



**Arab American University
Faculty of Graduate Studies**

**Assessing the Statistical Process Control Implementation in
Palestinian Food Industries: An Empirical Study**

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**This thesis was submitted in partial fulfillment of the
requirements for the master's degree in
quality management**

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Thesis Approval

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Declaration

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**Assessing the Statistical Process Control Implementation in Palestinian Food Industries: An
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I declare that this thesis has been composed solely by myself and has not been submitted, in whole or in part, in any previous application for a degree, except where states by reference or acknowledgment that the work presented is entirely my own.

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III

Dedication

To

My mother and my father

My wife and kids

My brothers and sisters

For martyrs and prisoners

All the loved ones who contributed to
this achievement

Appreciation and love.

Acknowledgment

I want to express my great thanks to **God** Almighty for his generosity and grace in granting me the health and the ability to accomplish this thesis.

Fortunately, I am among the few who have had the honor of being a student of the supervisor whom the more you learned from him, the more you wanted, the teacher who taught us to act morally and honestly above all.; **Dr. Yahya Salah**, thank you for inspiring, supporting, guiding, and correcting me through my journey of preparing my thesis. I will never forget every piece of advice, comment, and word you gave me.

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My heartfelt gratitude to **my wife and my father** for their continuous support and motivation.

Last but not least, my sincerest appreciation to **my family** for their endless encouragement and support.

Abstract

The study assesses the degree of implementing statistical process control (SPC) in the Palestinian food industry following a descriptive-analytical research work. The food industry occupies a vital position within the Palestinian industrial sector and is considered a pillar for potential economic growth. The benefits of implementing SPC tools are well documented in the literature; however, little is known about implementing SPC among Palestinian manufacturers. To achieve the purpose of this thesis, regarding the extent to which SPC tools are applied in Palestinian food factories, we analyze the collected data from a sample of 65 Palestinian food companies. According to the Palestinian Federation of Food Industries, 75 companies operate formally in the West Bank and represent the research population. Their products are mainly foodstuff and beverages, which number. The partial least squares structural equation modeling (PLS-SEM) method was used to analyze the collected quantitative data.

The study reveals several essential results; surprisingly, only 55% of the targeted companies do not implement SPC tools. Several challenges face the Palestinian food companies in deploying and implementing SPC. These obstacles include the poor quality culture as a supreme value in the work environment, the prevalence of old machines, and the lack of training. Driven by the literature, the proposed model suggests four drivers for SPC implementation: managerial actions, audit and review, process approach, and decision making. Results show that audit and review, and decision-making functions are significant drivers for better SPC implementation within the study's settings. Several recommendations have been reached. The Palestinian Food Industries Federation is recommended to raise awareness of SPC benefits among members. Managers may focus on training technical staff on SPC, continuously calibrating machines, and examining raw materials before receiving them. Improving inputs increase the likelihood of conformity with specifications. Finally, the study clarified the limitations of this research work, the most important of which was that participants perceived SPC as an advanced tool. This thesis employs a quantitative method, better understanding, and

explores the influencing factors that could be achieved when conducting aqualitative research in future research.

Keywords: Statistical process control (SPC); Quality; Palestinian Food Industry; Challenges, Implementation.

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List of Abbreviations

AVE	Average Variance Extracted
CI	Continuous Improvement
CR	Composite Reliability
CSF	Critical Success Factors
DOE	Design Of Experiment
EVOP	Evolutionary Processes
F ²	Effect size
GDP	Gross Domestic Product
GMP	Good Manufacturing Practice
GoF	Goodness of Fit model
HACCP	Hazard Analysis Critical Control Point
HTMT	Hetertrait-Monotrait Ratio
ISO	International Organization for Standardization
JUSE	Union of Japanese Scientists and Engineers
LCL	Lower Control Limit
MAS	Palestine Economic Policy Research Institute
MoNE	Ministry of National Economy
PA	Palestinian Authority
PCBS	Palestinian Central Bureau of Statistics
PFIU	Palestinian Food Industries Union
PLS-SEM	Partial Least Square Structural Equation Modeling
PSI	Palestine Standards Institution
Q ²	Coefficient of determination
R&D	Research and Development
R ²	Predictive Relevance
SPC	Statistical Process Control
SPSS	Statistical Package for the Social Sciences
SQC	Statistical Quality Control
TQM	Total Quality Management
UCL	Upper Control Limit

Chapter One

Introduction

1.1 Overview

This chapter manifests a background of the research in the first section; the following sections address the problem statement, aim, and objectives, the significance of the study and the research questions and proposed hypotheses to be evinced. The thesis structure is presented in the last section.

1.2 Background

Rapidly-changing economic and market environments make it ever more important for businesses to meet their customer's needs. Reducing costs, innovating every aspect of their company's operations, and continuously improving their products, services, and process performance are relatively crucial. It is impossible to inspect or test the quality of all the goods, so the products must be manufactured right first time. All those involved in the process (including operators, engineers, quality control and managers) must be able to monitor the state of process performance and reduce variability in key parameters to ensure processes remain statistically stable (Sargut & Demirörs, 2006). Furthermore, the quality system must address the technical and soft aspects of quality improvement, facilitating continuous improvement (CI) in every aspect of business operations if the company remains competitive. On-line statistical process control (SPC) is widely used across the manufacturing sector, though not so far in the food industry (He et al., 2002). The foundation of this technique is coming from a solid statistical theoretical background of the control chart, which has been proven until now; it has not changed since it was introduced.

In today's complex and dynamic business world, organizations are expected to perform well in their line of business to stay competent and profitable. This study shows how SPC can help organizations improve the quality of their products. Quality is a concept whose definition has changed over time.

The traditional definition of quality is based on the viewpoint that products and services must meet the requirements of those who use them. In the past, “Quality means fitness for use” (Oakland, 2014). That is, if output falls within acceptable limits, called specification limits, around the desired value, called the target value, it is deemed conforming or acceptable. We refer to this as the 'objective' definition of quality; as Deming defined it 'Quality should target customer needs, present, and future (Oakland, 2014). The totality of a product or service's features and characteristics depends on its ability to satisfy stated or implied needs (Prasad et al., 2017). Quality has become one of the most important consumer decision factors in selecting competing products and services (Montgomery, 2005). Therefore, quality leads to business success and growth, increases competitiveness, and improves the work environment. Understanding and enhancing quality are key factors leading to business success, growth, and enhanced competitiveness. According to Montgomery (2005), quality improvement reduces variability in processes and products. Quality control and improvement involve the set of activities used to ensure that the products and services meet requirements and are improved on a continuous basis. Variability is often a major source of poor quality, statistical techniques, including SPC is the major tool of quality control and improvement.

Food manufacturers are interested in increasing the quantity of production and reducing the quantity of defective products to develop the industry and increase profits. More specifically, some of the SPC tools in the food industry include introducing new methods and techniques, developing new processes, adopting new techniques in production, and the control of lower and upper limits (Toledo et al., 2017). SPC is one of the manufacturing industry's most widely used techniques for process control and improvement. Still, very few studies have reported the successful application of SPC in the food industry, so SPC is an effective technique for improving process performance in manufacturing companies (Lim, 2016). This study assesses the implementation of different SPC tools in Palestinian food industries.

1.3 The Research Problem

It was noted through the literature review that the application of SPC posed a challenge to food companies because it not only requires the creation of control schemes but also the implementation of a series of projects to monitor, control, and improve the performance of their operations. Therefore, previous studies looked at the main factors for successful implementation. However, the food industry sector is one of the most crucial manufacturing industries contributing to numerous economic indicators in Palestine. More specifically, the Palestinian manufacturing industries contribute approximately 17.6 % to the gross domestic product (GDP). Specifically, the food industry is the oldest, producing a wide variety of products, contributing about 22.2 % to the manufacturing industry and approximately 4% to the GDP (Palestinian Central Bureau of Statistics [PCBS], 2017). This indicates the substantial importance of the Palestinian food industry sector in its contribution to economic growth.

The quality of food products is a key issue since food products are directly related to human health and safety. Thus, considerable attention has been given by the Palestinian Authority (PA) to this industry to control the quality of food various products. On the other hand, this sector is becoming more attractive for investors, as the percentage of household spending is estimated at approximately 31% of all living expenses (PCBS, 2017), which emphasizes the significance of this sector in producing high-quality food products and thus there is a high need for more competitive industry. According to the Palestinian Food Industries Union (PFIU), the total investment in the food sector is estimated at approximately \$580 million (PFIU, 2018).

By the end of year 2017, the number of Palestinian food manufacturers that have a registration from Ministry of National Economy (MoNE) was 3038, employing nearly 17583 workers, representing 18.5 % of the total employment in the Palestinian manufacturing industry (PCBS, 2017). Consequently, this industry leads other industries in workforce employment and utilization.

Over the last years, specifically during the period (2010-2017), it was noticed that the food industry's market share has declined, despite the increase in production. This decline could be attributed to the increased competition with the imported food products, especially Israeli products and other regional sources (e.g., Turkey and Egypt). In addition to increasing export-oriented production in some of the sub-industries, particularly meat products. Thus, the food industry is considered the second major exporter after the stone and marble sector (PCBS, 2017).

One of the most pressing issues facing the food industry is the unfair competition with Israeli products due to smuggling food products that invade the local market and local products from Israeli settlements, regardless of their compliance with Palestinian technical regulations. This situation has negatively affected the competitiveness of Palestinian food products. Meanwhile, among Palestinian consumers, the perceived quality of Palestinian products lags behind the perceived quality of Israeli products. In light of this unfair competition environment and the poor quality perception of Palestinian food products, the Palestinian food industries encounter a real and big challenge that threatens their sustainability in the local and global markets (PFIU, 2018).

Aside from the competitive environment, the food industry confronts many challenges; high cost of raw materials, high cost of exporting due to the barriers to entry into new markets, and limited access to international markets. Moreover, the inability of the local market to absorb all local production, especially during the changeable financial and economic situation in Palestine. According to a study conducted by Palestinian Economic Policy Institute (MAS) in the year 2019, food industry sector encounters many challenges related to the internal productive environment that negatively affect the competitiveness of this industry such as; limited research and development (R&D) activities, ineffective implementation of large number of food manufacturers for the quality control systems, and lack of professionalism and required technical skills ((MAS), 2019).

These challenges force food manufacturers to deploy total quality management (TQM) to increase effectiveness, efficiency, and productivity. Many food manufacturers adopt TQM as a comprehensive strategy for improving productivity, profitability, customer satisfaction, enhancing competitiveness in local and international markets, and increasing their export capacities (Kristianto et al., 2012).

To achieve the standards of quality, health, and safety, some of food manufacturers in Palestine have acquired the Palestinian quality marks (PS), international organization for standardization (ISO) certificates in food safety, good manufacturing practice (GMP) and hazard analysis critical control point (HACCP).

On-line SPC is widely used for this purpose across the manufacturing sector, though not so far in the food industry sectors (Fotopoulos & Psomas, 2009).

1.4 Aim and Objectives of the Research

Many scholars have studied the impact of the successful application of SPC in the food sectors. Based on the previous results, the following question was asked: "*Does applying statistical process control (SPC) in the Palestinian food industries contribute to improving the manufacturing process?*" The purpose of this study is to address this question by examining the relationship between SPC and reducing the percentage of defective products. Indeed, examining the relationship between SPC and reducing the percentage of defective products. To reach this aim, the following research objectives have been developed:

1. To assess the prevalence of SPC implementation in the Palestinian food industry.
2. To determine the barriers to SPC implementation in the Palestinian food industry.
3. To develop a conceptual framework for implementing SPC tools in the Palestinian food industry.

1.5 Significance of the Research

The importance of this research lies in ascertaining the possibility of SPC tools playing an important role in the development of the food industry sector. The food industry in Palestine has a high competitive potential, and Palestinian industries are constantly improving their products.

Food industry sector is one of the most crucial manufacturing industries that contributes to numerous economic indicators in Palestine. More specifically, the Palestinian manufacturing industries contribute approximately 17.6 % to GDP. Specifically, food industry is the oldest industry producing a wide variety of products contributing approximately 22.2 % to the manufacturing industry and about 4% to GDP (PCBS, 2017). This indicates the substantial importance of the Palestinian food industry sector in its contribution to economic growth.

Food businesses are under increasing pressure to transform their manufacturing practices to survive and thrive in the local marketplace, as the food industry has less scope for growth due to a limit on consumer intake capacity. Therefore, this sector critically depends on the quality improvement of the product continuously (Lim, 2016).

The low level of research and development is a major problem that must be addressed to enhance the industry's ability to successfully implement SPC to achieve the sustainability of a competitive economy. In addition, the lack of cooperation between the industrial sector, research and development institutions, and higher education institutes hamper Palestinian industrial manufacturers' effectiveness in SPC application. On a macro level, all these industry challenges are forcing manufacturers to implement SPC. Hence, it is highly recommended to launch competing products and adopt new technologies in operational processes to meet the changing needs of consumers.

At the micro level, in terms of the in-house operating environment, traditional techniques in manufacturing and minimal R&D negatively affect competitiveness and thus earnings and profits,

which poses an urgent need to take advantage of SPC implementation to enhance cooperation between operators.

1.6 Research questions and hypothesis

This research aims at answering the following questions:

1. To what extent are SPC tools are applied in the Palestinian food industry?
2. What factors critically inhibit and facilitate the SPC implementation in the Palestinian food industry?
3. What is the proper conceptual framework for implementing SPC tools in the Palestinian food industry?

In this research, a set of hypotheses was formulated to find the relationship between the dependent variables represented by the SPC tools implementation in the Palestinian food industry and the independent variables represented by the factors affecting the implementation of SPC.

The following null hypotheses that are related to the study's questions were developed to be investigated in this research:

- First null hypothesis (H1): Management action has no significant impact on SPC implementation in Palestinian food industries.
- Second null hypothesis (H2): There is no significant impact of the process approach on SPC implementation in Palestinian food industries.
- Third null hypothesis (H3): Decision-making has no significant impact on SPC implementation in Palestinian food industries.
- Fourth null hypothesis (H4): There is no significant impact of auditing and review of SPC practices on SPC implementation in Palestinian food industries.
- Fifth null hypothesis (H5): There is no significant impact of quality obstacles in the company on SPC implementation in Palestinian food industries.

1.7 Thesis Structure

This research includes six chapters. Chapter two reviews the existing literature and its basic concepts, it consists of the definition of controlling the process and the types of tools used in industries of various kinds. Then few previous studies and their success factors and the limitations they faced were presented. Chapter three summarizes the methodology used in conducting the study, including in its detail how the research was designed, sampling procedures, data collection methods, types of this data, and methods of data analysis used, and ended with a brief illustration of the "smart- PLS" package which was used to analyze the data to investigate the relationships between the study variables. Chapter four presents the results of the data analysis, where the first section consists of descriptive statistics of the population profile of respondents, the demographic profile of respondents and the main constructs of the study. Then, the final section of this chapter contains the analysis of the collected data and testing of the proposed relationships through partial least squares structural equation modeling (PLS-SEM).

The fifth chapter discusses the results of data analysis and the results of hypothesis testing; then presents the theoretical and practical implications of the research study. While the last chapter contains the conclusions and recommendations of this study and finally addresses the limitations in which the possible future works were done.

Chapter Two

Literature Review

2.1 Background

This chapter outlines relevant previous studies. The first section explains the theoretical background, including SPC in terms of definition and the tools used. The next section deals with the relationship between inspection and SPC. Concerning the application of SPC, as well as the benefits, obstacles, and then critical success factors and limitations that were on previous studies in the last section.

2.2 The Concept of Statistical Process Control (SPC)

2.2.1 Definition and History

SPC was defined by Montgomery (2020) as a powerful and extensive set of problem-solving tools that contribute to process stability and capability improvement through variance reduction. The primary objective of SPC implementation is to identify and reduce variances of specific causes of process stability. SPC is an analytical tool used in decision-making that allows you to know when a process is working correctly and when it is not. Variation is present in any process, and determining when a change is normal and when it needs to be corrected is key to quality control.

The primary role of SPC is to prevent rather than to identify product or process degradation, but Xie & Goh (1999) suggested its new role in effectively identifying process improvement opportunities. The main tools in SPC are control charts. A control chart is a graphical way of displaying control results and evaluating whether a measurement procedure is under control or out of control; where control charts are used to monitor the process and reduce variance. This is done through continuous process monitoring (Jensen et al., 2006).

SPC was first developed by Dr. Walter Shewart in the 1920s when he joined Western Electric to help an engineering team improve the quality of their telephone equipment. This technique gained

popularity after World War II (1945) and in the 1980s the US Army used new sampling techniques to check their equipment. SPC was also adopted by other American industries such as the automotive and semiconductor industries, which had to stand up to high-quality competition from Japan (Benneyan et al., 2003).

Numerous and comprehensive attempts have been made to extend the concept of SPC beyond process control technology and accordingly, SPC has been categorized into several types of topics, such as:

1. Operations management technology (Bissell, 1994).
2. Control Algorithm.
3. A component of TQM.
4. One of the quality management systems in the food industry (Caswell et al., 1998).

A product must generally be produced through a stable or repeatable process if it meets or exceeds customer expectations. In clearer terms, the process must be able to operate with little change around the objective or nominal dimensions of the product's quality characteristics (Lim, 2016). SPC methods extend the use of descriptive statistics to monitor product and process quality. Using the statistical control of the process, we want to quantify the normal variance. Then we monitor the production process to ensure that production remains within the normal range. That is, we want to ensure that the process is controlled. The most widely used tool for production process control is the control chart. Various types of control charts are used to monitor different aspects of the production process (Benneyan et al., 2003). A control chart is a graph that shows whether a sample of data falls within the range of normal variation. The control chart includes upper and lower control boundaries that separate customizable causes of variance. The control scheme consists of a central line, an upper console, and a lower console. Characteristic values plotted on the graph representing the state of the process. If all these values are plotted within the control limits without any particular trend, the process is considered to be in the controlled state; otherwise, it is out of control (Lim, 2016).

2.2.2 Statistical Process Control (SPC) versus Statistical Quality Control (SQC):

SPC is the application tool to control process inputs (independent variables). However, SQC is the application of statistical and analytical tools to monitor process outputs (dependent variables).

2.3 SPC Tools

Based on the definitions of SPC discussed in the previous section, it is assumed that the tools related to SPC are broad and comprehensive enough to include all statistics-based techniques starting from random sampling to the very sophisticated design of experiments (Montgomery et al., 2011). There is no standard set of tools within the SPC. However, Gaafar & Keats (1992) and Duffuaa & Ben-Daya (1995) argue that there is general agreement on the seven tools, including data collection, flow chart, check sheets, Pareto diagram, cause and analysis effect, scatter plot, histogram and control chart. However, it is generally agreed that a control scheme is an essential tool within the SPC.

Arguably, the SPC is more involved than sports literacy issues. According to Rungtusanatham et al. (1997), the term SPC implementation requires a clear understanding of the procedures to be adopted and the activities to be undertaken using a set of tools that refer to participatory management. Therefore, this argument is supported by the implications of the dual concepts of SPC, the statistical control process” and the “statistical control case” proposed by Shewhart & Deming (1986). There is an urgent need to develop dedicated food industry guidelines to apply and systematically integrate all these tools into the right problem. In 1974, Dr. Kaoru Ishikawa compiled a set of process improvement tools into his Quality Control Textbook. Ishikawa developed seven basic quality tools so that the average person can analyze and interpret data without needing experts (Neyestani, 2017).

2.3.1 Flow Charts

A flow chart is a diagram showing the development of something through different stages or processes. A flow chart is a pictorial representation that shows all the steps of a process (Shakil et al., 2013). The main purpose is to understand the process flow and improvement process, communicate

with others about how the process is conducted and document the process. It is based on the principle of brainstorming activities (Srikaeo & Hourigan, 2002). Figure (2-1) shows an example of flow chart.

