner to find detail of the problems that NAS Foods Plc. currently facing. The other data source was secondary data which was used to meet the research objectives, reviewing the existing research work of 48 journals, government reports, some reference books & paper related to lean thinking, six sigma, Malcolm Baldrige national quality award programs, strategies, role impacts on manufacturing and food processing industries. The key challenges, potentials and strategies to integrating continuous improvement tolls also considered. The Early search results show that a total of 400 article reports and thesis were found from various textbooks, academic and professional journals. Then read and sort for relevance to the continuous improvement and waste minimization strategy and tools and for their integration. The article would be assessed of methodology, method of measurement and finding results. Finally 48 article, reports and thesis selected are important and related to this study. The research methodology used the continuous quality improvement tool integration to reach its conclusion (Refer to **Figure 3**).

6. Result and discussion

6.1 Quantitative result

6.1.1 Bivariate correlation analysis

Correlation analysis is used to quantify the association between two continuous variables (between an independent and a dependent variable or between two independent variables. Pearson (r) correlation is the most widely used correlation statistic to measure the degree of the relationship between linearly related variables. The correlation value $r = -1$ indicated that strong negative correlation existence, $r = -0.5$ negative correlation, $r = 0$ with no correlation, $r = +0.5$ with strong correlation and $r = +1$ is the strong positive correlation (**Figure 4**).

This study showed the respondent result from questioner and it has 4 sections and 25 questions so in order to see the correlations of all indicators it is preferable to make analysis using SPSS. Based on the above principle the study develop the relationships between the waste measurement variance as we see in the next (**Table 3**) in the SPSS output Pearson correlation r (value of statistical test) should close to $+1$ and the sig (2-tailed) or p -value is less than 0.05 for strong relation. As we see the table below there is strong relation in each relation.

6.1.2 Analysis of awareness of waste measurement

Waste measures are included seven perspectives in lean typical. In this study it identified each because waste issue is different from process angle and to see further correlation between each viewpoint. Waste minimization is the basic for any

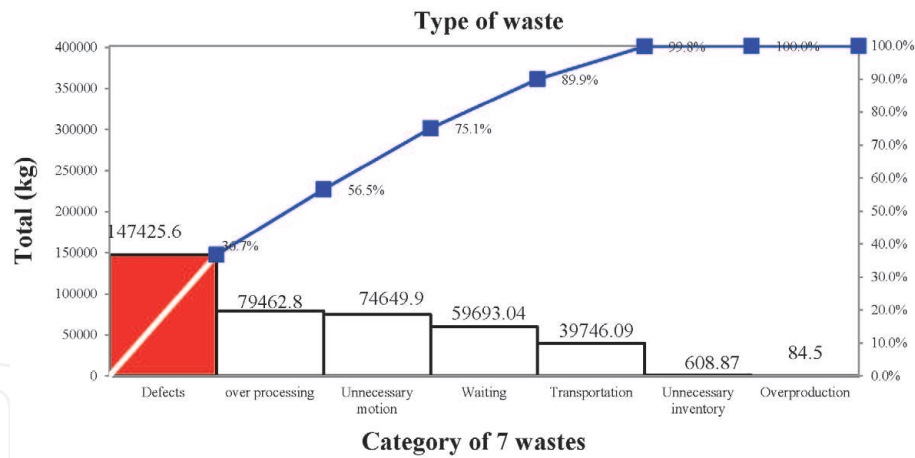


Figure 4.
Pareto diagrams of seven wastes)

Factors	Excessive transport	Unnecessary inventory	Unnecessary motion	Inappropriate processing	Overproduction	Waiting time	Defect time
Excessive transport	1	0.749**	0.662**	0.579**	0.696**	0.630**	0.680**
Unnecessary inventory		1	0.898**	0.692**	0.661**	0.920**	0.779**
Unnecessary motion			1	0.882**	0.814**	0.899**	0.848**
Inappropriate processing				1	0.906**	0.762**	0.903**
Overproduction					1	0.659**	0.894**
Waiting time						1	0.828**
Defect							1

***Correlation is significant at 0.01 level with Person (2-tailed) and list wise N = 100.*

Table 3.
Bivariate correlation in between waste measurement parameter.

organization, in this study waste minimization of NAS food plc. The awareness of each respondent comprised (Table 3).