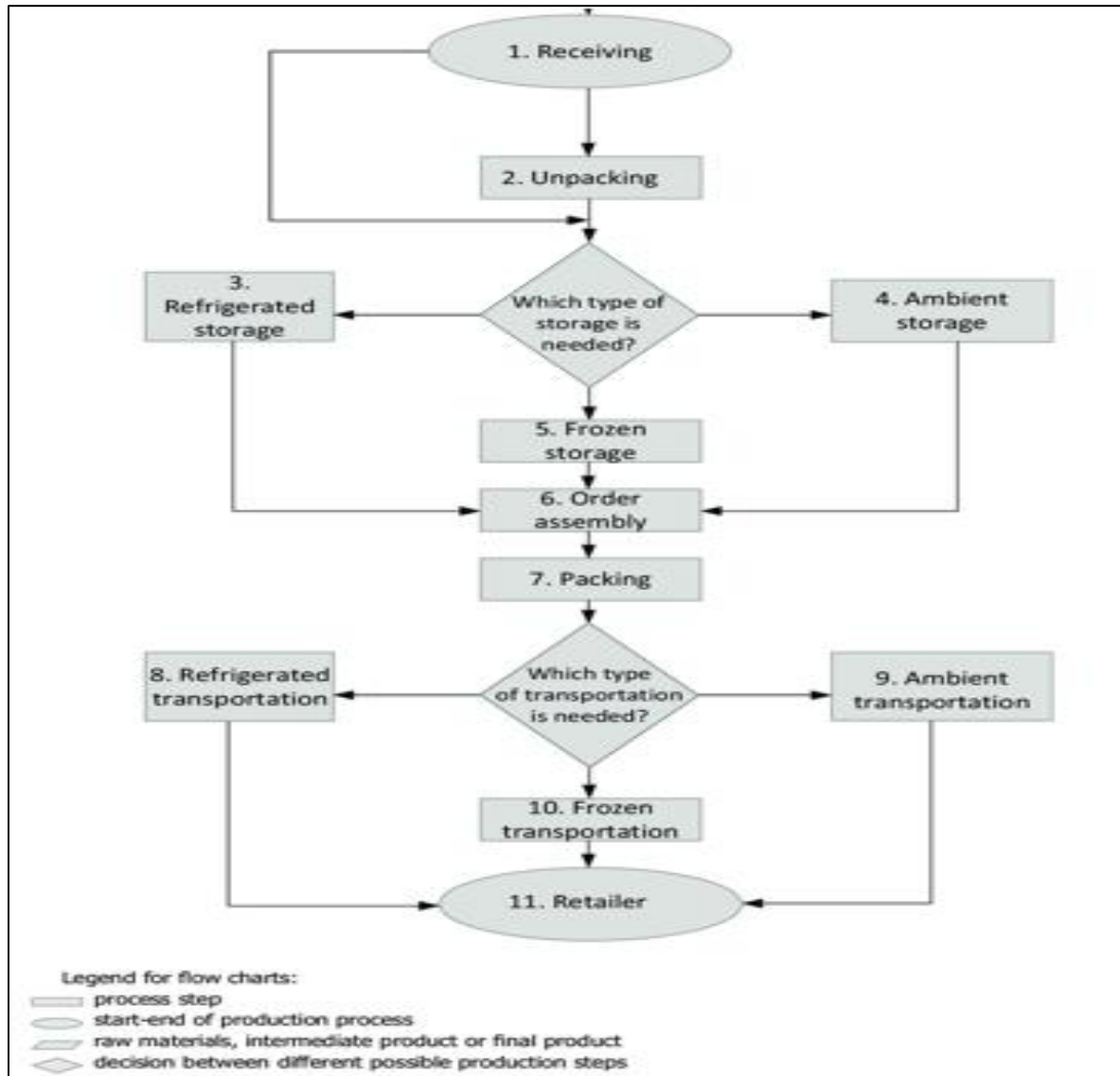


Figure (2-1): A Flow Charts (an example)

2.3.2 Check-Sheets

A form has already been printed in which quality characteristics are checked so that data can be easily collected. It is used to calculate the occurrence of defects or causes which are addressed by the graph as shown in Figure (2-2). Therefore, the check sheet is a powerful tool for data logging (Leavengood & Reeb, 2002). The main purpose is to provide a simple means of logging data and to enable the

analyst to determine the relative frequency of occurrence of different categories of data and depends mainly on brainstorming activities.

Name of the operator -		Date -				
Location -		Section -				
Defect Types	No of occurrences					Total
	Mon	Tue	Wed	Thu	Fri	
Bottles broken	II				III	5
Cap loose		II		I		3
Missing label	III		II		I	6
Dirt	I		II	II		5
Wrong order		III	I	II		6
Damage while packaging	II		II		II	6
Total	8	5	7	5	6	31

Figure (2-2): A Check-Sheets (an example)

2.3.3 Pareto Charts

A Pareto chart was first developed in 1906 by the Italian economist Vilfredo Pareto, and then applied by Joseph Juran in the classification of quality problems. The Pareto Principle, also known as the 80/20 rule, states that “few vital causes” of the 20% is responsible for producing most of the 80% (many minor problems) (Grosfeld-Nir et al., 2007). It is used to discover problems by classifying them, showing their repetition in the process, and prioritizing them. Pareto charts allow the user to focus on some critical problems in the process and make it easy to see which of the many problems have the most severe impact on quality, productivity, cost, safety, morale, and delivery time. The primary purpose of this tool is to prioritize the order of the data, in descending order, from the highest frequency of facts to the most frequent occurrence of laws. Whereas the basic principle of 80/20, as

pointed out by Varzakas & Arvanitoyannis (2007) is based on the need to focus first on 20% of the important causes without completely ignoring the remaining 80% as shown in Figure (2-3).

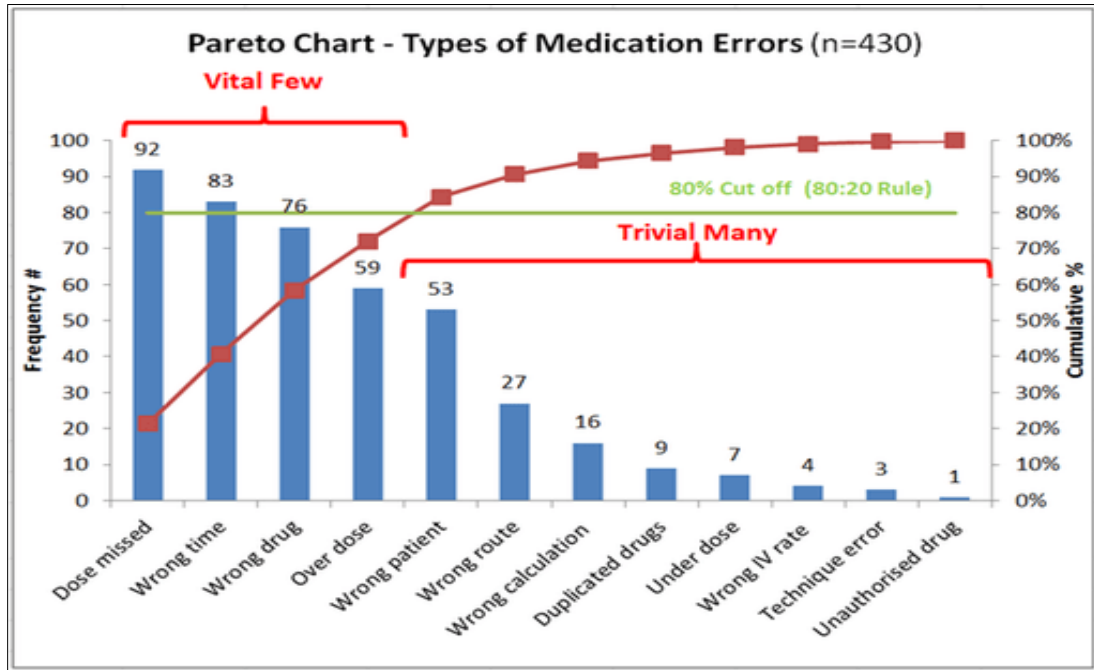


Figure (2-3): A Pareto Charts

2.3.4 Cause-and-Effect Diagram

It is sometimes called the Ishikawa diagram because Dr. Ishikawa invented it in 1943. It is also called a fishbone diagram because it resembles a fish bone. A cause-and-effect diagram is a tool that identifies, categorizes, and displays the likely cause of a particular problem or outcome. It is mainly used to capture and arrange all possible causes without supervision or forgetfulness (Ahmed & Ahmad, 2011). It allows to see many factors simultaneously, and everyone can use it. An image of lines and symbols is designed to represent a meaningful relationship between effects, cause, and effect (characteristics that need improvement) on the right and causes on the left, as depicted in Figure (2-4). The main purpose is to identify possible causes of the problem, detect differences in processes, and determine where and why the process is running. Based on the principle of defining all possible relationships between input and output variables, there are six categories of the following skeleton

(machines, methods, materials, manpower, measurements, and environment (Varzakas & Arvanitoyannis, 2007)

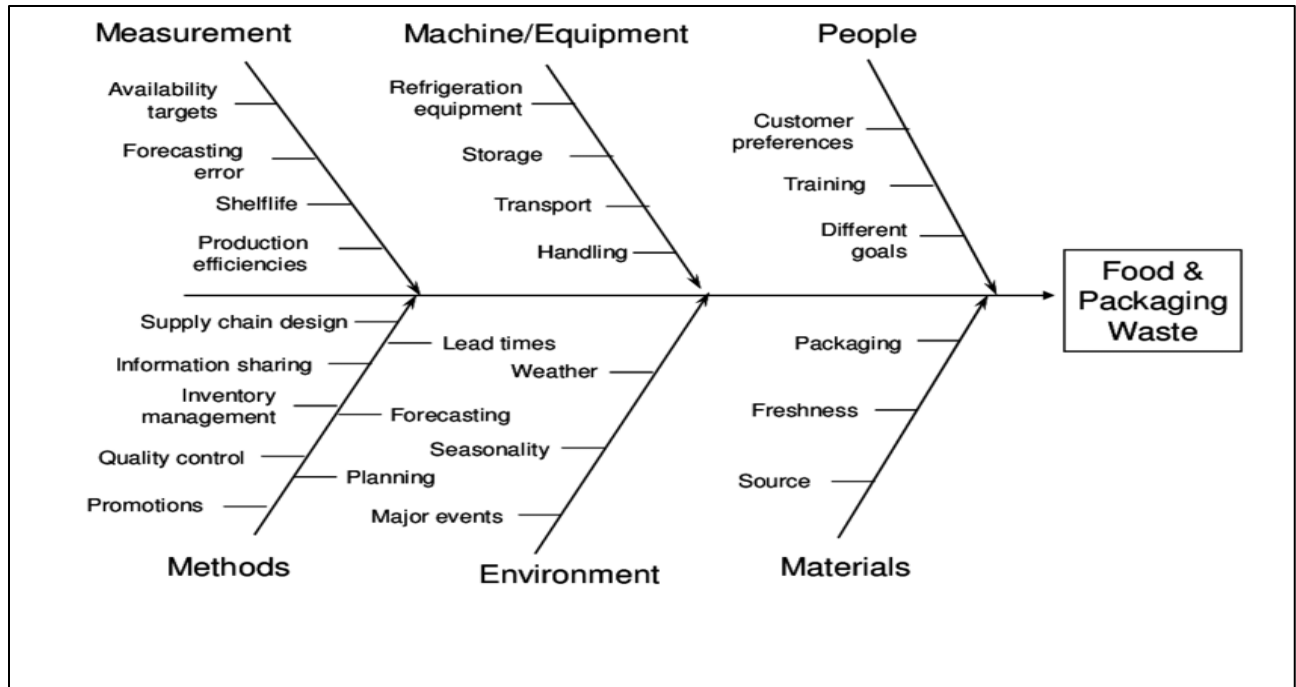


Figure (2-4): A Cause-and-Effect diagram

2.3.5 Scatter Charts

The scatter diagram shows the correlation between two variables in a process. Its purpose is to determine if there is a correlation between paired data sets to determine which association between a quality characteristic and the factor that may affect it. If the variables are correlated, the points lie along a line or curve, and the better the correlation, the tighter the points hug the line (Koutras et al., 2007). It is based on the principle of clarifying the results of a series of experiments applied to document the relationship between variables, as shown in Figure (2-5).

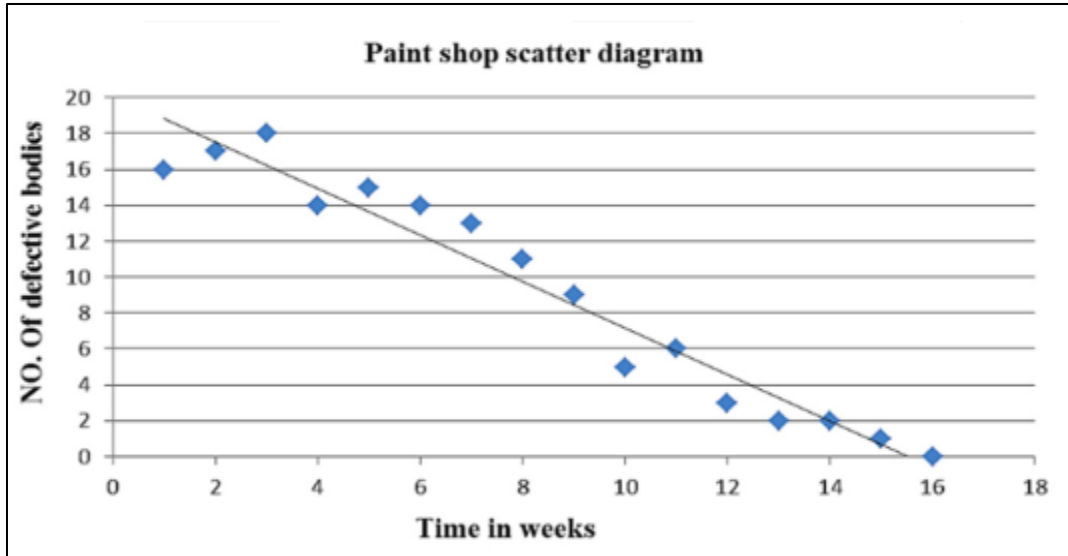


Figure (2-5): A Scatter Charts

2.3.6 Histogram

Histograms are the most commonly used tool for showing frequency distributions over appropriate time intervals and are ordered by magnitude (Jagadish et al., 1998). It is helpful in studying the distribution patterns or the distribution shape and comparing it with the specifications or standard values. A histogram organizes the collected data in an easy-to-understand manner, as illustrated in Figure (2-6). The primary purpose is to clarify and define the distribution of observations from a data set. It is based on the principle of a graphical representation of the process frequency in points or a category representing a group of data points (Ooi & McFarlane, 1998).

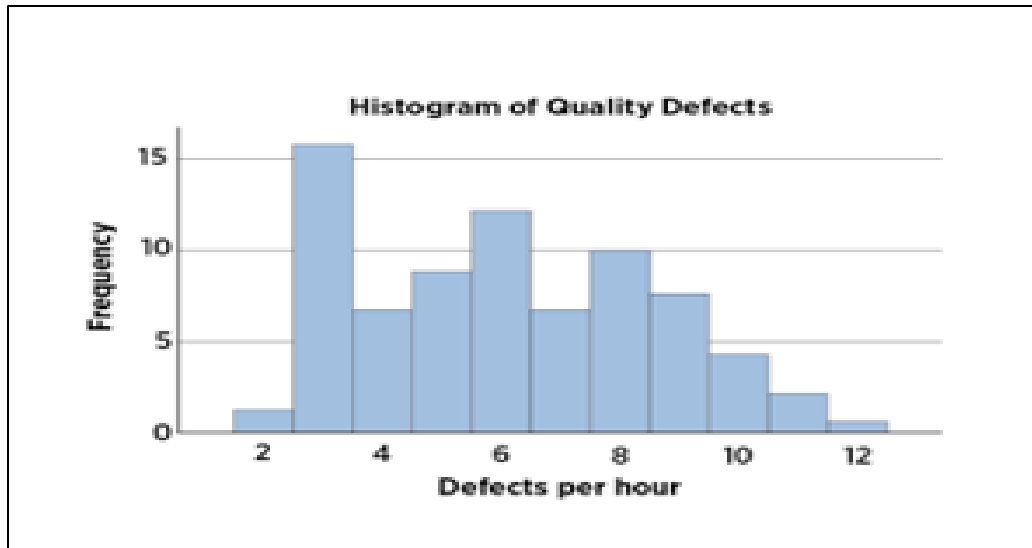


Figure (2-6): A Histogram

2.3.7 Control Charts

A control chart is a graph used to study how a process changes over time. It is used to analyze the process and determine if the process will treat a product with consistent measurable properties (Woodall et al., 2004). The control chart always has a center line for the mean, an upper line for the upper bound of the control and a lower line for the lower bound for the control, and these lines are determined from the historical data. By comparing the data in these lines, you can draw conclusions about whether the process is under control or unpredictable. While the main purpose is to study process changes over time, to control ongoing processes by finding and correcting existing problems, to predict the expected range of outcomes from the process, to determine whether the process exists, to analyze evidence of process variation from special causes or common causes, whether it is a project quality improvement should be to prevent spasm problems or to make fundamental changes to the process. It is based on the graft principle of sequentially plotted process characteristics and includes the process average computed for statistical control limits (Grigg & Walls, 2007). Figure (2-7) is an example of a control chart. If your process is in control, then.

- 99.73% of all the data points will be inside those lines or no sample points outside limits.
- Most points are near process average.

- An about equal number of points above and below center line points appear randomly distributed.

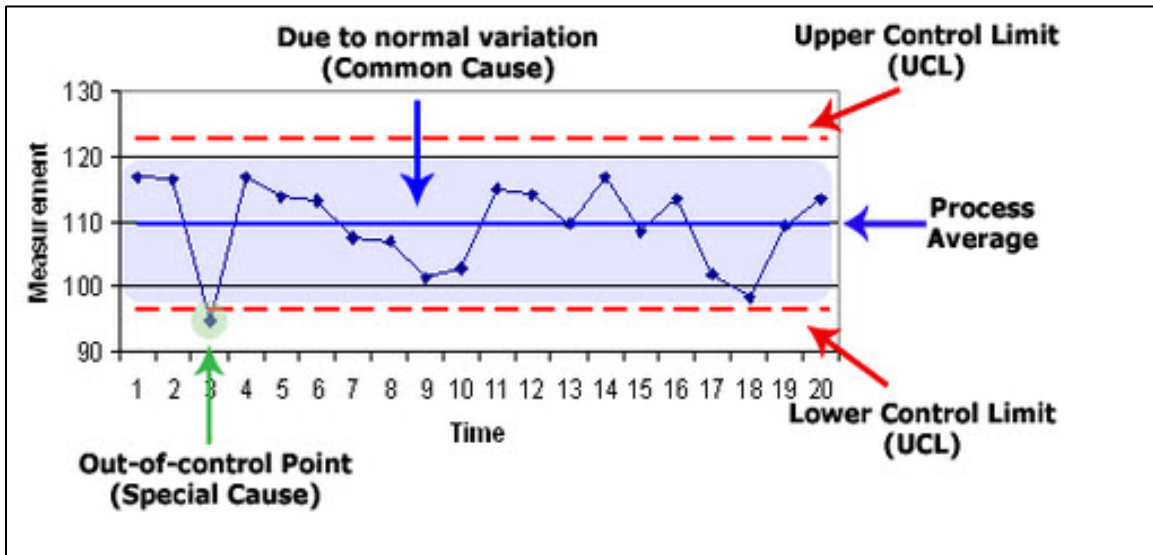


Figure (2-7): A Control Charts

2.4 The Seven New Quality Control Tools:

In 1976, the Union of Japanese Scientists and Engineers (JUSE) saw the need for tools to promote innovation, communicate information, and successfully plan major projects (Aichouni, 2007). A team researched and developed these seven new quality control tools, often called the seven management and planning tools or simply the seven management tools (Mizuno & Bodek, 2020):

2.4.1 Affinity Diagram

It allows the team to creatively generate many ideas and then organize and summarize the natural groupings among them to understand the core of the problem and propose solutions. Figure (2-8) presents an example of an affinity diagram.



Figure (2-8): An Affinity Diagram

2.4.2 Interrelationship Diagram

It shows cause-and-effect relationships and helps analyze the natural links between different aspects of a complex situation. Figure (2-9) gives an illustration of an interrelationship diagram.