When it has been seen the relationship of each variable in waste perspective have strong relation with significance level of 0.01 and the causal Pearson Correlation of variable of excessive transport vs. inappropriate process their value is 0. 579 which show moderate positive relationship and the highest Pearson correlation in waste perspective is between unnecessary inventories vs. waiting their value is 0.920 it mean that waiting in NAS food is highest factor in unnecessary inventory analysis. There is also highest Pearson correlation that the value is greater than 0.9 between inappropriate processing vs. over production and inappropriate process vs. Defect.

6.2 Analysis of Malcolm criteria measurement

Malcolm measures are included seven criteria in management perspective. In this study it identified each because Excellence issue is diverse from management angle and to see further correlation between each viewpoint. Quality improvement is the basic for any organization (Table 4).

When we see the above relationship of each variables in management perspective, they have strong relation with significance level of 0.01 and the causal Pearson

Malcom Criteria measurements	Leadership style strength	Strategic planning improvement	Customer and market focus management	Information and data analysis efficiency	Human resource focus	Process management	Business result capability
Leadership style strength	1	0.896**	0.960**	0.845**	0.855**	0.926**	0.929**
Strategic planning improvement		1	0.922**	0.820**	0.921**	0.861**	0.884**
Customer and market focus management			1	0.877**	0.882**	0.927**	0.958**
Information and data analysis efficiency				1	0.856**	0.843**	0.904**
Human resource focus					1	0.837**	0.881**
Process management						1	0.923**
Business result capability							1

***Correlation is significant at 0.01 level with Person (2-tailed) and list wise N = 100.*

Table 4.
Bivariate correlation in between Malcolm criteria measurement.

Correlation of most variable has a strong positive relation and their value is greater than 0.9 whereas the leadership vs. customer and market their value is 0.960 and it has highest value than the others which shows strong positive relationship.

6.3 Analysis of waste minimization tools measurement

Waste minimization tools measures are included six perspectives in this study. It identified each because waste issue is different from process angle and to see further correlation between each viewpoint. Waste minimization is the basic for any organization; the company does not adopt any particular standardized approach to larger improvement projects (Table 5).

When we see the above relationship, each variables in waste minimization tool perspective have strong relation with significance level at 0.01 and 0.05 whereas the causal Pearson Correlation of JIT vs. Six- sigma their value is –0.370 which show negative relationship and the highest Pearson correlation in waste minimization tool perspective is between lean vs. JIT its value is 0.920 which mean that JIT in NAS food is highest factor in Lean analysis.

6.4 Analysis of competitiveness measurement

Competitiveness measurements are included five perspectives that help evaluation and decision making within organizations that occupy in waste issue. It identified the correlation between quality, price, time, customer satisfaction and environmental views (Table 6).

When we see the above relationship of each variables in competitiveness measurement perspective they have strong relation with significance level of 0.01 and the causal Pearson Correlation of most variable has a strong positive relation and their value is greater than 0.9 whereas the time vs. customer satisfaction and

Factors	Lean	Just in time	TQM	Kaizen	Work Study	Six sigma
Lean	1	0.960**	0.042	0.858*	0.866**	0.335**
Just in time		1	0.0.34	0.858*	0.833**	0.37**
TQM			1	0.114**	0.244*	0.717**
Kaizen				1	0.868**	0.141
Work Study					1	019
Six sigma						1

*Correlation is significant at 0.05 level with Person (2-tailed) and list wise N = 100.
**Correlation is significant at 0.01 level.

Table 5.
Bivariate correlation in between waste minimization tools.