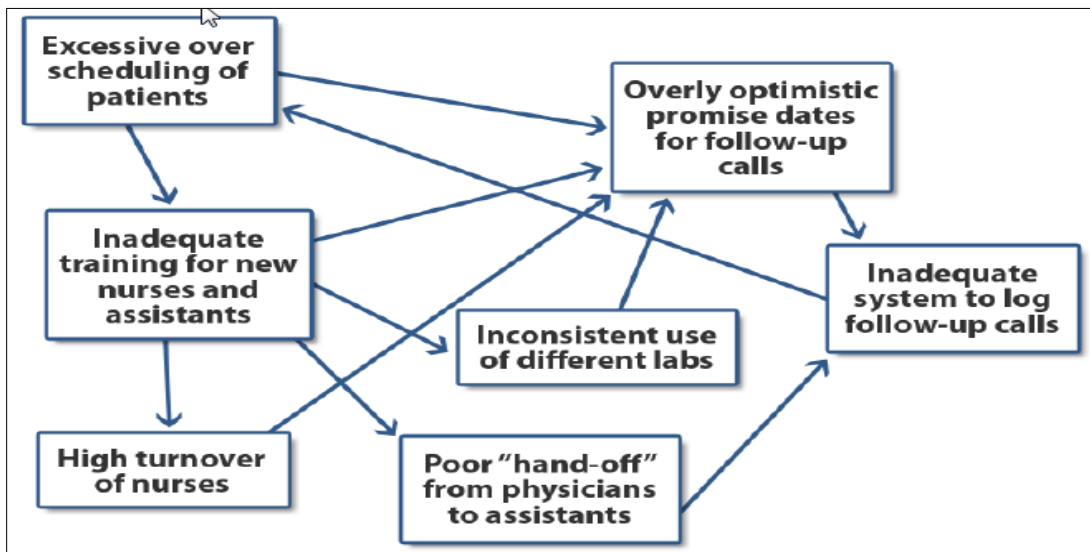


Figure (2-9): An Interrelationship Diagram

2.4.3 Tree Diagram

It breaks down broad categories into finer and finer levels of detail, helping to move step-by-step thinking from generalities to specifics as depicted in Figure (2-10).

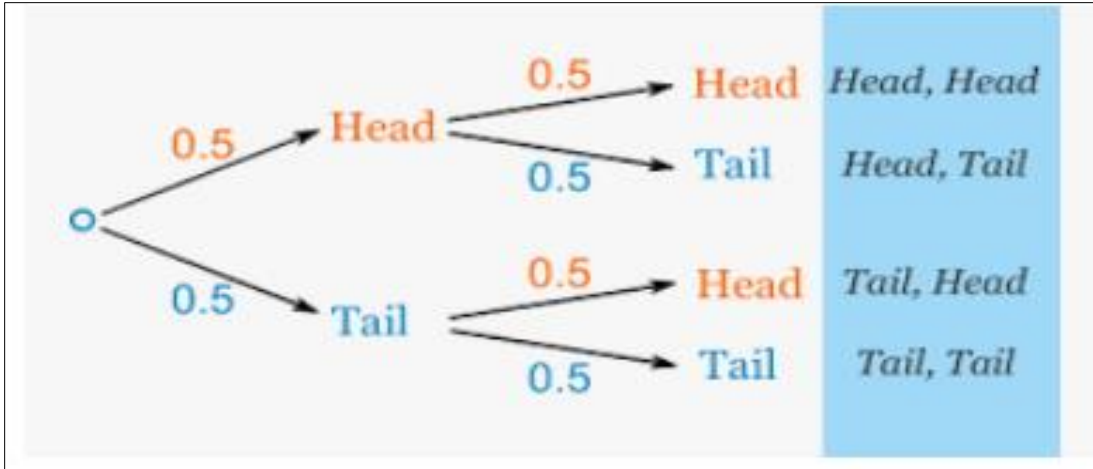


Figure (2-10): A Tree Diagram

2.4.4 Matrix Diagram

It shows the relationship between two, three, or four information groups. It can give information about the relationship, such as its strength, the roles played by various individuals, or measurements, as shown in Figure (2-11).

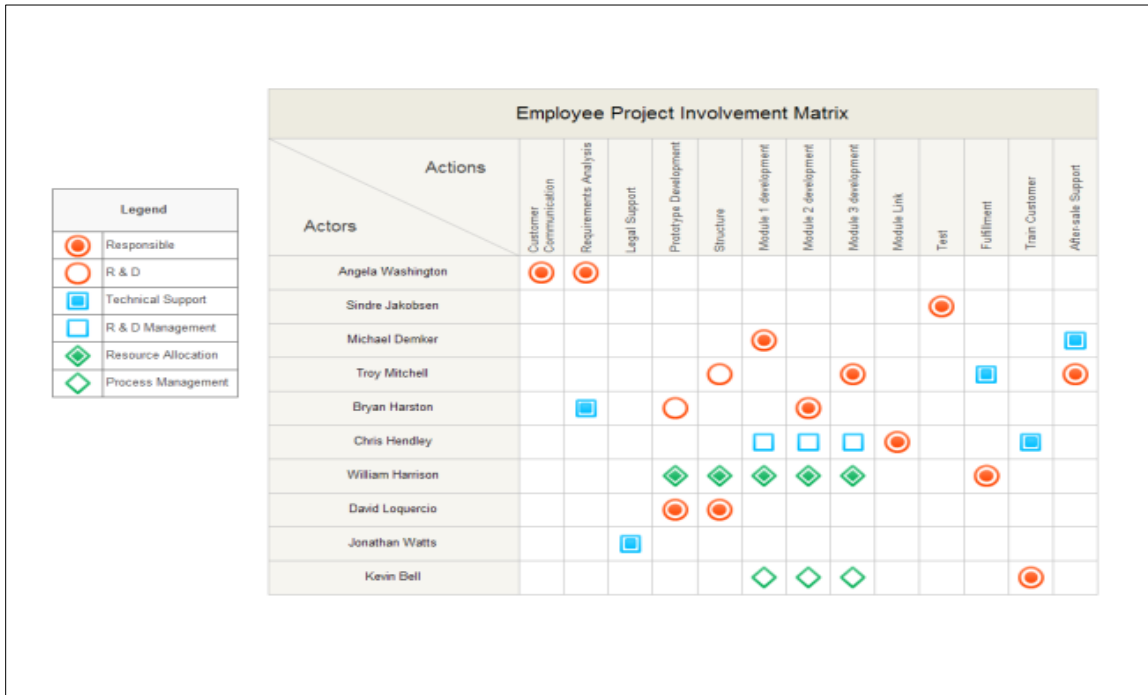


Figure (2-11): A Matrix Diagram

2.4.5 Matrix Data Analysis

A complex mathematical technique for analyzing matrices, often replaced by the similar prioritization matrix. A prioritization matrix is an L-shaped matrix that uses pairwise comparisons of a list of options to a set of criteria in order to choose the best option(s) as shown in Figure (2-12).

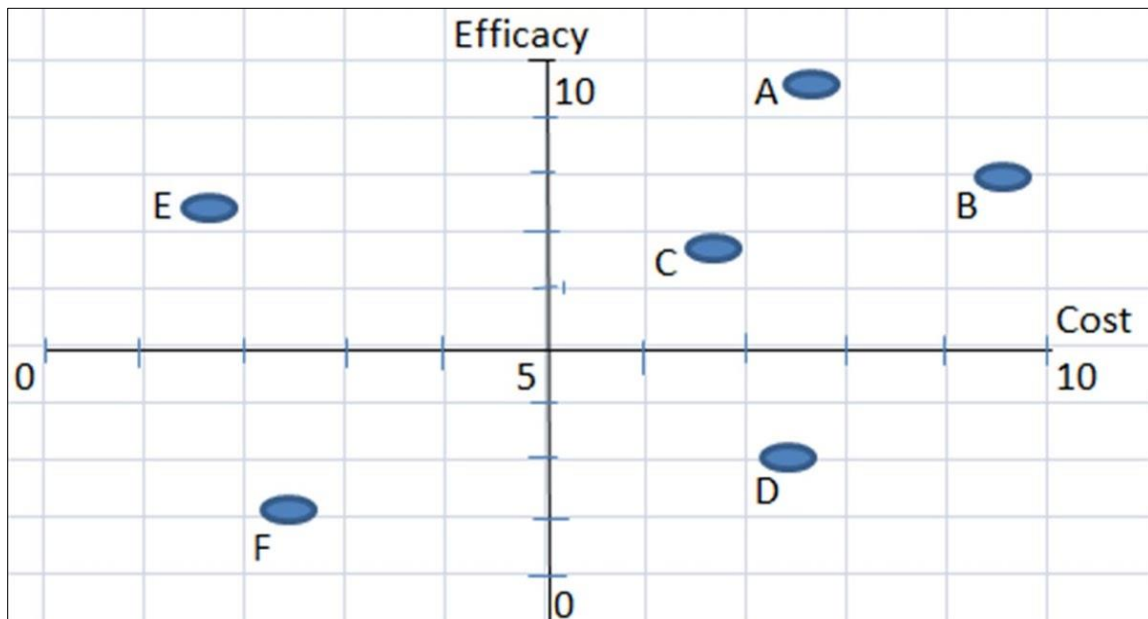


Figure (2-12): A Matrix Data Analysis

2.4.6 Arrow Diagram

It shows the required order of tasks in a project or process, the best schedule for the entire project, and potential scheduling and resource problems and their solutions as shown in Figure (2-13).

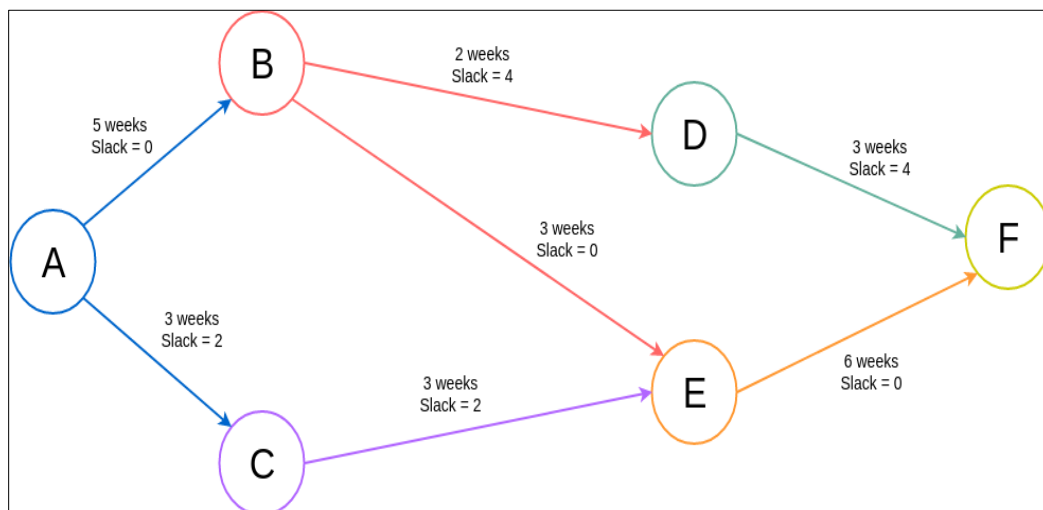


Figure (2-13): An Arrow Diagram

2.4.7 Process Decision Program Chart

It systematically identifies what might go wrong in a plan under development as depicted in Figure (2-14).

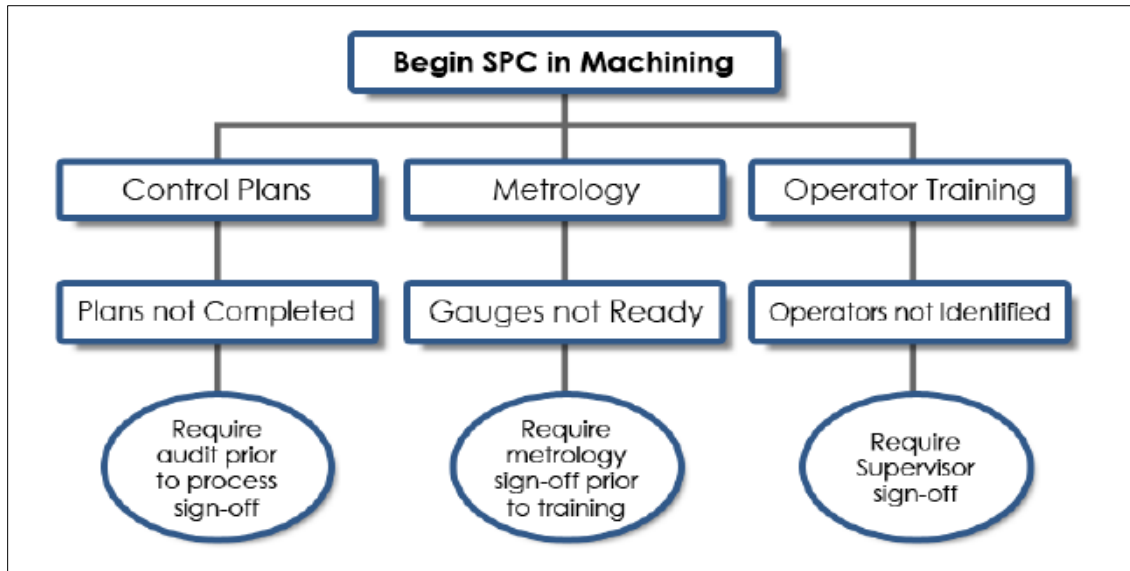


Figure (2-14): A Process Decision Program Chart.

2.5 SPC and Inspection

Inspection is a process by which a structured examination is evaluated for formal evaluation practice. The results obtained are usually compared with the established requirements and criteria to determine if the goal is achievable. In 1922, the inspection was formally linked to quality management with the publication of the book *Quality Control in Manufacturing* (Paiva, 2013). At the same time, the examination aimed to send only non-defective products to customers, which is similar to the reasons for applying SPC. Critical differences are opting not to participate in the inspection as a quality control technique as shown in Figure (2-15).

Deming (1986) criticized American manufacturing industries that apply mass inspection because the practice of quality control has significant drawbacks and leads to the industry's decline. Similarly, some critics of the inspection practices are listed below, (Prosser, 2009; White, 2013; Fotopoulos and Psomas, 2009; Hurst and Harris, 2013):

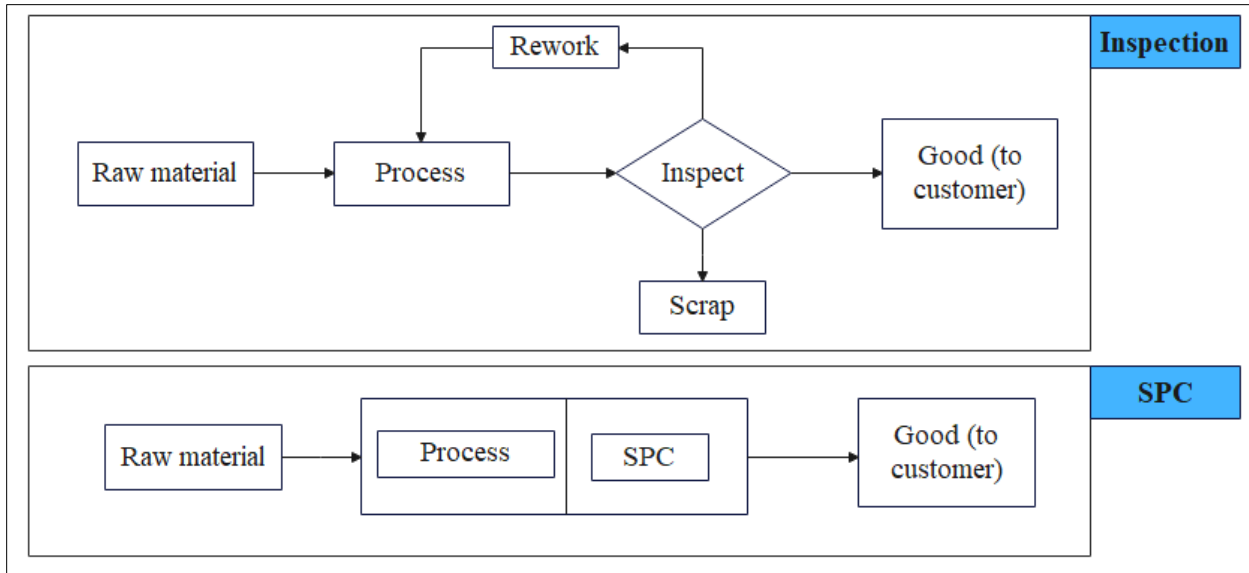


Figure (2-15): SPC versus Inspection (Antony and Taner, 2003)

1. It is not an economical and ineffective measure to closely examine each component.
- 2- Quality inspectors do not add value to the product yet are paid.
- 3- Quality improvement inspection is considered too late, ineffective, and costly.
- 4- It was noted that there is a demoralizing effect of the inspection on employees, which reduces the likelihood of no defect in production, a finding reached by Toyota Production System Engineer Taichi Ohno after his study tour at Ford in Detroit (the early 1950s). He said, “The errors of mass-production characteristics to keep the line running caused the errors to multiply infinitely. Any worker could reasonably believe that errors would be discovered at the end of the line and would likely be disciplined for any action that caused the line to stop” (White, 2011).
- 5- There is no infallible inspection system.

Deming (1986) accentuated that even if every end product is inspected, it does not necessarily assure quality. Deming (1986) and Crosby (1984) agreed on the basic policy of eliminating product defects by prevention instead of reaction. It also means that quality control should start at the production process instead of production end-line, leading to the implementation of SPC. The differences between SPC and inspection are shown in Table (2-1).

Table (2-1): Differences between SPC and inspection.

SPC	Inspection
Proactive.	Reactive.
Prevention.	Detection.
Exist feedback on the production process for improvement.	No feedback on the production process.
Control start at the production process.	Control starts at the production end light.
Output information gained: process behavior, process trend, process performance.	Output information gained: yes /no, go/no-go, defect/non-defect, conformance/non-conformance, accept/reject.

2.6 Evolution of SPC in the Food Industry

The origins of the statistical approach to quality control go back to the invention of the control scheme by physician Walter Andrew Shewart for the Bell Telephone Laboratory in the 1920s. However, it was not until the late 1940s when Edwards Deming adopted Shewart's work and found that using statistical techniques, such as control charts, could benefit the manufacturing industry. Pereira & Aspinwall (1991) report that it was not until the mid-1950s that the use of SQC methods in the food industry did not matter.

An opportunity for improvement in process control techniques was opened when the food industry began applying the SQC method and combined it with operational research technology, known as evolutionary processes (EVOPs). Developed by George Box in 1950, EVOP is a technology for improving operations through regular experimentation. Compared to the design of the experiment (DOE), 41% of article samples conducted case studies; three studies applied SPC by applying the Six Sigma methodology. Among the remaining sources, all SPC studies depicted the integration of other quality tools and techniques such as DOE,(Lim, 2016). Table (2-2) summarizes the evolution of SPC in the food industry.

The case studies presented in Table (2-3) indicate that many critical parameters involved in nutritional processes have been identified. These are special organoleptic characteristics (such as size, weight, texture, color, and length) and safety characteristics (i.e., the number of microbes). In the same way, for the food industry, the main characteristics of quality SPC implementation include food safety traits, organoleptic traits, and packaging characteristics of products (Raju, 2005).

The previous studies that were mentioned showed that the implementation of SPC requires teamwork from all parts of the company to achieve the goals that are always seeking to be completed, as some studies indicated many benefits such as reducing the percentage of defective products, reducing cases of non-conformance, applying new tools such as Six Sigma and achieving financial returns in return, but there are obstacles facing the implementation of SPC in companies, as studies have shown, such as that these tools are advanced and need financial support and lack of experience among employees

Table (2-2): Evolution of SPC in the food industry.

Development of SPC application for food quality	Focus on canning and preserving industry	The importance of managerial aspects	Major concern is Food products safety and consumer protection		Quality standards and certifications	Organizational learning in SPC
	Basic statistical techniques for monitoring food quality	Preventive quality control	Quality assurance in food industry	SPC in food quality management		SPC in business improvement programs
		Statistical methods as a management tool	An improvement in national standards	Consumer focus in food business		Statistical thinking
						Quality improvement activities linked with strategic planning
	1950s	1960s	1970s	1980s	1990s	2000 2010
Quality tools, techniques and programs	<ul style="list-style-type: none"> . Inspection . Sampling plan . Control chart 	<ul style="list-style-type: none"> . Design of Experiment . SPC . Process Capability . Zero Defects 	<ul style="list-style-type: none"> . Total Quality Control . Quality Costs 	<ul style="list-style-type: none"> . Total Quality Management (TQM) . ISO 9000 . HACCP 	<ul style="list-style-type: none"> . ISO 9000:2000 . Lean Six Sigma 	

Table (2-3): SPC application in the food industry

Articles and Country	Commodities (Product)	Issues	Quality Charact.	Type of SPC tools	Quality program	Output: Benefits and Duration
(Srikaeo & Hourigan, 2002) -Australia	Eggs	- There is no evidence of the effectiveness of HACCP elements.	-Temp. - pH - Chlorine level	-Individual chart	HACCP	- The CCP value is validated (All control measures can design critical limits exceptchlorine level). - 6 months
(Augustin & Minvielle, 2008) - France	Meat processing and preserving	The low rate of unsatisfactory batches of <i>Enterobacteriaceae</i> and <i>Pseudomonas</i> count detection caused doubt on the efficiency of the traditional control scheme.	Microbial count	- Moving Average chart, - Box plot - Histogram	HACCP	The assumption of microbiological contaminationvariances is in control (2% variances above the control limit).
(Dalgiç et al., 2011) -Turkey	Meat processing and preserving	There is a demand for more effective quality control techniques to assist in HACCP implementation.	-Moisture content - pH	- Process mapping - Pareto chart - Scatter plot - Ishikawa - X-bar chart	TQM HACCP ISO 2200 ISO9000 FMEA	- Stabilise the moisture content (reading approximately 40%). - Enable plant operators to take action quickly. -3 months
(Rai, 2008) India	Tea	The critical problem faced in tea production is the weight variation in the teapacket	- Weight	- CUSUM - X-bar chart	None	Reduction of the out-of-control situation from 66% to 4%

Articles and Country	Commodities (Product)	Issues	Quality Charact	Type of SPCtools	Quality program	Output: Benefits and Duration
(Knowles et al., 2004) -UK	Sugar confectionery (Medicated sweets)	The variation in the sweetsize caused reworks, scraps, machine downtime.	- Sweet thickness	- X-bar chart - R chart - Histogram - Scatter plot -Ishikawa diagram	Six Sigma Taguchi method	- Saved £290 000 - Improve <i>C_{pk}</i> from 0.5 to 1.6 -12 months
(Daniels, 2005) -USA	Bakeries	The major customer filed complaints on the crust strength and risk of losingthe customer.	- Crust strength	- X-bar chart - Box plot - Pareto chart	HACCP Six Sigma DOE	- Reduce scrap rate 40% - Saved £274, 983
(Grigg, 1998) -UK	Fish	Product giveaway and unnecessary check weightier rejection	- Package weight	- X-bar chart - R chart	None	Reduce product give away and rejection rate.
(Negiz et al., 1998) -USA	Dairy	In dairy pasteurisation, if the product temperature drops below 1610F (15s holding time), the product must be diverted immediately to comply.	- Temp.	Hotelling T ² chart	None	- 20% over processing were detected. - Receive signals for non-compliance.

2.7 Types and Causes of Variation in SPC

Mesele (2021), says that no two products are exactly alike due to slight differences in materials, workers, machines, tools, and other factors. Based on this, the product's quality characteristics are not completely at the same level. This is called random causes of variance. Mesele (2021) also says that the common cause of difference depends on random causes that cannot be determined. These types of variation are inevitable, and there must be slight differences in treatment. Also, he stated the other type of variance involves differences where the causes can be precisely identified and eliminated and thus can be observed. These are called assignable causes of change. There are many examples of this type of variances, such as variance in the poor quality of raw materials, or an employee who needs more training, or a device that needs repair or calibration. In each of these examples, the problem can be identified and corrected. If the problem is allowed to persist, it will continue to create a product quality problem as the data drops above and below pre-defined lower and upper control limits (LCL and UCL) indicating that a variance has been developed due to customizable causes that can also be identified and corrected.

Current literature supports the applicability and advantages of implementing SPC in the food industry, not only during the manufacturing process but also after the manufacturing process in packaging. Grigg and Walls (1999) assisted a food company in creating an SPC system for controlling, weighing, and measurement control in fish products manufacturing. In this case, from using the control chart within the SPC, the LCL avoids “underfilling,” and the UCL prevents 'overfilling'.

Training of operators and quality specialists is fundamental to the implementation of SPC. However, there are challenges due to the lack of understanding, knowledge, and awareness of top management and the technical approach used (Rohani & Chan, 2001, Jamaluddin et al., 2012).

Implementing SQC in the food industry focuses on improving food safety management and reducing product spoilage. Companies in the food industry contribute to agribusiness in any country, as this field provides significant commercial returns to the country's economy. In addition, focusing on the aspects of quality and management is important for the organization so that it can manage it

appropriately and under constant supervision to be an effective approach in integrating quality activities.

There are several reasons for the necessity of implementing the use of SQC tools in small and medium enterprises in the food industry, of which we mention two reasons, as shown by Abd Rahman et al.(2015).The first reason is the increased demand for high-quality products by large enterprises; the second reason is the requirements of the enterprise to be more proactive and competitive in good quality control to create a competitive business environment. Sintok (2015) indicated that applying the SQC tools is a complex technique involving a change in the overall work culture that will affect the performance of the organization. However, a literature review found that implementing SQC is very useful for improving quality because an organization is able to detect anomalies in processes, meet timeliness, check critical parameters, reduce variance and maintain process stability.

2.8 SPC Implementation

According to Ignatio Madanhire (2016) in SPC application, it is important to understand and identify the key product characteristics that are critical to customers or the main process variance which fall within the main steps of implementing SPC, which are: defining the specific process, identifying the measurable attributes of the process, describing the natural variance for attributes and tracking difference if the process is controlled, continuing the process, otherwise selecting and removing assignable causes. Figure (2-16) summarizes a conceptual framework for SPC implementation.

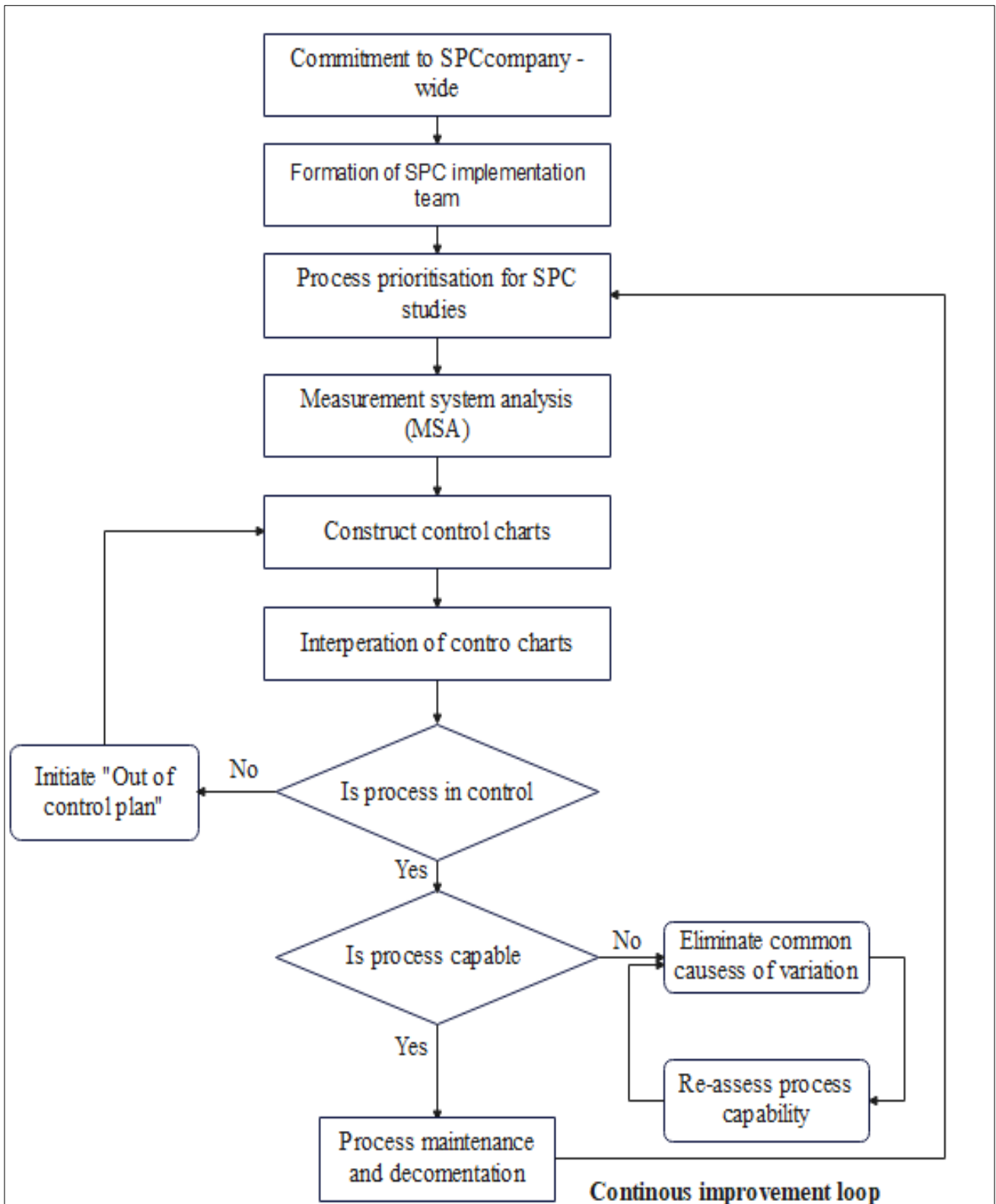


Figure (2-16): A conceptual framework for the implementation of SPC
 Source: (Antony and Taner, 2003)

2.9 Benefits of Implementing SPC

The result of this review indicated that the highest benefit cited was reduction in defective products, food safety and financial advantage. As most of the articles mentioned that reducing product variance can be achieved due to effective application of control charts. However, applications of other SPC tools have rarely been discussed. This practice is said to be inconsistent with the definition of SPC— SPC is a mixture of statistical methods and problem solving where the control chart is one of the tools included in SPC (Montgomery, 2017). Table (2-4) shows some benefits to the implementation of SPC.

Table (2-4): Benefits of implementing SPC

Factors	References
<i>Reduced non-conforming products.</i>	
<ul style="list-style-type: none"> • Process variation reduction. • Increased consistency in product. 	(Grigg & Walls, 2007)
<i>Improved cost savings.</i>	
<ul style="list-style-type: none"> • Reduced process waste. • Reduced rework. • Reduced scraps. 	(Mazu & Conklin, 2012)
<i>Competitive advantage.</i>	
<ul style="list-style-type: none"> • SPC indirectly generates higher business sales through consistently to produce quality products. • SPC is able to strengthen company's survival in the global market. 	(Grigg & Walls, 2007)
<i>Improved customer satisfaction.</i>	
<ul style="list-style-type: none"> • Reduced customer complaints. 	(Alsaleh, 2007, Grigg et al., 1998)

2.10 Barriers to SPC Implementation in the Food Industry

Multiple obstacles are impeding the implementation of SPC in food factories, some of which can be summarized in the Table (2-5).

Table (2-5): Barriers to SPC implementation in the food industry

Factors	References
<i>Resistance to change</i>	
<ul style="list-style-type: none"> • Current food organizations have not fully accepted the need for CI techniques • Fear of failure 	(Bjerke & Hersleth, 2001, Hsiang-Chin & Ming-Hsien, 2011)
<i>Lack of management support</i>	
<ul style="list-style-type: none"> • Resistance to provide sufficient resources • Lack of management awareness on SPC • Reduced scraps 	(Hsiang-Chin & Ming-Hsien, 2011, Mazu & Conklin, 2012)
<i>Lack of statistical knowledge</i>	
<ul style="list-style-type: none"> • Unfamiliar with the use of advanced statistical technique 	(Alsaleh, 2007, Bjerke & Hersleth, 2001)
<i>Poor measurement system</i>	
<ul style="list-style-type: none"> • Lack of awareness the importance of capable measurement system 	(Gauri, 2003, Grigg, 1998)
<i>Lack of experience</i>	
<ul style="list-style-type: none"> • Lack of experience in using quality tools 	(Hsiang-Chin & Ming-Hsien, 2011)

2.11 Critical Success Factors (CSF)

Daniel (1961) introduced the idea that there are quite few factors critical to a company's success. Later, Rockart (1979) elaborated on the concept of critical success factors (CSFs) as he defined essential factors of success as the limited number of key areas where satisfactory outcomes ensure the successful competitive performance of an individual, department or organization.

Previous studies have shown that top management is the most prevalent factor associated with the success of the SPC implementation system and any quality management system. Senior management

commitment is a latent variable, which cannot be measured directly, but is often seen as providing adequate resources, commitment, support, and project approval.

Also, training is essential to overcome resistance to change by food companies towards SPC implementation as the courses can provide adequate information and knowledge about SPC implementation. Furthermore, in a study by Bjerke & Hersleth (2001) and Davis & Ryan, (2005), the competency level of employees in the food industry was moderately low, and it was said to be associated with a lower ability to achieve statistical reasoning. The working definition of 'proficiency' in the study was a combination of formal education, knowledge, and experience. Hence, in the implementation of SPC in the food industry, training plays a crucial role during its application to overcome the challenging factors of SPC implementation and reduce the limiting factors of SPC. In addition to many other factors such as teamwork/ implementation team, CI culture, data requirement, documentation, program planning, cultural change and identification of critical quality characteristics.

2.12 Limitations of SPC Implementation

Limitations of SPC implementation in the food industry are shown in Table (2-6). Based on the results of previous studies which are compared with the restrictions in Palestine in chapter five, the most cited limitation is the lack of statistical thinking (ST) culture in the food industry, followed by the consideration of SPC as an advanced tool for non-statisticians, and the lack of applicable guidelines available in the context of the food industry.

Table (2-6): Limitations of SPC application

Limitations	Details/examples	References
	<i>Lack of statistical thinking (ST)</i>	
	<ul style="list-style-type: none"> Decision-making based on data is not a customary practice in the food industry 	(Bjerke & Hersleth, 2001, Gauri, 2003)
	<i>SPC is considered too advanced</i>	
	<ul style="list-style-type: none"> SPC is perceived as too advanced for the food industry Multivariate control chart application is too challenging for the shop floor employees to handle 	(Paiva, 2013)
	<i>Costly technique</i>	
	<ul style="list-style-type: none"> SPC is considered as a luxury option due to training and software requirements for its application 	(Alsaleh, 2007)
	<i>Existing manuals cannot comprehend food manufacturing applications</i>	
	<ul style="list-style-type: none"> Current available manual within the food industry for control and monitoring is arguably too complicated for real application in food manufacturing Quality parameters depend on multiple factors, increasing the time needed for corrective action 	(Gauri, 2003, Grigg & Walls, 2007)

Chapter Three

Methodology

3.1 Overview

This chapter discusses the methods used in conducting this research, starting by the research design that focuses on planning for the research work through determining the type of the research according to its primary purposes. Then, research approaches are covered, illustrating the quantitative, qualitative, and mixed research approaches and the differences between these approaches. The data collection techniques and sampling methods are also addressed in later sections. Finally, this chapter deals with the methods and techniques of data analysis to reveal the relationships between the study variables.

3.2 Research Design

Research is defined as a systematic and objective academic activity of seeking knowledge to form a problem solving or generalization of theoretical formulation by defining the problem, formulating hypotheses, collecting and analyzing facts and data, and arriving at conclusions (Kothari, 2004).

Research is classified into several types according to the classification of Goddard & Melville (2004):

1. **Experimental research:** this research is concerned with cause and effect by revealing the effect of the changes in the independent variables (causes) on the changes in dependent variables (effects). Two groups are formulated, the experimental group and the control group.
2. **Creative research:** this research introduces new theories, inventions and procedures, involving theoretical research concerning creating new theories as well as new models and practical research concerning the design and physical issues, mainly through trial and error.
3. **Descriptive research:** this research (case study) addresses a particular situation to explore if a general theory has emerged.
4. **Ex Post Facto Research:** this research looks backward at the effects to explore the causes. In other words, it is (from after the fact), which is in contrast to the experimental research.

5. **Action Research:** this research is participatory and emancipatory identifying a specific problem, gathering comprehensive data about the situation as well as involving the stockholders to take the recommendations to make the change. Moreover, the researcher would monitor the effectiveness of the implemented changes.
6. **Historical research:** this research addresses the previous related studies to examine a current situation deducing cause-effect relationships to predict the situation in the future.
7. **Expository research:** this research includes introducing new insight about a particular subject as a result of reviewing existing information, and comparing contradictory arguments from previous studies.

Regarding the research objectives Kothari (2004), points out that three broad categories are found for the researches; the first one, is explanatory research that addresses the causal relations variables (cause and effect) by data collection, statistical testing and analyzing the data to explain the effect of the independent variables on the dependent variables. The second one is exploratory research which aims to explore into a specific topic or a problem via formulating hypotheses rather than testing them. In contrast to exploratory, a third alternative is a descriptive research that addresses a certain situation to explore if a general theory is emerged via the structuralized process for testing the hypotheses. Based on the aforementioned types of researches, the explanatory research approach is adopted and used in this study as the aim of this study is to assess the implementation of SPC in food factories, so data were collected using a questionnaire and then analyzed using PLS-SEM via Smart PLS package.

3.3 Research Approach

Research methods are the procedures and plans for formulating hypotheses, collecting, analyzing and interpreting the required data (Vanderstoep & Johnson, 2008).

3.3.1 Main Research Approaches

Silverman (2013) explained that there are three main types of research approaches that can be summarized as follows:

- **The first approach is the deductive approach**, formulated by developing hypotheses based on pre-existing theories. This is suitable for a positivist approach that leads to an acceptable probability level (Snieder & Larner, 2009).
- **The second approach is the inductive approach**, commonly applied in qualitative research. It is used in the absence of theories. Thus, the starting point in this approach is observation and a new theory is generated (Bryman & Bell, 2011).
- **The third alternative is the hijacking approach** which focuses on interpretations of facts that cannot be explained within existing theories (Vanderstoep & Johnson, 2008).

The selection of the appropriate research approach depends on several factors which are the purpose of the research as well as the problem to be solved

3.4 Research Strategy

A research strategy can be defined as a systematic approach to collecting and analyzing data to collect reliable information to answer research questions (Bryman & Bell, 2011). Whereas, the research strategy is descriptive because it allows data to be collected through sample-based questionnaires, which helps to know the point of view of the population.

3.4.1 Qualitative Research Method

This approach consists of an investigation in which the researcher seeks answers to a question, systematically uses a predetermined set of procedures to answer the question, gathers evidence, draws out results that were not previously identified, and produces relevant results outside the immediate confines of a study. Non-standardized techniques are used to collect data, such as interviews. Then, the collected data is analyzed using a procedure (e.g., data classification) that generates or uses non-numerical data (Creswell, 2003).

3.4.2 Quantitative Research Method

This approach is generally related to the deductive approach, which deals with and analyzes quantitative variables to obtain results. It involves using and analyzing numerical data using specific

statistical techniques to answer questions. Expanding on this definition. Aliaga (2002) describes quantitative research methods as an explanation of an issue or phenomenon by collecting data in numerical form and analyzing it with the help of mathematical methods.

3.4.3 Mixed Research Method

Tashakkori & Teddlie (2021) explain that in the mixed-method approach, the combination of quantitative and qualitative methods allows the researcher to compensate for their weaknesses and select the most appropriate technique to address the research questions the study unfolds (Johnson et al., 2007). Table (3-1) compares the qualitative, quantitative, and mixed method approaches.