Do the following factors affect biscuit product	price affect competitiveness	quality affect the competitiveness	Time affect the competitiveness	Customer satisfaction affect the competitiveness	Environment affect the competitiveness
price affect competitiveness	1	0.898**	0.869**	0.803**	0.833**
quality affect the competitiveness		1	0.914**	0.895**	0.912**
Time affect the competitiveness			1	0.934**	0.940**
Customer satisfaction affect the competitiveness				1	0.913**
Environment affect the competitiveness					1

**Correlation is significant at 0.01 level with Person (2-tailed) and list wise N = 100.

Table 6.
Bivariate correlation in between competitiveness measurement.

environment their value is 0.934 & 0.940 respectively and it has highest value than the others which shows strong positive relationship it mean that time affect the competitiveness of biscuit product in NAS food is highest factor in customer satisfaction and environment analysis.

6.5 Analysis on waste level using the 7 lean wastes

There are certain techniques obtained from previous studies to analyses the seven lean wastes. Among them, the following stages were used.

- **Defining Stage:** The biscuit production process and determination of VA/NVA activities of NAS manufactures varies biscuits’ production lines. The production process of line is run fulltime. According to many studies biscuit production and design revealed that the biscuit production process covers the stages of raw material preparation, mixing, forming or molding, baking by oven, cooling and packing [31, 32]. Each process has a certain design and layout

in order to obtain quality, process capability and good capacity in order to meet the needs of consumers.

- **Measure Stage:** it a Waste Identification stage. During the field observation, the biscuit production process in NAS factory, there were several waste of resources identified i.e. non-standard process, fail on the ground, Crimean machine waste area, Rapper wastage, Packaging scrap product drops, error metal detector detection, broken, oval, overweight or small products, imperfect shape, non-standard water content, malfunction process, and engine breakdown. According to [33] Toyota identifies seven types of waste and they include 1. Overproduction, 2.waiting time, 3. Unnecessary transportation, 4. Excessive or erroneous processing, 5. Excessive inventory, 6. Unnecessary movement and 7. Defective product.to identifies the observed. The results of this identification were illustrated by a value stream mapping diagram, to determine the actual condition of the observed objects in several indicators, including value added and non-value added time. The value of Process Cycle Efficiency (PCE) was calculated to determine the value of Lean application level at NAS. Measuring stage is the process of measuring and identification of waste occurring at every stage of production process. The occurrence of each waste was measured and classified using the approach of 7-waste classification and finally calculated by Pareto analysis [34].

Analysis on the mapping process of the whole series of biscuit production is illustrated by some activities that are classified as non-value-added activities and some value-added activities (**Tables 7 and 8**). Based on the time measure of the VA and NVA activities, the value of Process Cycle Efficiency (PCE) of 49.64% was obtained. The value of PCE is the result of division between Value Added Time and Total Cycle Time.

A company can be considered Lean if the ratio of value-to-waste ratio has reached a minimum of 30%; therefore, if the company is not lean and can be

Activity	Time(minute)
Preparation of flour material	5.0
Preparation of oil material	4.5
Preparation of packaging material	3.05
Weighing of other materials	11
Mixing process	20
Cutting & forming process	6
Baking process	4.5
Cooling process	5
Stacking process	7.8
Cream mixing process	10
Packing process	7.03
Cartoons process	4.8
Total	78.88

Table 7.
The value added process in the biscuit manufacturing for 3 month.

Activity	Time(Minute)
Lay time-dough	50.0
QC product check	30.0
Total	80.0

Table 8.
Non value added process in the biscuit manufacturing for 3 month.

categorized as a traditional company [8]. Because of the value of waste ratio is 36.7%.

- **Analysis Stage:** the definition and analysis of this stage is given as Determination of Critical to Quality (CTQ) and CPM value Critical to Quality. CTQ is a standardized or critical measure at every stage of production processes in order to produce quality products that meet the consumers' expectation in accordance with the capabilities of process technology available. Gazperzs [34] suggests that the characteristics of quality that will satisfy customers should first be identified. Here, the quality characteristics considered as critical should be classified and controlled. Each quality characteristic that has been classified should be determined to see whether it can be controlled through material, machines, work processes, and others control. CTQ standardization helps us to set up a maximum tolerance limit and a minimum tolerance limit. The values of USL and LSL are determining the process variation for each classified quality characteristic. They can also be used as signposts for product and process developments. According to the study by Hasan [35] stated that range of USL and LSL values is determined by the value of $\pm n$ sigma, and the Six-sigma approach (DMAIC method) is used as a reference in order to decrease waste or loss (**Table 9**).