Table (3-1): Differences between quantitative, qualitative and mixed-method research

General issue	Qualitative	Quantitative	Mixed-method
Research aim	Most involve the statement of research questions.	Involves research hypothesis/research questions or both.	May involve the statement of both research questions and hypotheses
Sampling	Emphasizes purposive sampling.	Emphasizes probability sampling.	Includes both purposive and probability sampling
Data collection	Involves unstructured observations, open-ended interviews, focusgroups and unobtrusive measures.	Involves structured observations, closed-ended interviews, questionnaires and tests.	All data collection strategies included.
Data analysis	Thematic analysis, categorical strategies,	Statistical analysis (descriptive, inferential statistics).	Both thematic and statistical analyses. Data conversion techniques are used.
Validity	Emphasizes trustworthiness, credibility and various authenticity criteria.	Emphasizes statistical conclusion validity, internal validity, construct validity and external validity.	All inference and validity issues are subsumed under inference quality and Inference

More specifically, the research design strategies that are followed in quantitative research are experimental strategy, case study strategy, correlational design strategy or survey research design strategy, as discussed below:

1. Experimental research strategy: refers to much control on the environment of the research commonly used in physics, biology, chemistry, and medicine as well as investigating the effect of some of the variables on others (Vanderstoep & Johnson, 2008).
2. Case study strategy: refers to a specific contemporary phenomenon based on multiple sources of data (Vanderstoep & Johnson, 2008).
3. Correlational design strategy: a process identifying the relationships between the dependent variables and independent variables. The correlation has both direction and magnitude; regarding the direction, the correlation can be positive or negative (Vanderstoep & Johnson, 2008).
4. Survey strategy: a procedure particularly applied in the quantitative approach to collect a sample representing a population with standardized methods to describe the characteristics, attitudes, opinions, and trends of all the population, thus reaching to generalization of the sample to the population. This strategy uses questionnaires and structured interview techniques for data collection (Creswell, 2003).

Therefore, this research applied the quantitative deductive approach in which the survey strategy was adopted through the data collection process that was carried out by designing a questionnaire.

3.5 Research Methodology

To achieve the objectives of this research, a quantitative deductive methodology has been applied as Figure (3-1) demonstrates.

- The first stage: In this stage, the scope of the research and the problem to be solved were determined, and the importance and justification for conducting the research were clarified. An extensive literature review was conducted to reveal the extent of the application of SPC in food factories, and consequently, research questions were developed, and hypotheses were

proposed for testing. In the end, the research strategy is structured to achieve the research objectives.

- The second stage: data collection by defining the research community and determining the number of the representative sample, as well as choosing the technique for collecting the required data by choosing the survey strategy where the questionnaire was designed and distributed to the selected sample.
- In the third stage: the collected data were analyzed and interpreted using the PLS-SEM and SPSS programs to explore the relationships between the study variables and test the proposed hypotheses. In the last phase of this process, study results were summarized, in addition to that, conclusions and recommendations were made based on the results of the study along with the data analysis.

3.6 Questionnaire Design

Indeed, the questionnaire is the main research method and population survey tool. It is a tool for collecting quantitative data. The purpose of the survey is to represent a particular population group where each respondent has an equal chance of being selected (Gillham, 2008). In this study, the closed-ended questions of the respondents were pre-defined. The scale adopted was the five-point Likert scale, which is “a psychological scale that contains multiple categories from which respondents choose to indicate their opinions, attitudes, or feelings about a particular issue,” (Nemoto & Beglar, 2014).

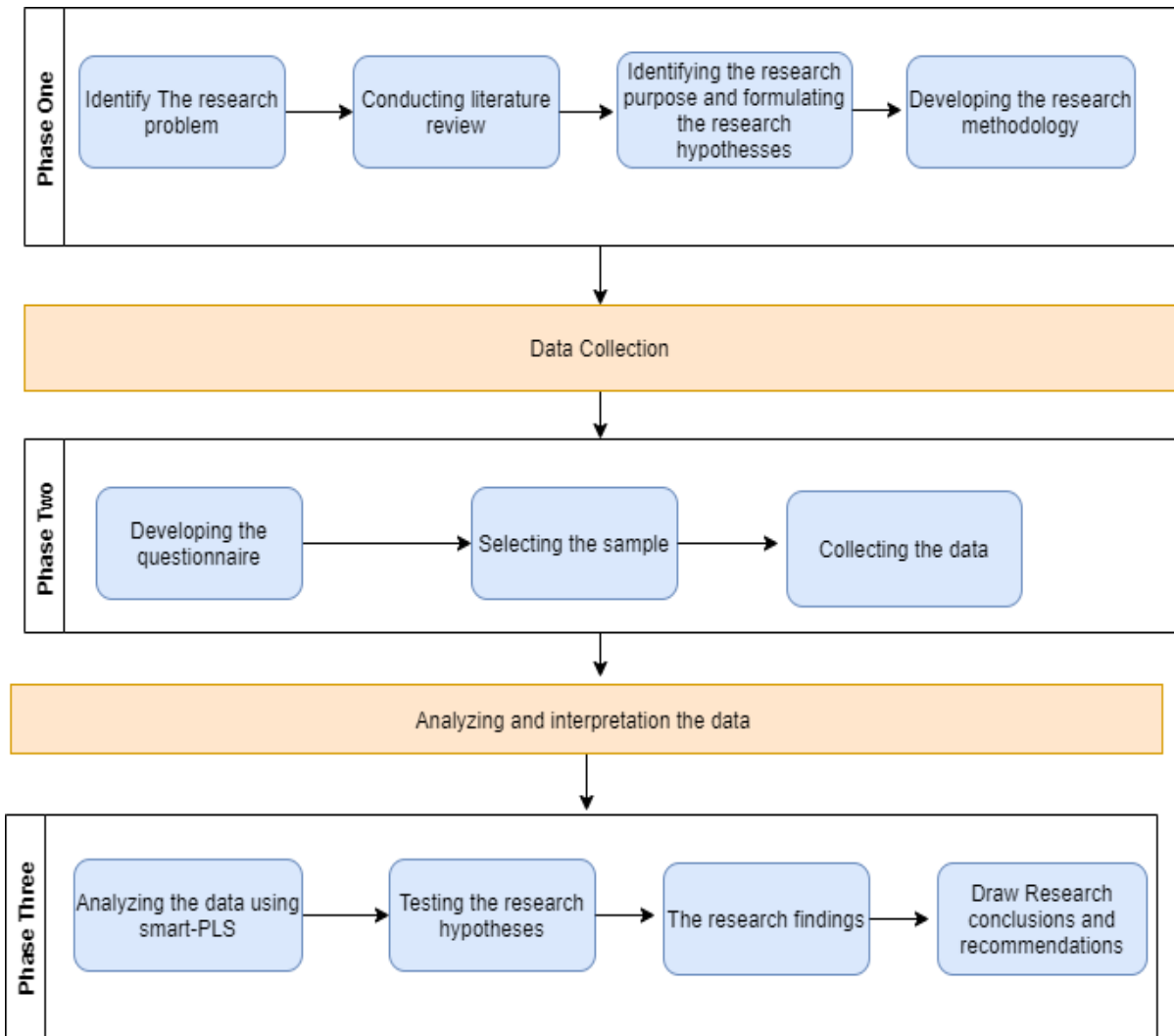


Figure (3-1): Flowchart of Research methodology

The research questionnaire was developed based on an extensive literature review. Four local experts judged the questionnaire to assess the wording, clarity, repetition, and ability of the elements to represent each particular structure. A final questionnaire is available in English and Arabic in Appendix (1) and Appendix (2), respectively.

The questionnaire consists of three main sections. The cover letter displays the title of the research, the objective of the research, the time taken to fill out the questionnaire, the complement of cooperation, and finally, the researcher's full contact details for any inquiry.

The first section deals with eligibility to participate in the questionnaire through which the company that applies SPC is identified or not, and then the tools used in the company in the case of SPC application.

The second section deals with facts related to the demographic profile of the respondents. Gender, education, position, and years of experience. This section also includes geographical location, number of employees, years of work in the Palestinian market, and the different products companies produce. The third section consists of six subsections to evaluate the application of SPC in food factories. It includes administrative procedures, process approach, decision-making, training on statistical methods, auditing, review of SPC practices, and finally, the main obstacles related to quality in the company.

To determine the degree of approval or objection to a formula or phrase, a five-point Likert scale was used in this study, which is anchored by “1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree.”

The last section includes an open-ended question to allow respondents to express their opinions or comments about something not covered in the survey.

Because the mother tongue in Palestine is Arabic, the survey was designed and approved in this official language, and the data was developed using Google forms (Questionnaire pro). In addition, the questionnaire was delivered to the target sample by sending an email to some companies that were difficult to reach, in addition to attaching an official letter requesting to facilitate the research task directed by the Arab American University, as shown in Appendix (3). Some other companies were also visited, where Appendix (4) presents the list of the 65 companies that responded to the questionnaire. Moreover, the data collection start phase was in April 2022 and ended at the beginning of July 2022, and all data collected anonymously was stored on google drive database to be analyzed.

3.7 Sampling Techniques

According to Blanche et al.(2006), sampling is “the selection of research participants from an entire population, and includes decisions about which people, place, events, behavior, and/or social processes to monitor.” Furthermore, the main objective is to select a representative sample that is representative of the entire population. Table (3-2) shows the types of samples used in data collection.

Table (3-2): Sampling methods

Sampling method	Details	Advantages	Limitations
Random	Each unit has an equal chance of being selected.	Can provide accurate estimates, avoids the opportunity for bias.	Rarely perfectly representative of the population.
Systematic	A sample unit is selected in a systematic way from beginning to end of the frame, every nth number.	Its only advantage over the random sampling technique is simplicity.	As long as the list does not contain any hidden order, this sampling method is as good as the random sampling method.
Stratified	Probability method that uses subsets and their representation of the total population.	Reduces sampling error. Can be used when one or more of the subset in the population have a low incidence relative to others.	Time consuming
Judgement	Selecting the sample based on knowledge of the process being studied.	Extension of convenience sampling, inexpensive approximation of the truth.	Must be confident that the chosen sample is truly representative of population.
Convenience	Selecting sample from the most accessible or convenient sampling units or elements.	Inexpensive approximation of the truth. Convenient, gross estimate of the results, without incurring the cost or time required to select a random sample.	Gross approximation only.

This research aims to evaluate the application of SPC in food factories. Thus, companies from the Palestinian food sector are the target population in this study.

According to the Ministry of National Economy (MoNE), 598 companies operating in the food industry were registered in the West Bank including the bakery sector. The food industries sub-sectors

are; Milk and dairy products, manufacture of meat products, vegetable oils and fats, manufacture and canning of fruits and vegetables, feed industry, wheat flour and grain products, carbonated and non-carbonated drinks, pasta, sugars and sweets, sterilized water, bread, and bakery products. Excluding bakeries, food product packaging, slaughterhouses, and feed industry, the operating companies are 278. Thus, all 278 companies were investigated by contacting the MoNE, the Palestinian Standards Institution (PSI), and the Federation of Food Industries, the 75 companies in all food subsectors are legally registered and licensed to operate in Palestine. Thus, the population size is those 75 companies. Steven Thompson's formula (Thompson, 1987) was used to calculate the sample size by:

Equation (3-1): Sample size calculation

$$n = \frac{N \times p(1 - p)}{[[N - 1 \times (d^2 \div z^2)] + p(1 - p)]}$$

ITEM NEEDED	
N	Population size
n	The sample size
p	Proportion of property offers and neutral
z	the upper $\alpha/2$ of the normal distribution (for 95% confidence level 1.96)
d	Error margin

The following parameters were used $N = 75$, $p = 0.5$, $d = 0.05$ and $z = 1.96$ for 95% confidence level. Applying the equation mentioned above,

$$n = \frac{75 \times 0.5(1 - 0.5)}{[[75 - 1 \times (0.05^2 \div 1.96^2)] + 0.5(1 - 0.5)]}$$

The sample size is approximately $n = 63$ and selected by convenience sample method.

To obtain this required sample, the questionnaire was distributed in two ways. The first was to spread a hard copy to companies and then an electronic copy to companies that were difficult to reach.

3.8 Measurement Development

Based on a comprehensive review of the existing literature to explore questions that would measure the study's main variables, 40 items (questions) were developed to measure the structure of the study.

So these questions were divided as follows:

From the previous studies, 30 items were developed to evaluate the application of SPC, in addition to 10 items that were developed based on what was learned from previous studies and what fits with the Palestinian context. More precisely, seven elements explain managerial actions, six elements explain the process approach, five elements show decision-making, eight elements for training on statistical methods, seven elements for auditing and reviewing SPC practices, and seven elements explaining the main related obstacles to quality in the company. Table (3-3) presents the sources checked and used as guiding tools for developing the questionnaire.

Table (3-3): Variables measurement

Variable	Dimensions	Construct Items	References
SPC practices	Statistical Method Training (SMT)	SMT01:SMT08	(MESELE, 2021)
Factory practices	Managerial actions (MA)	MA01:MA07	(Lim, 2016)
	Process approach (PA)	PA01:PA06	(Lim, 2016)
	Decision-making (DM)	DM01:DM05	(Lim, 2016)
	Audit and review SPC practices (AR)	AR01:AR07	(MESELE, 2021)
	Major quality obstacles (MQO)	MQO01:MQO07	(MESELE, 2021)

3.9 Data Analysis Techniques

The information obtained through the questionnaire was just raw data; some analysis needs to be done to turn them into valuable and meaningful information. Several statistical programs were available for conducting the statistical analysis; however, in this research two types of analysis were used: the

first is by using the Statistical Package for Social Sciences (SPSS) to perform descriptive statistics analysis for personal information, descriptive statistics for each construct in the study, and appropriate charts to be drawn. The second analysis is by using SEM-Smart PLS for testing the research hypotheses in order to examine the relationship between a number of independent and dependent variables in one theory.

SPSS is statistical software that was designed by IBM corporation in which it accepts both correlational and comparison statistical tests in the framework of univariate, multivariate and bivariate analysis for both statistical techniques: parametric and non-parametric.

On the other hand, Smart PLS accepts SEM analysis using the Ordinary Least Square (OLS) estimation technique, some developers developed it in the academia of Germany and it is commonly used by researchers who mainly aim to explore theories (Ong & Puteh, 2017). As this research aims to observe the causal-effect relationship between several independent and dependent variables, the SEM was the best method. It is worth noting that one of the most popular software for SEM-PLS is the Smart-PLS.

3.9.1 SEM -PLS Path Model

The Partial Least Squares (PLS) approach was used to analyze the quantitative data generated from the questionnaire using the Smart-PLS software, which Herman World developed in 1982. It is important to mention that there are many benefits to using PLS-SEM; due to its ability to deal with small sample sizes and non-normalized data; because PLS is a non-parametric statistical tool. In addition, it can estimate complex models with a large number of indicators, constructs, and structural paths regardless of the data distribution (Hair et al., 2019).

The PLS analysis is a two-step approach, the first step is the outer model, which is concerned with building and testing the measurement model to assess the relationship between the constructs and the indicators.

The second step is the inner model that focuses on building and testing the structural model (Path model) to assess the relationships between the constructs, which are the independent and dependent

latent variables. It is worth noting here that the variables were classified as exogenous or endogenous variables. The exogenous variable represents the independent variable where it includes arrows that head outward in the structural model. At the same time, the endogenous variable represents the dependent variable where the arrows head inward in the structural model (Hair et al., 2011). Figure (3-2) below summarizes the components of the SEM.

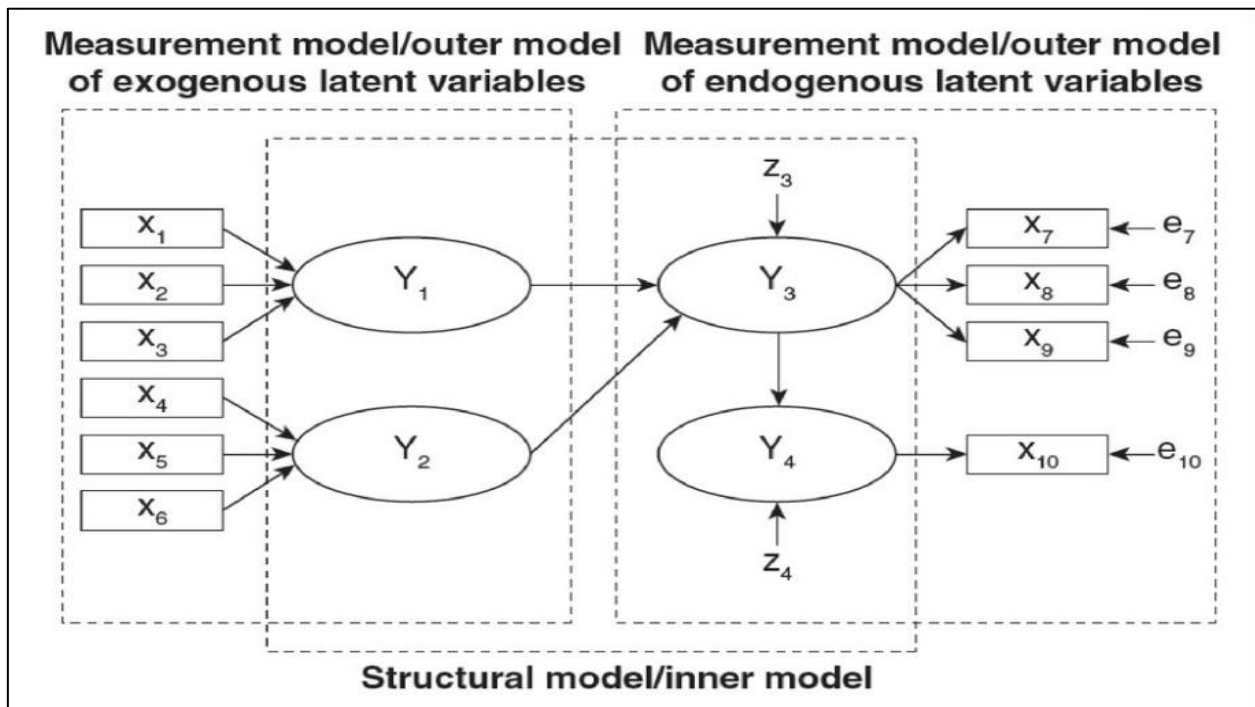


Figure (3-2) Inner and outer model in an SEM (Source: Hair et al., 2019)

Furthermore, there are two measurement models; the first is the formative model, in which it's assumed that the indicators cause the construct. As a result, deleting or removing one indicator would change the construct's nature because every indicator reflects a specific facet of the construct's meaning. The second is the reflective measurement model; deleting or removing an indicator in this model would not affect the variable's conceptual meaning since the indicators are correlated and very strongly related (Hair et al., 2019).

In this study, a reflective formative model was used while the dimensions that formed the study's latent variables, such as (MA, PA, DM, AR, and MQO) relate to plant practices.

Figure (3-3) represents the study's model that was developed to investigate the relationship between factory practices as an independent variable and SPC practices as a dependent variable.