As shown in **Figure 5**, the research found the values of six sigma calculation and enter the number defect observed is 5.25, enter the size of the sample are 78 and the defects per million (DPMO) of 67,308, and sigma of 3. This shows that the biscuit production of has a production capability with a failure of 67,308 every 1000,000 productions, or equivalent to 6.73% loss, and this indicates the production process still has a high failure rate. Also the research calculate DPOM, percentage of defect, percentage of yield, process sigma by process sigma calculator with inserting the number of defect observed and opportunities then automatically it calculate give result as we see above in the picture.

- **Improvement Stages:** this is the place where determination of FMEA is to be conducted and analyzed. A number of improvement steps were established at each stage of the existing processes from the preparation of raw materials, mixing, forming, baking, cooling, stacking and packing. Then, this stage tabulation was carried out on FMEA analysis. The FMEA method was used to determine the failure of the process and to analyze and improve the production quality [31, 36] (**Table 10**).

6.6 Qualitative result

Analysis on Baldrige model with six sigma methodology they state that “Baldrige provides the framework, Six Sigma the methodology.”

Process stage	Critical to quality (CTQ)	Measurement	LSL	Target	USL
Preparation of raw materials	Process 1	Kg	6	6.5	7.1
	Process 2	Kg	10	10.5	11.3
	Process 3	Kg	12	12.5	13.2
Mixing	Process 4	Kg	31.5	32	32.7
	Process 5	Kg	199.5	200	200.8
	Process 6	Kg	89.5	90	90.7
Forming	Process 7	Gr	19.5	20	20.7
	Process 8	Gr	17.5	18	18.8
Oven	Process 9	Mm	49.5	50	50.6
	Process 10	Mm	44.5	45	45.7
	Process 11	%	2.5	3	3.8
	Process 12	PH	8.5	9	9.7
Cooling	Process 13	Wt.	39.5	40	40.6
	Process 14	Wt.	9.5	10	10.6
Stacking	Process 15	Gr	29.5	30	30.6
	Process 16	Mm	34.5	35	35.8
Packing	Process 17	Gr	139.5	140	140.7
	Process 18	Gr	29.5	30	30.8
Factors			PPM - Cpk Calculator		
Parts per million above USL			150		
Parts per million below LSL			-50		
Total PPM			100		
Zupper			5.12		
Zlower			6.25		
Z (Sigma)			5.22		
Cp			1.74		
Cpk			1.71		

Table 9.
CTQ of biscuit production process in one line in NAS food plc.

The experience of Motorola with Six Sigma helped the company to won the Baldrige award in 1988. According to Sumberg [37]; Parast [1] the Six Sigma quality laid the foundation for Motorola to be the first company to win the Baldrige award. Such a link between the Six Sigma methodology and the Baldrige model exists in practice.

The MBNQA framework has extended its application beyond businesses. According to the studies, it has specific guides for Education and Health Care organizations [38, 39]. MBNQA seven categories are Leadership, Strategic Planning, Customer and Market Focus, Measurement, Analysis and Knowledge Management; Human Resource Focus; Process Management; and Business Results [3]. Leadership shows how upper management chiefs the organization and organization community. The strategic planning is also the organization establishment of plans to

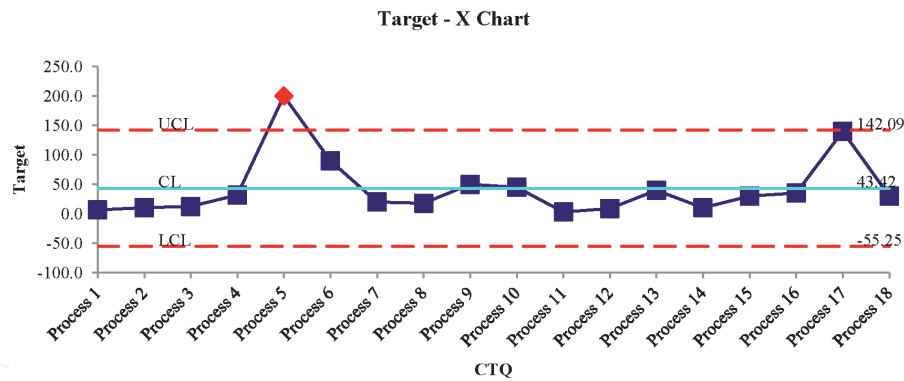


Figure 5. Control chart for UCL and LCL.

implement strategic directions. Customer and Market Focus is the organization that builds and maintains strong, lasting relationships within customers. Measurement, Analysis and Knowledge Management are also the organizations use of data to support key processes and manage performance while human resource focus is outlining of the importance of human resources. Process Management uses powerful tools like Continuous improvement program, Zero Defect, and Re-engineering. Continuous improvement recognizes that, even when no errors occur, there are opportunities to improve the design of the process or product. All the time, the competitors are seeking to gain an advantage by making their products better. If the companies do not seek to improve, it will get left behind. Company should expect to receive no complaints from customers. This goes beyond the idea of keeping complaints to a minimum. It indicates that the company should adopt a new approach, perhaps checking that each customer is satisfied with his purchase [40]. Finally, business results is an indication of the organization improve in terms of customer satisfaction, finances, human resources, supplier and partner performance, operations, governance and social responsibility and how the organization compares to its competitors.

6.7 Proposed continuous quality improvement model

The integration lean, six sigma and Baldrige model understand separately and define similarity and dissimilarity in each alignment some criteria are considered based on the literature review. These include: focus on work condition in addition to process, easily understandable and having proper metrics; addressing the possible root cause of continuous quality improvement problems; being continuous improvement tool; having clearly defined improvement goal; flexibility to apply from operation to firm level and involving all, including top management to low.

6.8 Feature of the proposed model

6.8.1 Applying six sigma in the lean philosophy

It is true that there is established link between Six Sigma methodology and the lean manufacturing with in the previous studies. The proposed integrative six sigma and lean manufacturing is based on the following basic pillar principles. These principles are:

- The Six-Sigma methodology is linked with the lean. It becomes part of the Lean six sigma (LSS) for achieving waste and defect reduction techniques.

Processes	Steps/ Inputs	Failure mode	Failure Effects	SEV	Causes of failure mode	OCC	Current control	DET	RPN
Biscuit making	Material preparation	Wrong ingredient	Inconsistent quality	10	Substandard material supplied by supplier	5	Undetectable	10	500
		No electricity power	Damaged dough	8	Main Distributor Panel Trip	6	No monitoring	10	480
		Blocking wheat at hopper	Line stop	7	Damaged Filter	6	No monitoring	10	420
Mixing Process	Mixing	Different usage of water between shifts	Unstable dough and waste	6	Differences in methods by operators	10	Controlling only after mixing is finished	6	360
		Frequently error censor	Down time and safety issue	6	Unstable socket pad	10	Alarm system of mixer is on	5	300
Forming Process	Forming	Product Tailing	Product jam	10	Uneven surface of blades	10	Checklist of forming	6	600
		Product Tailing	Product Jam	10	Loose molder Teflon	10	Visual control	5	500
Oven Process	Baking Process	Irregular thickness of biscuit	Unbalanced thickness of biscuits	10	Uneven weight among rows	10	Check list of intense monitoring	5	500
		Product Jam	One side of Wire mesh is loose	10	One side of Wire mesh is loose	10	Visual control	7	700
Cooling process	Cooler	Product is Excess Calm	More rejected products	10	Scrap was taken accidentally	10	Only Visual	5	500
Stacking process	Sandwich	Thin or thick biscuits	packing machine often starts or stops	10	Cream texture is different since the icing weight is different	10	No control/ monitor	10	1000
	Mixing cream	Unbalanced Cream	Waste/ thin or thick	10	Inaccurate balance or weighing scale	10	Inappropriate display	8	800
Packing Process	Product packaging	Broken Products	Dead machine, quality potential	10	No sorting tool of sandwich since taken accidentally to packing	10	Visual	10	1000
		Poor packaging material	Inconsistent quality	10	Substandard material supplied by supplier	6	No control	10	600

Table 10.
Improvement process 5) control stage: Plan to continue measuring the success of the updated process is usually created and any documentation, process or training material is updated.