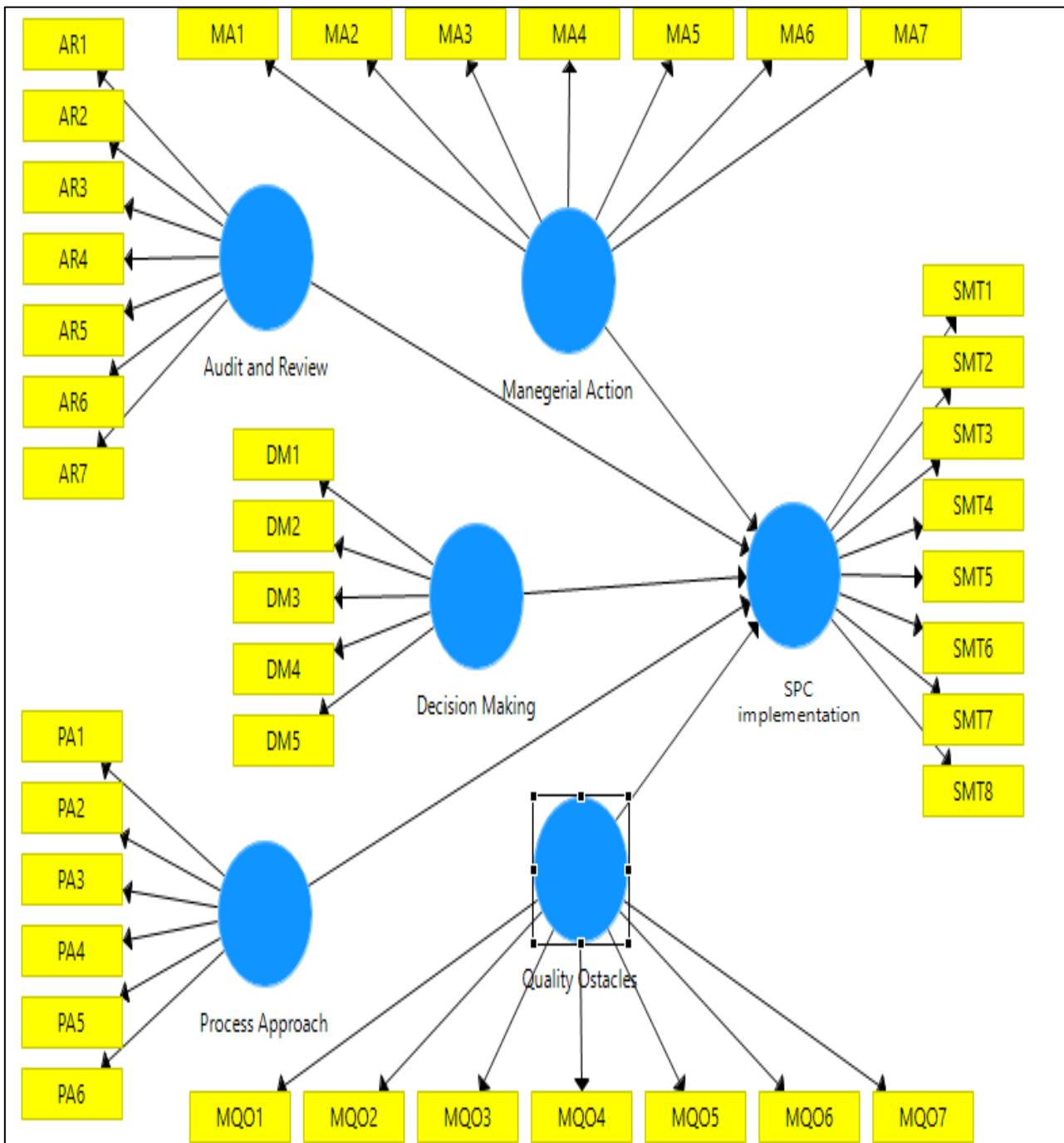


Figure (3-3): The Research proposed model

SEM -PLS Path model is a diagram that visually connects the variables, two types of theories are needed to develop the path model: measurement theory and structural theory. Measurement theory specifies the relationship between the construct and its indicators (measurement model) to assess the validity and reliability of the measures. Composite reliability is measured to assess the internal consistency reliability. In addition to estimating convergent validity and discriminant validity. Later to asserting valid and reliable measures, the relationship between variables is examined as well as the

model's ability to predict is evaluated (structural model). Thus, coefficients of determination (R^2 values), the level and significance of the path coefficients, the predictive relevance (Q^2) and the effect sizes (f^2) are estimated (Hair et al., 2019).

Chapter Four

Data Analysis and Results

4.1 Overview

This chapter includes an analysis of the collected data, which consists of two parts. The first section discusses the results of the descriptive statistics of the demographic variables of the respondents, in addition to the demographic variables of the targeted food companies using the SPSS program. And then the second section in which the data collected is analyzed to test the proposed hypotheses using the Smart-PLS program.

4.2 Demographic Profile

This part analyzes the descriptive information of a sample of 65 participants from different types of Palestinian food industries using the SPSS program. Where this part consists of two levels, the first level relates to the demographic profile of the respondents such as gender, age, educational level, years of experience, and the nature of their work in the company. While the second part deals with the company's profile. It includes the size of the company, "the number of employees in it", the company's age, and the quality certificates obtained, in addition to the products produced by the company.

4.2.1 Demographic Profile for the Respondents

4.2.1.1 Gender

The first demographic variable related to the target sample for the study is gender. The results showed that - of the 65 questionnaires collected and completed - 80% were males (54 respondents), compared to 16.9% females (9 respondents), as shown in Figure (4-1).

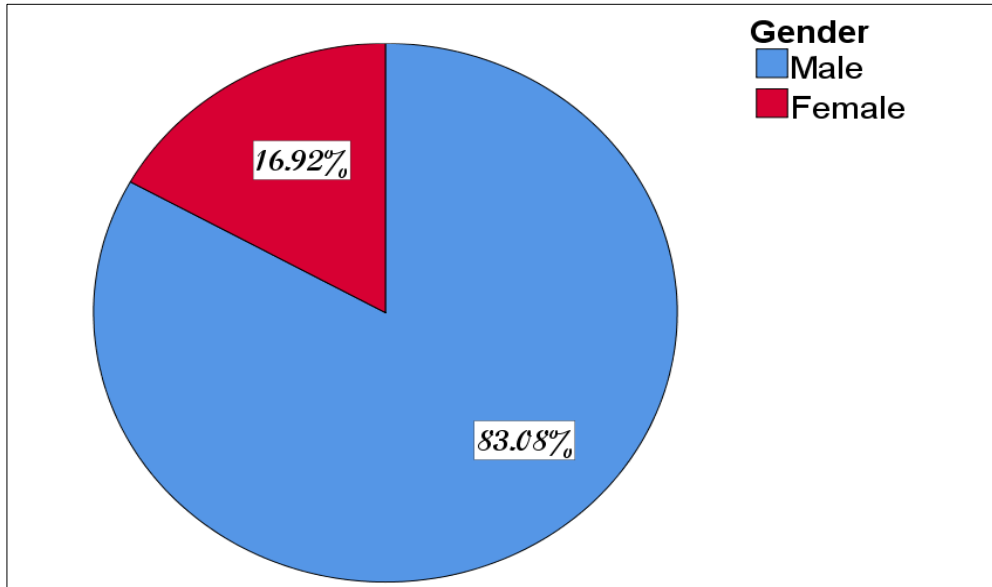


Figure (4-1): Respondents' Gender

4.2.1.2 Educational Level

The second variable in demographic information is the educational level, about 77% of the respondents hold a bachelor's degree (50 members), and 10.7 % have a master's degree (7 respondents) as well as a diploma, and 1.5% have a Tawjihi certificate (one participant). The educational level of the respondents is shown in Figure (4-2).

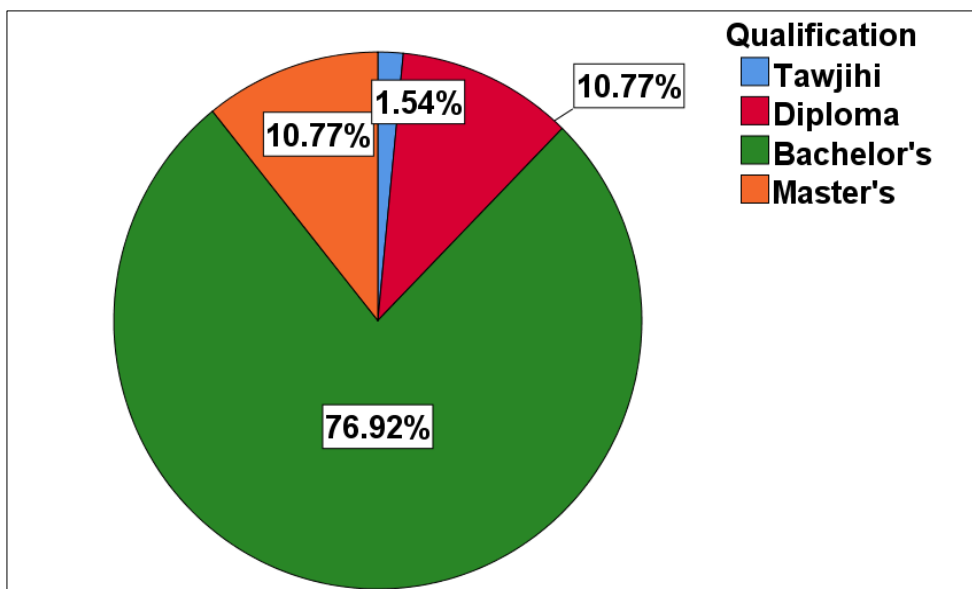


Figure (4-2): Respondents' educational level

4.2.1.3 Positions in the Targeted Firms

Figure (4-3) shows that 32% of the respondents were quality managers, 24% of the respondents were quality controllers, 18% were department heads, and 16% were technical managers, while the little participation was from administrative employees and general managers by 3% and 4%, respectively.

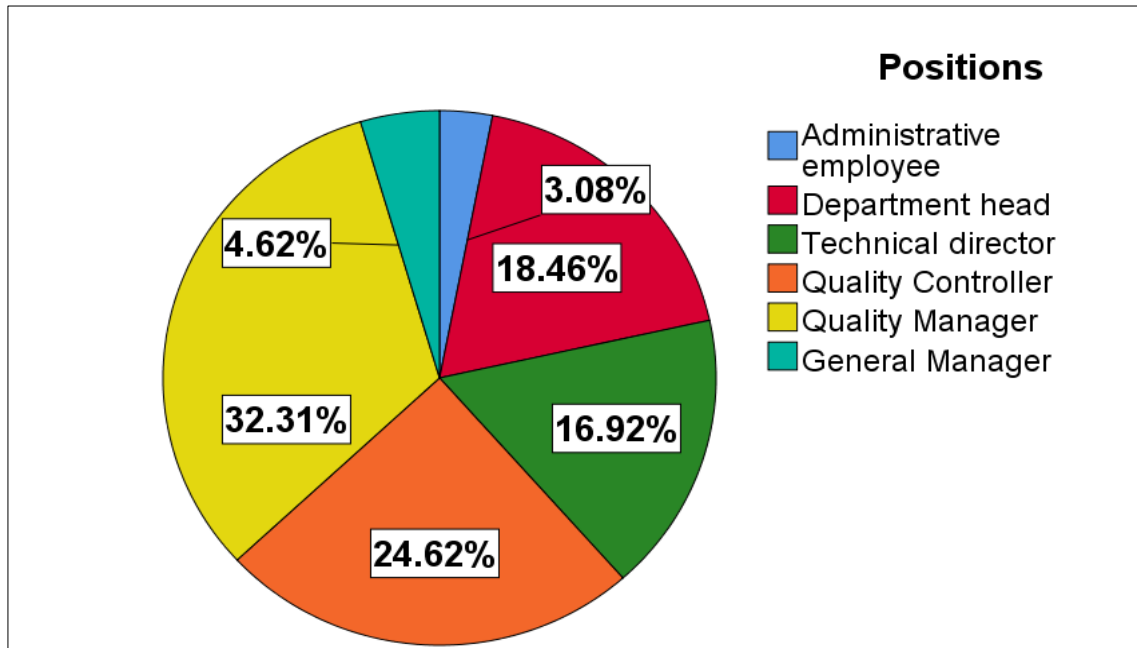


Figure (4-3): Respondents' positions

4.2.1.4 Years of Experience

On the other hand, about 35% of the respondents have an experience of 6 to 10 years in the food manufacturing sector (23 respondents), 32% have an experience of 11 to 15 years (21 respondents), and 15% have an experience of 16 to 20 years (10 participants) and 12% is less than 5 years old (8 respondents) and 4% is more than 20 years old (3 respondents), as it appears from Figure (4-4).

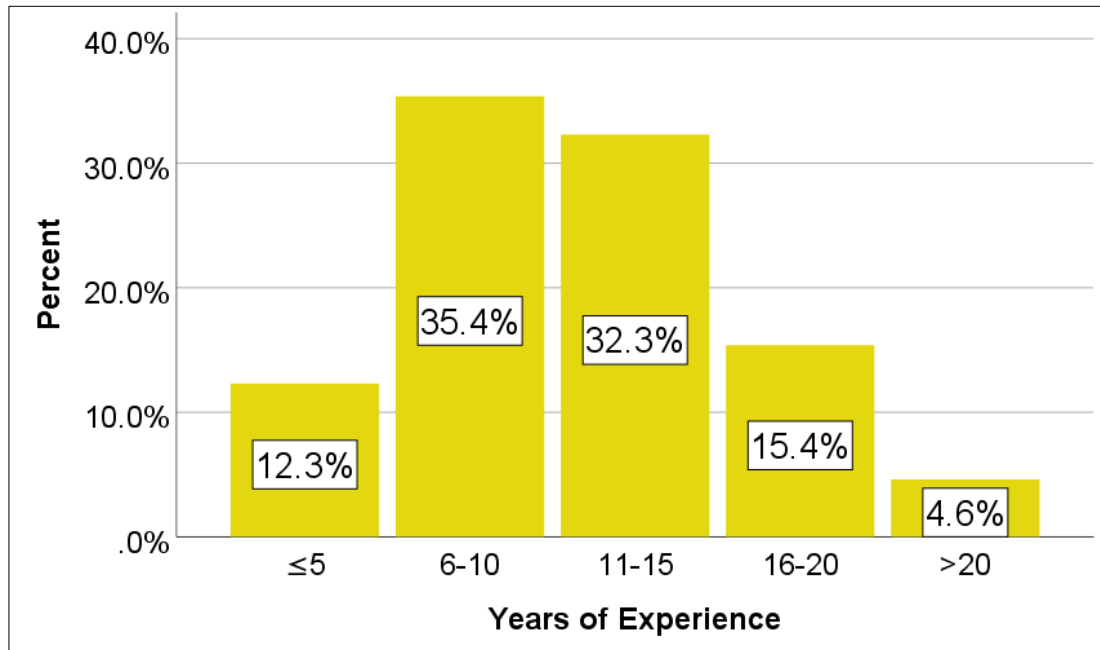


Figure (4-4): Respondents' years of experience

4.2.2 Demographic Profile for the Responding Food Company

4.2.2.1 Eligibility to Participate in the Questionnaire

Out of the 75 selected food manufacturing companies, 65 companies responded to the questionnaire, as not all companies that responded to the questionnaire apply SPC, as it can be seen in Figure (4-5) that about 44% of the responding companies apply the SPC system in their manufacturing operations (29 respondents), and about 55 percent do not apply the SPC system in their manufacturing operations (36 companies).

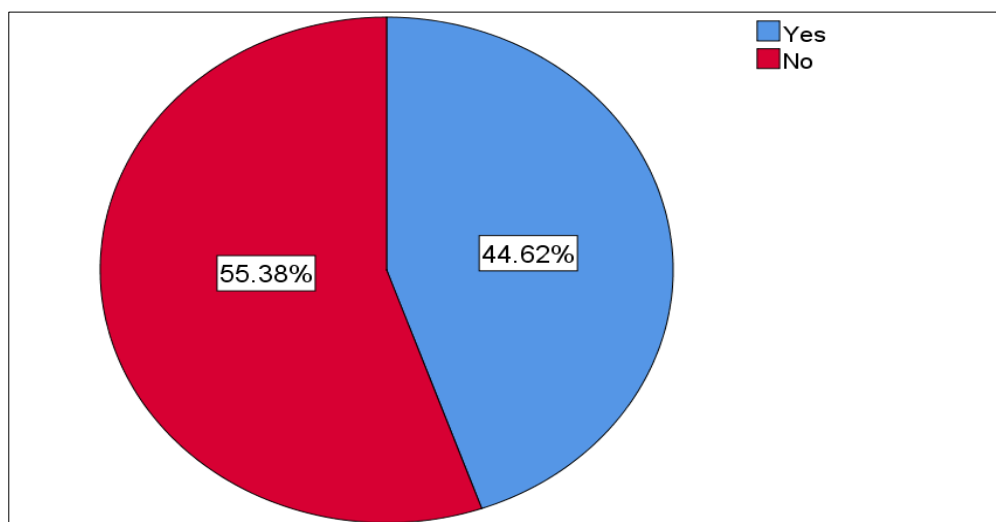


Figure (4-5): Eligibility to participate in the questionnaire

Through the previous part, which represents eligibility to participate in the questionnaire, 36 companies that do not apply SPC in their manufacturing operations were not excluded in order to identify the reasons that prevent the application of this system, and as for the 29 companies that apply this system, the transition to the second section of eligibility to participate in the questionnaire. In the identification of the tools used, the following results appeared: 27.5% of the tools applied are basic statistical processes (8 responding companies), 24.1% apply the check sheet (7 participating companies), 20.6% apply the histogram (6 companies), and 17.2% of the companies Control charts (5 responding companies), 10.3% apply flow charts (3 participating companies), while none of the companies apply the other tools such as Pareto schema, fishbone diagram and scatter plots as shown in Figure (4-6). While the other new tools, such as the affinity diagram and the tree diagram, there was no application of them in all the companies that responded to the questionnaire.

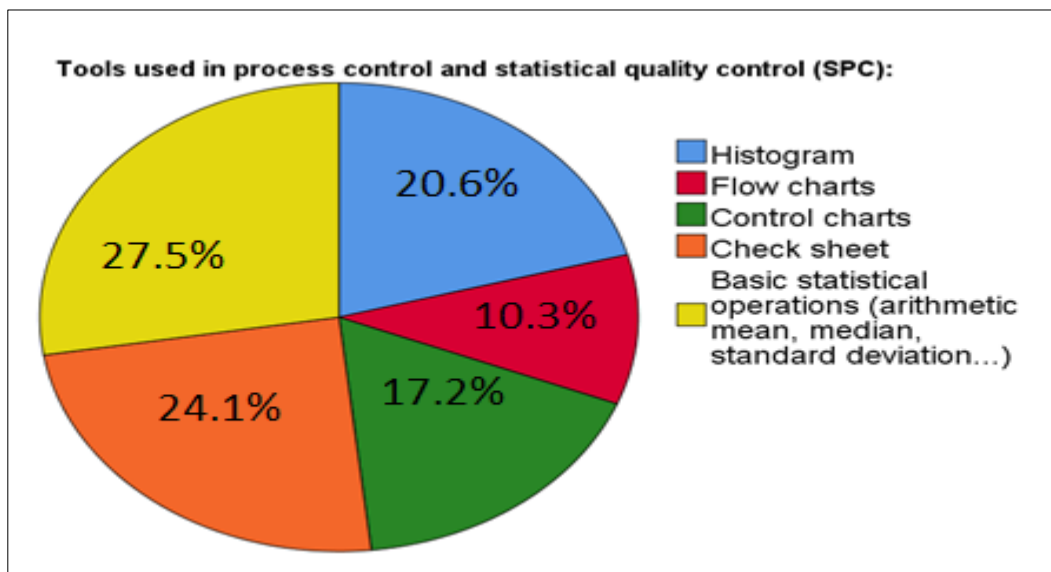


Figure (4-6): Tools used in the company

4.2.2.2 Company's Location

As shown in Figure (4-7), most of the companies surveyed are located in Hebron, with a frequency of 26%, while 21% are located in Ramallah and Al-Bireh. And 15% in each of Nablus and Tulkarm. Also, 12% in the governorate of Jericho and the Jordan Valley, 3% in each of Jerusalem and Jenin, and 1.5% of the companies were located in Bethlehem and Qalqilya, while there were no companies in Tubas.

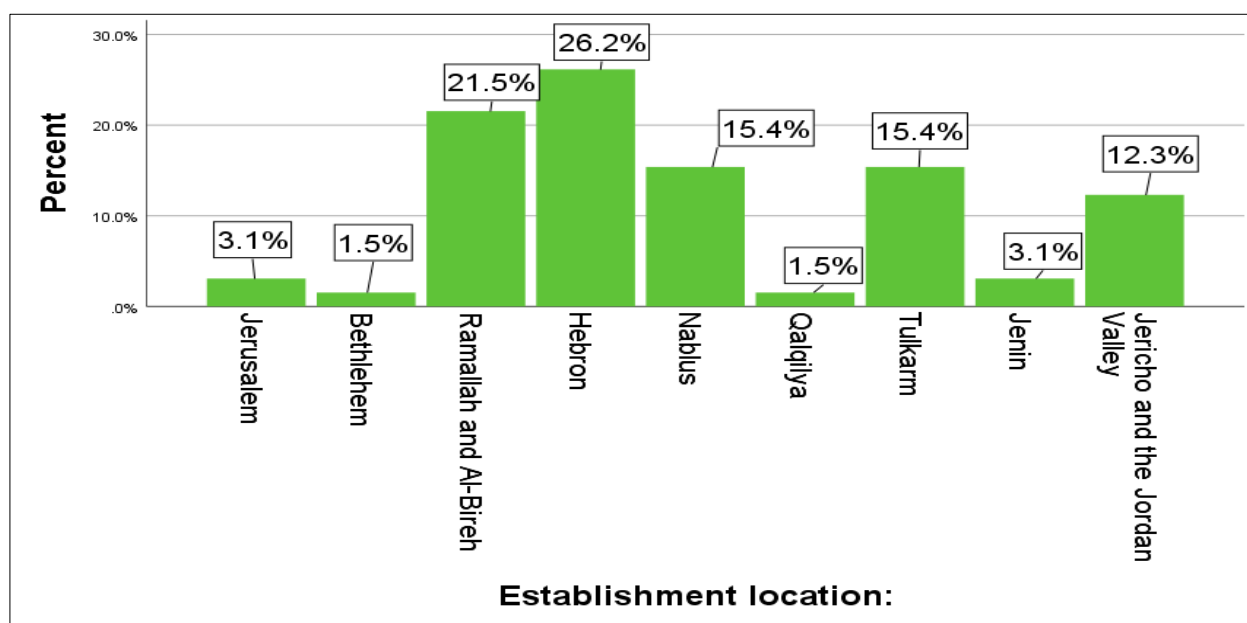


Figure (4-7): Firms Locations

4.2.2.3 Number of Employees

The analysis found that about 7% of the companies surveyed have more than 250 employees, 41% of them have (50 to 249) employees, and 52% of companies have (1 to 49) employees, as shown in Figure (4-8). According to the European Union (EU) and Organization for Economic Co-operation and Development (EU/OECD) classification of company size, companies with (1-49) employees are classified as small, and companies with (50 to 249) employees are classified as medium Companies with more than 250 employees are considered large. Thus, most of the representative companies (52%) are classified as small-sized, and (41%) of the target companies are medium-sized. Meanwhile, only 7% of the target companies are classified as large companies.