- The lean self-assessment includes the assessment of each seven waste in the six-sigma (DMAIC).
- The proposed model for the integrative lean Six-Sigma is capable of addressing the core values of the lean. Areas such as overproduction, waiting time, unnecessary transportation, excessive or erroneous processing, excessive inventory, unnecessary movement and defect can be addressed by Six Sigma methodology.

6.8.2 Applying Six Sigma in the Baldrige Model

It has been established a link between six sigma methodology and the Baldrige model in similar fashion as six-sigma with leans. The proposed integrative six sigma and Baldrige model given in **Figure 6** is based on the following principles.

- The Six-Sigma methodology is linked with the Baldrige model. It becomes part of the Baldrige model which is considered as a single unit for achieving performance excellence. This performance analysis requirement is set by the top management. After the establishment of Baldrige model goals, Six Sigma methodologies are used to increase the processes and meet quality purposes.
- Six-Sigma projects can be applied to all types of the projects, processes, and products. Based on this application, the selection, administration, and control mechanisms were directed by the top management used in this proposed model.
- The proposed model for the integrative six-sigma-Baldrige Quality in **Figure 6** is capable of addressing the core values of the Baldrige model. Areas like

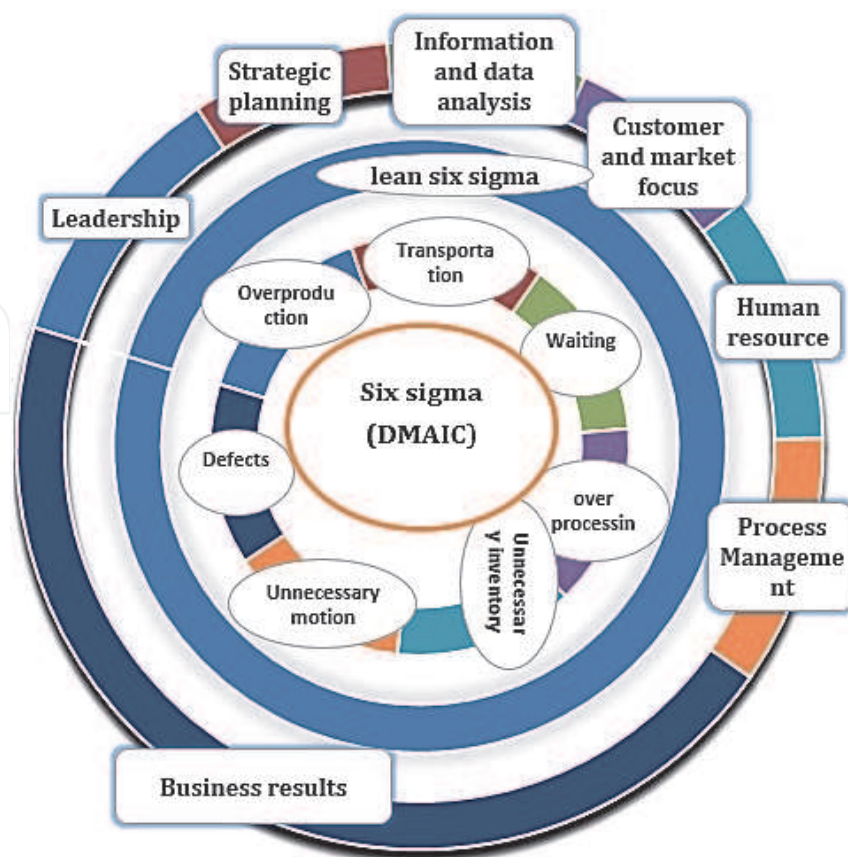


Figure 6.
Integrated lean-six sigma model.

leadership competencies, strategic development and deployment, and human resource management can be addressed by six-sigma methodology which is a powerful tool.

6.8.3 Applying six sigma in the Baldrige model and lean

We established a link between six sigma methodology and the Baldrige model also six -sigma and lean. The proposed integrative lean Six Sigma and Baldrige model is based on the following principles:

When lean, six sigma integrated with Baldrige model. In fact, it becomes part of Baldrige model for achieving excellence. Such a performance requirement is set by the top management. Afterward aligned with the requirement of the Baldrige model, lean and six sigma methodologies become used for improve the process and meet quality objective.

The Baldrige self-assessment includes both the assessment of each seven categories in the Baldrige model as well as the efficiency and effectiveness of the six sigma projects. Such an approach toward six sigma and lean projects ensures that the company is gaining benefit from implementing the lean- six sigma methodologies.

The proposed models for the integration of lean, six sigma with Baldrige is capable of addressing the core value of the Baldrige model and identify the seven waste of lean. Area such as leadership competencies, strategic development and human resource management can be address by six sigma methodology whereas for the integrative lean Six Sigma identifies such area overproduction, waiting time, unnecessary transportation, excessive or erroneous processing, excessive inventory, unnecessary movement and defect can be addressed by Six Sigma (DMAIC) methodology.

7. Conclusion

The conclusion of this research is that the waste minimization at NAS food Plc. as production process applying the lean process. In such cases, the standard DMAIC cycle may provide structure and ensure that each step is improve thoroughly, thereby helping the success of the project. Lean can contribute to these projects by staking out the direction; that is, indicating where to start, for example through the use of value stream mapping where the process is reviewed in order to find waste. Analysis on the mapping process of the whole series of biscuit production is illustrated by some activities that are classified as non-value-added activities and some value-added activities.

In this paper both qualitative and quantitative analysis are applied and the result of qualitative by using (DMAIC) based on the time measure of the VA and NVA activities, the value of Process Cycle Efficiency (PCE) of 49.64% was obtained. And the research found the value of waste ratio is 36.7%, this show non lean in the company and the values of six sigma calculation and insert the number defect observed is 5.25, the size of the sample are 78 and the result defects per million (DPMO) is 67,308 and sigma of 3. This shows that the biscuit production of has a production capability with a failure of 67,308 every 1000,000 productions, or equivalent to 6.73% loss, and this indicates the production process still has a high failure rate. And improve by using FMEA analysis was carried out each stage of the existing process used to determine the failure of the process and to analyze and improve the production quality and the result of highest RPN on Stacking and packaging process so they should take action for waste minimization and continuous quality improvement. In addition, Organizations try to implement the Baldrige

model as a means for achieving excellence. The seven categories within the Baldrige model is integrated and related with the purpose of addressing quality challenges so that companies can be competitive in the dynamic business environment.

In quantitative analysis used SPSS software and the Correlation and regression analysis is used to quantify the association between two continuous variables (between an independent and a dependent variable or between two independent variables). The result of this shown relationship of each variables in waste measurement perspective they have strong relation with significance level of 0.01 and the causal Pearson Correlation of most variable has a strong positive relation and their value is greater than 0.8, likewise The good regression results of equation is selected in each section which is explained R2 value about 0.9 or 90% with statistically significant ($P < 0.01$) level.

However, In this paper, relying on a review of the national and international literature, 25 key indicators was selected based on the correlation having strong 'r' value under four improvement perspectives were identified to assess measurement system of the organization. The Lean Six Sigma & Baldrige application studied here does not point toward one well-defined Lean Six Sigma approach; the company does not adopt any particular standardized approach to larger improvement projects. Instead, the company supports the integration at this level by ensuring that their improvement specialists are widely trained in Lean, Six Sigma and Baldrige model.

8. Recommendation

Further research is required for biscuit manufacturing in terms of waste minimization at each process stage using this DMAIC methodology. This study needs to be continued in terms of FMEA usage along with the development selection model for waste minimization and improving the production process. Instead, the company supports the integration at this level by ensuring that their improvement specialists are widely trained in Lean, Six Sigma and Baldrige model.

Similar research also should be conducted in order to provide added value in the fields of food or agriculture with the application of lean six-sigma and Baldrige model.

Conflict of interest

The authors declare no conflict of interest.

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