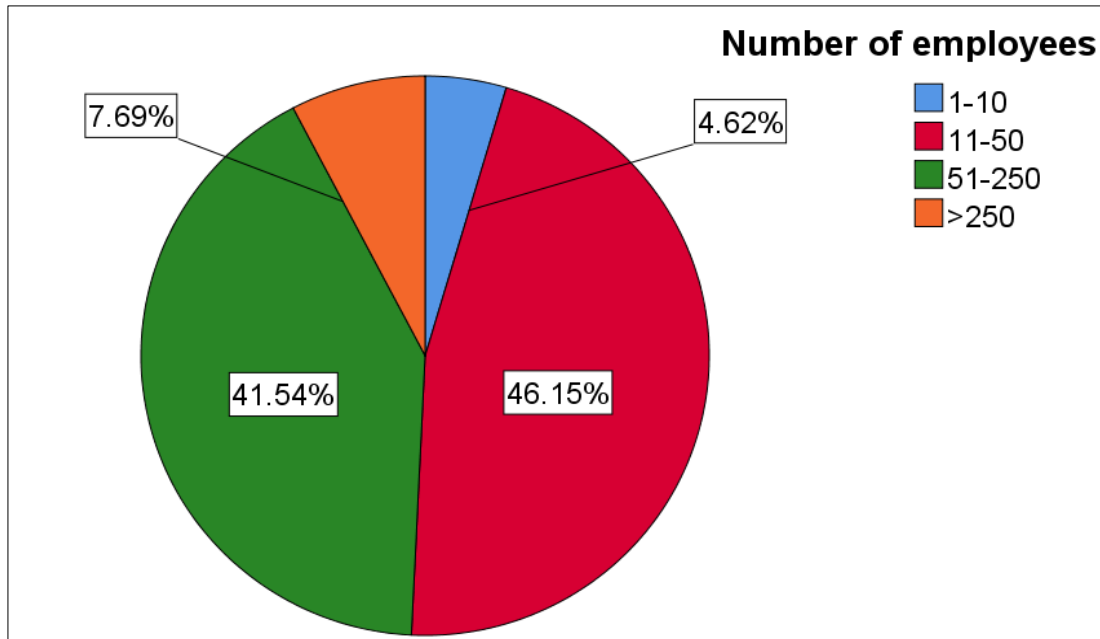


Figure (4-8): Number of Employees in the Firm

4.2.2.4 Firms' Working Years in the Palestinian Market

Figure (4-9) shows that 44% of the targeted companies have been operating in the Palestinian market for 11-20 years, 26% have been operating for 6-10 years, and 14% of the companies have been operating for 21-30 years, while 7% of them work in The Palestinian market has been for 31 years or more, and 11% of the companies have been working in the Palestinian market from 6 to 10 years, and 6% of them have less than 5 years of work.

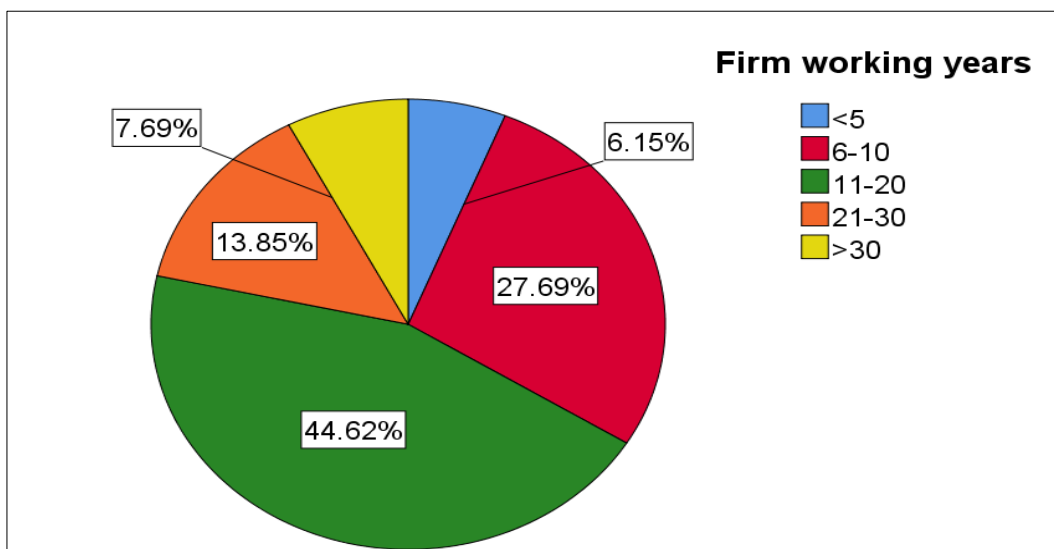


Figure (4-9): Firms Working Years in the Palestinian Market

4.2.2.5 Quality Certificates Obtained by Companies

The results show that 58% of the targeted companies hold PSI certification, 12% hold ISO 9001:2015 certification, 17% hold ISO 22000 and HACCP, and about 14% of the companies did not have quality certification while some of them were attending to obtain PSI certification, as shown in Figure (4-10).

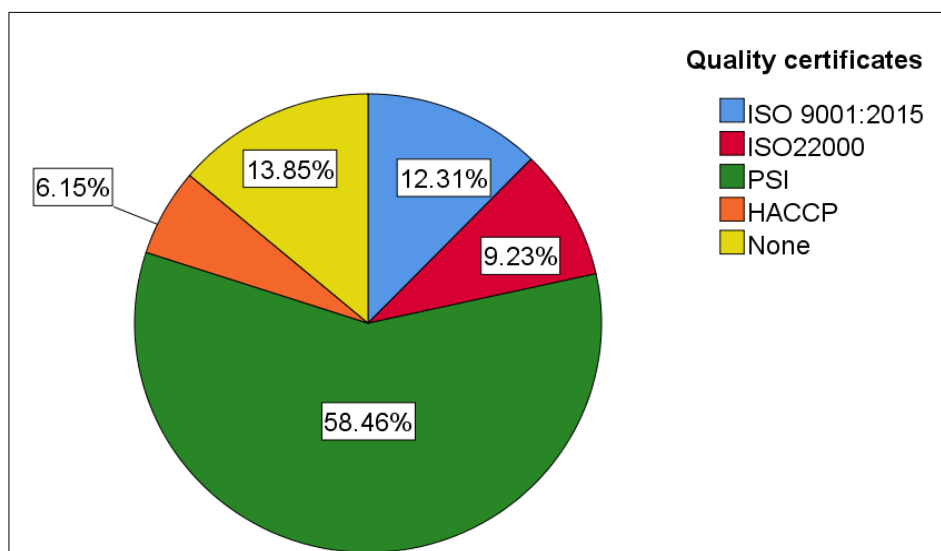


Figure (4-10): Quality certificates obtained by companies

4.2.2.6 Firms Food Subsectors

The sample that was targeted included 15% of the dairy sector companies and 12% of juices and gels, Vegetable and fruit manufacturing products, ice cream products and Ras al-Abed in addition to bottled water products accounted for 9% of each, as well as meat and chips products companies and other products such as salads and tahini, and coffee 7%, and 6% of chocolate and cocoa products, and vegetable and animal oils products and pasta products accounted for 4%, and finally wheat products and soft drinks accounted for 3%, as shown in Figure (4-11).

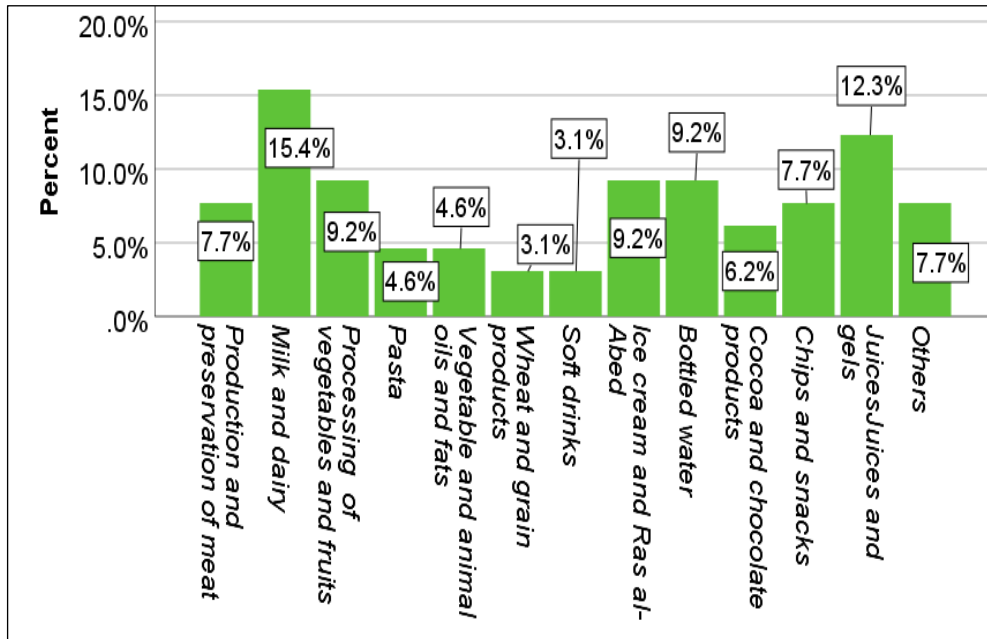


Figure (4-11): Firm's Food Subsectors

4.3 Descriptive Statistics

Descriptive statistics were used in order to assess the general situation inside the food factories in Palestine and to know the extent of SPC application. In this study, a five-point Likert scale was used. Therefore, for the purpose of interpretation of results; the following criterion shown in Table (4-1) has been adopted.

Table (4-1): Likert Scale Analysis (Mean Score)

Mean score	The level of implementation
0.00 – 1.79	Very low
1.80 – 2.59	Low
2.60- 3.39	Moderate
3.40– 4.19	High
4.20– 5.00	Very high

As shown in Table (4-2), the mean and standard of the variables were reported, and the results indicated that the general application level of SPC tools was high. As indicated, the average was slightly higher than the high level for most practices (such as administrative procedures, process

approach, decision making, training in statistical methods, auditing and review of SPC practices).

While in the main obstacles related to quality, the average was slightly less than the high level.

Appendix (5) presents the results of the descriptive analysis of all items used in the study.

Table (4-2): Study variables Implementation Level

Item	Mean	Std. Deviation	Implementation level
Avg_MA	4.127	0.685	High
Avg_PA	4.300	0.614	Very high
Avg_DM	3.920	0.697	High
Avg_SM	3.867	0.845	High
Avg_AR	3.789	0.883	High
Avg_MQO	2.646	1.238	Moderate
Average	3.775	0.827	High

4.4 SEM-Partial Least Squares (PLS) Analysis

4.4.1 Assessment of Measurement Models (Outer Model)

At the beginning, the validity and reliability of the measurement model were checked before analyzing the relationships between the study's variables. Construct validity means the ability of selected indicators to assess the latent construct identified to measure. On the one hand, construct reliability is related to the overall consistency of the measure; in other words: it's about providing same result under various conditions. Construct reliability indicates to what extent the selected items can measure the construct under various conditions in which those same results are to be obtained each time (Ab Hamid et al., 2017).

The outer model assessment includes several examinations, the first is examining convergent validity through measuring item reliability (factor loading), then the internal consistency reliability that can be measured by Cronbach's alpha and Composed Reliability (CR), lastly, the Average Variance Extracted (AVE). The second examination is related to assessing the discriminate validity through Cross loading, Variable correlation - Fornell-Larcker criterion, and HTMT criterion (Hair & Brunsveld, 2019a).

4.4.1.1 Convergent Validity

Convergent validity refers to the valuation or assessment that measures the correlation level of multiple indicators that are in agreement within the same construct. The construct shouldn't correlate with neither related variables nor dissimilar, unrelated ones (Hair et al, 2014). Hence, there are three consecutive approaches to establish the convergent validity within reflective measurement model:

- **Indicator Reliability (Factor Loading):** item reliability is the proportion of item variance that is demonstrated by the latent construct (variable). A common rule of thumb is that the value of outer loadings should be greater than 0.70 to be considered as a reliable item. Moreover, the value of outer loadings should be pointed for deletion if the indicator removal with outer loadings is between 0.40 and 0.70 if it underwrites an increase in composite reliability and AVE. However, outside loading indicators below 0.40 should always be removed and uninvolved (Hair et al, 2014).
- **Composite Reliability (CR):** This measurement is commonly used as an internal consistency tool that measures the reliability according to the interrelationship of the detected items variables. Generally, in exploratory research; values of the composite reliability/Cronbach alpha are considered acceptable between (0.60-0.70). However, values have to be higher than 0.70 in more advanced stages (Hair et al, 2014).
- **Average Variance Extracted (AVE):** The AVE indicates if a sufficient constructs validity exists, therefore it should be higher than 0.50 in which it would mean that the construct explains more than half of its indicator's variance. The average variance extracted can be calculated as the summation of the squared loadings values of the indicators on the construct divided by the number of indicators.

In the assessment process of individual indicator reliability, the current study applied the theory based on the rule that the item with loadings less than 40% should be removed. As a result, 1 item (which is PA01) out of 40 were deleted from the model.

After conducting the three above-mentioned tests to evaluate the convergent validity, Table (4-3) summarizes the final results of the convergent validity tests. It's clear that all indicators have acceptable loading, and the CR value was more than 0.70 for all indicators, which proves the reliability of all items. In addition, the AVE values were above 0.50 for all constructs; indicating an acceptable validity of all constructs.

Table (4-3): Results of Measurements Model- Convergent Validity

Constructs	Items	Item Loading	Composite Reliability (CR)	Average Variance Extracted (AVE)
Managerial Actions	MA01	0.728	0.849	0.546
	MA02	0.517		
	MA03	0.678		
	MA04	0.608		
	MA05	0.720		
	MA06	0.532		
	MA07	0.858		
Process Approach	PA02	0.798	0.862	0.557
	PA03	0.695		
	PA04	0.660		
	PA05	0.844		
	PA06	0.721		
Decision Making	DM01	0.617	0.909	0.669
	DM02	0.882		
	DM03	0.889		
	DM04	0.909		
	DM05	0.778		
Statistical Implementation	SM01	0.787	0.914	0.581
	SM02	0.951		
	SM03	0.818		
	SM04	0.849		
	SM05	0.845		
	SM06	0.711		

	SM07	0.507		
	SM08	0.508		
	AR01	0.579		
	AR02	0.893		
Audit and Review Practice	AR03	0.753		
	AR04	0.917	0.928	0.654
	AR05	0.896		
	AR06	0.855		
	AR07	0.706		
	MQO01	0.826		
	MQO02	0.859		
	MQO03	0.870		
Major Quality Obstacles	MQO04	0.820	0.934	0.671
	MQO05	0.768		
	MQO06	0.808		
	MQO07	0.777		

4.4.1.2 Discriminant Validity

Referred to as the degree of distinct concepts measurement or items differentiation between constructs through investigating the correlations amongst the measures of possibly overlapping constructs (Hair, 2011). Thus, the three criteria to assess the discriminant validity are:

- **Cross-loadings**

In order to examine validity, the correlation or cross loadings of the specific construct indicators should be greater than all loadings on other constructs in the model (Hair et al, 2011). It's obvious that the cross loadings discriminant validity method is confirmed; as shown in Table (4-4) that summarizes all cross loadings of other constructs of the model.

Table (4-4): Cross Loading - Discriminant Validity

Construct	MA	PA	DM	SM	AR	QO
MA01	0.728	0.419	0.345	0.230	0.504	-0.017
MA02	0.517	0.351	0.149	0.202	0.456	-0.218
MA03	0.678	0.303	0.414	0.361	0.571	-0.088
MA04	0.608	0.428	0.480	0.417	0.359	-0.128
MA05	0.720	0.207	0.326	0.330	0.390	0.012
MA06	0.532	0.149	0.211	0.276	0.217	0.227
MA07	0.858	0.535	0.588	0.500	0.477	-0.251
PA02	0.173	0.798	0.453	0.416	0.282	-0.406
PA03	0.446	0.695	0.451	0.315	0.304	-0.263
PA04	0.495	0.660	0.525	0.319	0.322	-0.275
PA05	0.528	0.844	0.573	0.483	0.478	-0.518
PA06	0.358	0.721	0.646	0.562	0.655	-0.295
DM01	0.156	0.261	0.617	0.413	0.403	-0.048
DM02	0.415	0.589	0.882	0.677	0.577	-0.471
DM03	0.492	0.587	0.869	0.674	0.481	-0.368
DM04	0.702	0.741	0.909	0.689	0.590	-0.515
DM05	0.503	0.684	0.778	0.646	0.651	-0.354
SM01	0.356	0.413	0.711	0.787	0.627	-0.213
SM02	0.552	0.588	0.724	0.951	0.707	-0.348
SM03	0.234	0.444	0.503	0.818	0.605	-0.410
SM04	0.521	0.529	0.621	0.849	0.681	-0.458
SM05	0.569	0.548	0.671	0.845	0.644	-0.341
SM06	0.308	0.577	0.575	0.711	0.541	-0.309
SM07	0.324	0.174	0.376	0.507	0.545	-0.058
SM08	0.245	0.112	0.411	0.508	0.197	0.017

AR01	0.439	0.389	0.326	0.55	0.579	0.084
AR02	0.774	0.587	0.714	0.742	0.893	-0.356
AR03	0.492	0.538	0.656	0.656	0.753	-0.378
AR04	0.467	0.514	0.592	0.656	0.917	-0.240
AR05	0.518	0.511	0.610	0.657	0.896	-0.183
AR06	0.349	0.365	0.383	0.575	0.855	-0.084
AR07	0.420	0.301	0.369	0.458	0.706	-0.214
QO01	0.037	-0.126	-0.155	-0.082	0.008	0.826
QO02	-0.007	-0.331	-0.261	-0.266	-0.142	0.859
QO03	0.042	-0.380	-0.249	-0.237	-0.152	0.870
QO04	-0.170	-0.457	-0.362	-0.291	-0.269	0.820
QO05	-0.248	-0.280	-0.376	-0.331	-0.157	0.768
QO06	-0.135	-0.578	-0.531	-0.442	-0.397	0.808
QO07	-0.030	-0.286	-0.400	-0.236	-0.084	0.777

- **Variable correlation - Fornell- Larcker criterion (1981)**

In the Fronell-Lacker measurement tool, the construct's variance and indicators were larger than any other variance of the construct. Therefore, the construct AVE has to be greater than its highest squared correlation with another construct (Abd Hamid et al., 2017). Thereafter, this has been confirmed for the model that used constructs as presented in Table (4-5)

Table (4-5): Fornell-Larcker criterion - Discriminant Validity

Construct	AR	DM	MA	PA	QO	SM
AR	0.809					
DM	0.666	0.818				
MA	0.626	0.580	0.672			
PA	0.581	0.723	0.525	0.747		
QO	-0.260	-0.456	-0.121	-0.480	0.819	
SM	0.771	0.769	0.526	0.586	-0.377	0.762

- **Hetertrait-Monotrait Ratio (HTMT)**

Heterotrait-Monotrait ratio of correlations (HTMT) is a third approach that is proposed to have better assessment of discriminant validity. Henseler et al (2015) stated that it must be highlighted that neither the Fornell-Larcker test nor the cross-loadings adequately determine the discriminant validity; as recent research proposes that - under certain circumstances- the Fornell-Larcker criterion is not effective, as the Fornell-Larcker criterion and the assessment of cross loadings have an unacceptably low sensitivity; which means that they are largely unable to detect a lack of discriminant validity. Therefore, HTMT is a new methodology to evaluate discriminant validity in the variance-based SEM. Values less than 1 mean sufficient reliability (Henseler et al., 2015). The model's discriminant validity is at the satisfactory level as shown in Table (4-6), which shows that the estimated values of HTMT's for all constructs were less than 1.

Table (4-6): Heterotrait-Monotrait Ratio (HTMT) - Discriminant Validity -

Construct	AR	DM	MA	PA	QO	SM
AR						
DM	0.731					
MA	0.757	0.651				
PA	0.624	0.821	0.679			
QO	0.281	0.471	0.315	0.485		
SM	0.842	0.864	0.608	0.655	0.395	

After checking the above-mentioned examinations, it can be concluded that the discriminant validity of this study's model was established. Figure (4-12) below shows the overall and adopted measurement model of the study.

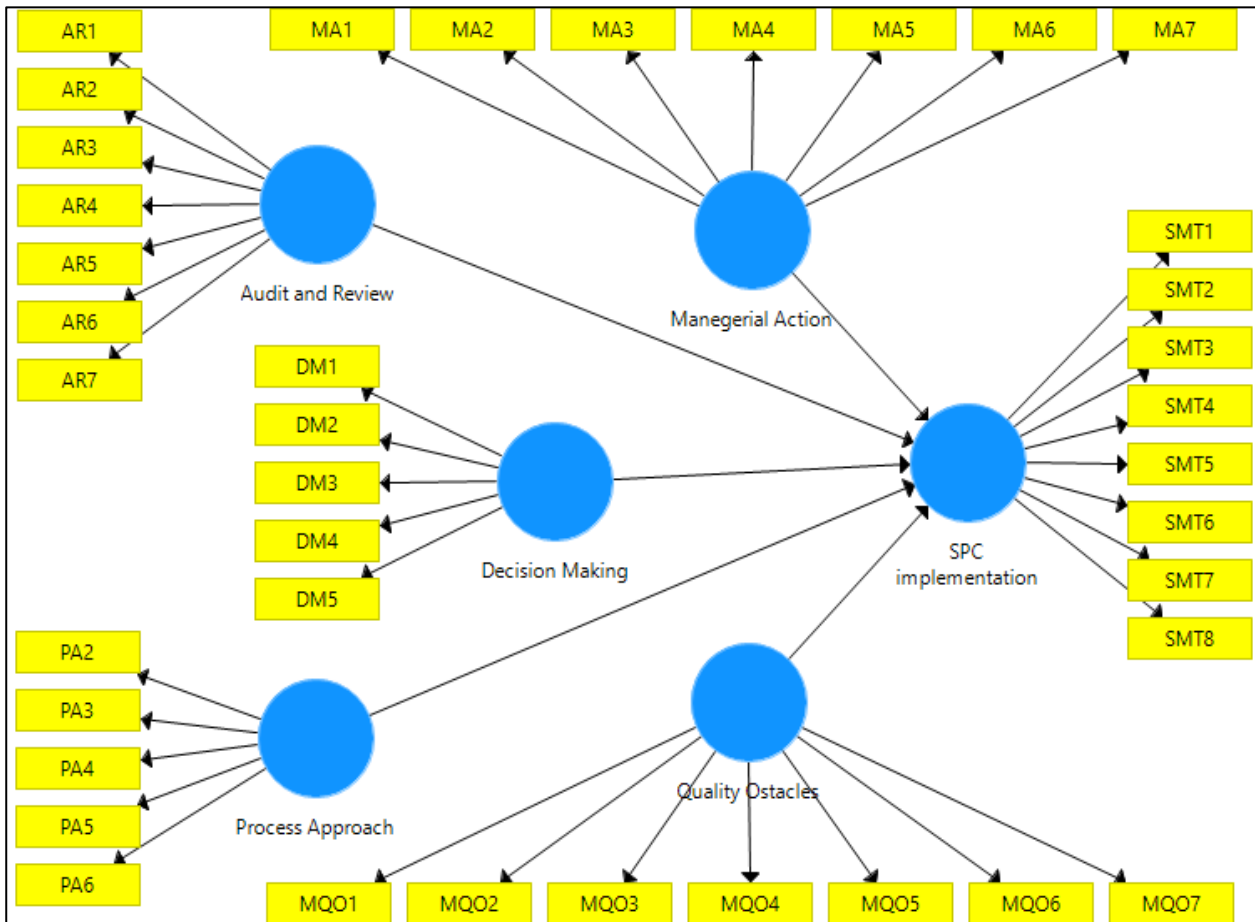


Figure (4-12): The measurement model

4.4.2 Assessment of Structural Models (Inner model)

After getting a satisfactory measurement model by confirming both reliability and validity of the model, the structural model results were checked by examining the constructs relationships and the predictive capabilities of the model. Therefore, in order to assess the structural model; four criterions were used: the significance of the path coefficients, the effect size (f^2), the coefficient of determination (R^2), and the predictive relevance (Q^2).

- **Coefficient of Determination (R^2)**

The coefficient of determination (R^2) embodies the model's predictive accuracy. It's a coefficient that is concerned in measuring the model's explanatory power and the variance enlightened by the endogenous constructs. The R^2 can range from 0 to 1, with lower values indicating lesser accuracy and explanatory power. Chin (1998), suggested that the values of R^2 that above 0.67 considered high, while values ranging from (0.33 -0.67) are moderate, whereas values between (0.19 - 0.33) are weak and any R^2 values less than 0.19 are unacceptable. Table (4-7) displays the value of R^2 for all endogenous latent variables, which indicates the dependent variable had achieved a high score of R^2 .

Table (4-7): Coefficient of Determination R^2

Construct	R Square	R Square Adjusted	Result
Statistical method implementation	0.718	0.694	High

- **Effect Size (f^2)**

The effect size (f^2) is progressively stimulated and encouraged by journal editors and reviewers. In addition to evaluating the R^2 values of all endogenous constructs, there is the f^2 that measures the change in the R^2 value when a specified exogenous construct is omitted from the model; that can be used to evaluate whether the omitted construct has a substantive impact on the endogenous constructs or not. Guidelines for assessing f^2 values are: if the value less than 0.02 then it means that it has no effect size, between (0.02- 0.15) means having small effect size, between (0.15-0.35) means medium size effect, and values above 0.35 are considered to have a large effect size (Hair et al, 2014).Table (4-9) displays the value of f^2 for all exogenous latent variables.

Table (4-8): The Effect Size (f^2) result

Construct	Statistical method implementation	Result
Audit and Review SPC Practice	0.402	Large effect size
Decision Making	0.274	Medium size effect
Managerial Actions	0.003	Small effect size
Process Approach	0.004	Small effect size
Major Quality Obstacles	0.010	No effect size

- **Blindfolding and Predictive Relevance (Q^2)**

This is a measure used as an indicator of the out-of-sample predictive power or relevance of the model. Blindfolding procedure is followed to estimate the Stone-Geisser's Q^2 value. In comparison, when a PLS path model displays predictive relevance, it precisely forecasts the unused data in the model estimation. Whereas in the structural model, Q^2 values larger than zero for a specific reflective endogenous latent variable specify the path model's predictive relevance for a specific dependent construct (Hair et al, 2014). Table (4-9) below summarizes the values of Q^2 for the endogenous latent variable, this value is greater than zero. Thus, the model has sufficient predictive quality.

Table (4-9): Cross-Validated Redundancy approach (Q^2)

Construct	*SSO	**SSE	$Q^2 (=1-SSE/SSO)$
Audit and Review SPC Practice	455.000	455.000	
Decision Making	325.000	325.000	
Managerial Actions	455.000	455.000	
Process Approach	325.000	325.000	
Major Quality Obstacles	455.000	455.000	
Statistical method implementation	520.000	311.325	0.401

*SSO is the sum of squares of observations

**SSE is the sum of squares of prediction errors.

It's significant to know that the Q^2 value is determined by using the cross-validated redundancy approach -as mentioned in Table (4-9) above- which embodies on the path model evaluations of both the scores of antecedent constructs (structural model) and the target endogenous construct

(measurement model) of data prediction. As a result, prediction by means of cross validated redundancy suits the PLS-SEM approach perfectly.

- **Goodness-of-Fit (GoF) Model**

The goodness of fit model (GoF) refers to the ability of relying on the model that was developed, for both the measurement and structural models. In other words, it represents the degree to which the study model was fit. It's calculated by the geometric mean of both AVE and R² of the endogenous through the following equation:

Equation (4-1): Goodness of Fit model calculation

$$\text{GoF} = \sqrt{R^2 \times AVE}$$

For this study, $\text{GoF} = \sqrt{0.694 \times 0.596} = 0.643$

Wetzels et al. (2009) derived the following criteria to judge GoF values:

- No fit: If GoF value is less than 0.1.
- Small fit: If GoF value between (0.1-0.25).
- Medium fit: If GoF value between (0.25-0.36).
- Large fit: If GoF value is greater than 0.36.

Thus, after applying the GoF equation- the calculated GoF value for the study's model was 0.643, which means that the model has a sufficient global PLS model validity.

- **Path Coefficients (Hypotheses Testing)**

After running the PLS-SEM algorithm, the structural model was estimated to test the relationships among the study model. The path coefficient test was used to validate the proposed hypotheses and estimate the path coefficient significance. The values of path coefficients were between (-1 to + 1). Values close to + 1 represent strong positive relationships, and values close to - 1 represent strong negative relationships. PLS bootstrapping was employed by for hypotheses testing. The results from deploying bootstrapping are depicted in Table (4-10). Specifically, the results showed that there was a strong positive significant effect of auditing on the implementation of SPC tools where the P value

was less than 0.05, which supports the proposed hypothesis (H1); where ($\beta = 0.496$, T-value = 0.066 and P-value = 0.000). Similarly, there is a strong positive effect of decision-making on the implementation of SPC tools where the P-value was less than 0.05, which supports the proposed hypothesis (H2); where ($\beta = 0.469$, T-Value = 0.085 and P-value = 0.000). On the other hand, a negative relationship was found for managerial actions with the implementation of (SPC) tools, but it was not significant, where the P-value was higher than 0.05 with ($\beta = -0.037$, T-Value = 0.085 and P-value = 0.672), indicating that H3 is not supported because the P-value was above 0.05. In addition, there was a negative relationship between the process approach and the implementation of (SPC) tools - which is also a non-significant relationship, since the P-value was higher than 0.05, which means that H4 is not supported, where ($\beta = -0.052$, T-Value = 0.131 and P-value = 0.691). As well as a negative relationship was found for the major quality obstacles with the implementation of (SPC) tools but it is a non-significant relationship. Where the P-value was higher than 0.05 with ($\beta = -0.064$, T-Value = 0.090 and P-value = 0.480), indicating that H5 is not supported because the P-value was above 0.05.

Table 1(4-10): Path Coefficient of the Research Hypotheses

HYP.	Path	Standard Beta (β)	Standard Deviation (STDEV)	T-value	P-value	Result
	Managerial Actions ->					
H1	Statistical method implementation	-0.037	0.087	0.423	0.672	Not Supported
	Process Approach ->					
H2	Statistical method implementation	-0.052	0.131	0.395	0.691	Not supported
	Decision Making ->					
H3	Statistical method implementation	0.469	0.085	5.510	0.000	Supported
	Audit and Review SPC					
H4	Practice -> Statistical method implementation	0.496	0.066	7.460	0.000	Supported
	Major quality Obstacles ->					
H5	Statistical method implementation	-0.064	0.090	0.708	0.480	Not Supported

Chapter Five

Discussion

5.1 Overview

In this chapter, the results of the analysis are interpreted and discussed. In the beginning, the results related to the evaluation of the application of SPC in food factories were discussed, and then the research questions and their answers are addressed, and then the tested hypotheses are explained.

5.2 Discussion of Results

Despite the successes achieved by the implementation of SPC in food companies in some countries of the world, as explained after previous studies, as shown in Table (2- 2), this study came to reveal the application of SPC in food companies in Palestine through an assessment that targeted most types of food industries. Based on the results obtained, the following theoretical implications are drawn.

5.2.1 Assessment of SPC Implementation in Palestine Firms

Based on what was obtained from the MoNE and the Federation of Food Industries about food companies in Palestine, most food companies are small. They depend on the old technology in machines, as it was found that 44.6% of the targeted companies implement SPC and that most of them are small companies in their size, 46% of the targeted companies. This means that the institution's size has a major role in the implementation of SPC because it depends on the method of competition between each other to obtain a larger market share. The rate of respondents' approval of the process approach achieved a score of (4.3), which means that each company has its approach and the method that differs from other companies and also varies based on the size of the company.

But in general, the responses from the questionnaire showed that most companies do not have good practices in every aspect of implementing SPC in the food industry. Limitations that have been investigated such as the lack of a clear plan from the top management to implement control schemes, the absence of a culture of quality as a supreme value in the work environment, outdated technology of machines and methods used, low skills of machine operators in the production process causing

inconsistency of basic product parameters. Also, sometimes management is not willing to accept suggestions, comments and complaints from employee related to parameters fluctuations in the process. The absence of periodic training for everyone in the department on SPC implementation tools, inconsistency to take corrective actions for defects, inability of the company to implement all SPC tools to control and improve the production process/products (use control chart only), inadequate training of production process operators, and some companies were found to implement part of the SPC tools. When comparing the data collected from these companies, the data shows that some production parameters are not under control. Some are slightly higher, and some are lower than the standards. This kind of difference is completely normal in the production process. Because no two products are exactly alike due to slight differences in materials, workers, machines, tools, and other factors, these are called common or random causes of variation. As these companies have successfully implemented some of the SPC tools, some benefits can be summarized as follows: reduced non-conforming products, reduced risk of product recalls, reduced customer complaints, and improved process visibility.

5.3 Critical Reflections on the Research Questions

The main objective of the thesis is to contribute, both theoretically and practically, to the evaluation of SPC implementation in Palestinian food industries. The research began with a broad question: How is SPC successfully implemented in the food industry? Three research questions were formulated following the research gaps identified in the systematic review:

5.3.1 RQ1: What extent SPC tools are applied in Palestinian food industry?

In addressing the gap in the knowledge body for SPC, this research determined that the broad application of SPC in the food industry in Palestine is still slow, with 44% of the 65 food companies participating in the research progressing to apply SPC in parts of their operations. Moreover, the majority of SPC users are aware of and apply some tools such as histogram, flowcharts, and basic statistical operations. In addition, contextual factors such as the size of the organization and the commodities of key products that influenced the adoption of SPC in this sector were identified.

However, certifications such as ISO 9001, ISO 22000, and HACCP do not have a significant impact on SPC implementation. It was identified that although these certifications require operations to be managed systematically, there is a lack of recommendation for implementing the SPC practices guidelines and SPC is not available.

On the other hand, previous studies showed as in Table (2-2) that the application of SPC in food industries of all kinds helps to reduce non-conforming products and continuous improvement of operations in addition to achieving financial returns for the company. The benefits have been achieved with the companies that apply SPC in Palestine, as it was found that they have a small percentage of defective products and have the ability to take appropriate corrective and preventive measures when a problem occurs during the production stages, in addition to that these companies are working on developing machines and training their employees to ensure the achievement and implementation of the tools that they use it in the company.

5.3.2 RQ2: What factors critically inhibit and facilitate the SPC implementation in Palestinian food industry?

Studies such as Bjerke & Hersleth (2001) and Davis & Ryan, (2005) illustrate some of the CSF for SPC implementation as a commitment of senior management, reliable measurement systems, understanding of ST among employees, employee training and communication, employee empowerment, and availability of SPC expertise. The results in this study indicated a new CSF for SPC implementation which is designating a dedicated leader for SPC.

The study showed some of the common inhibiting factors in companies such as lack of training for continuous improvement initiatives CI and lack of awareness about SPC and that food companies are under severe pressure to ensure a safe food product so employees are trained on food safety systems instead of training on CI. This study identified that intrinsic resistance to change has been cited as a significant hindrance that validated the finding in the literature, the slow spread of SPC and high resistance lead to investigation of why food companies did not adopt SPC. Lack of awareness of the existence of SPC and lack of knowledge of the basic philosophy of SPC and its advantages are

revealed. Again, this has contributed to a lack of training to teach and update quality improvement techniques to employees.

5.3.3 RQ3: What is the proper conceptual framework of implementing SPC tools in Palestinian food industry?

Based on the results of testing the hypotheses, Table (4-10), the conceptual framework shown in Figure (5-1) was reached, as DM and AR are among the most influencing factors on the implementation of SPC because every important operation requires serious decisions to be taken at the right time and place. Therefore, this decision does not need an implementation machine; I need to follow up, review and ensure its implementation.

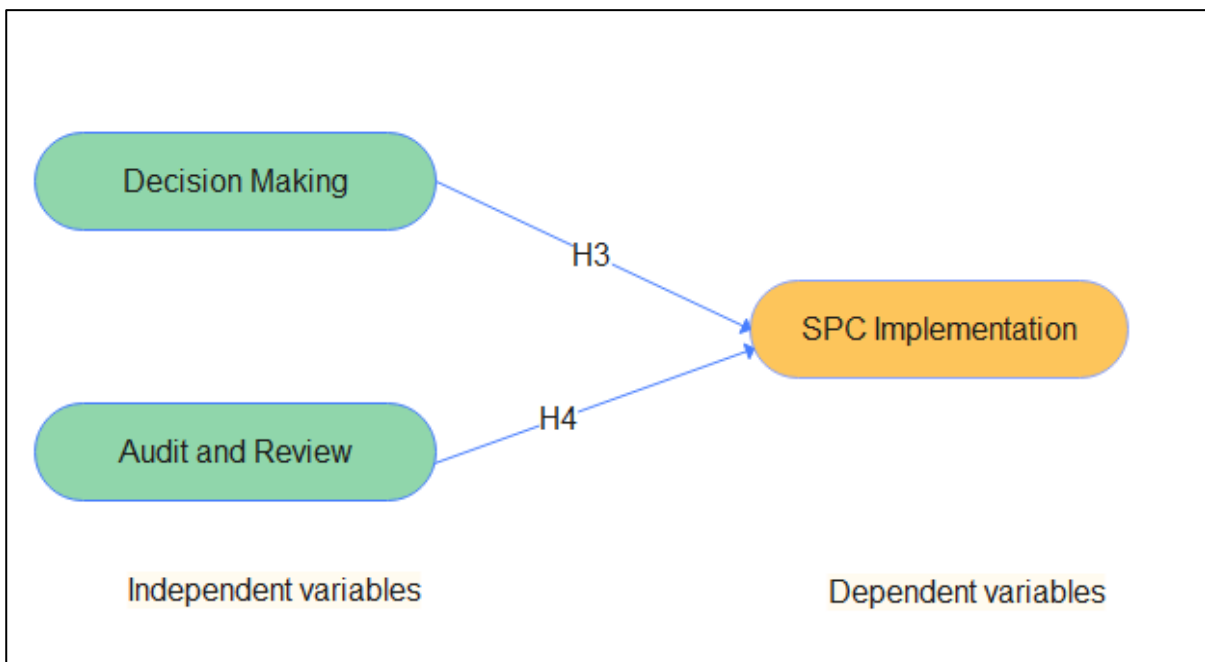


Figure (5-1): A Conceptual Framework

5.4 Hypothesis Testing Results

Depending on the results of hypotheses testing in Table (4-10), all the first, second and fifth hypotheses were rejected. This means that there is a statistically significant relationship between the MA, PA and MQO with the implementation of SPC.

As for the third and fourth hypothesis, it was supported and Fail to rejected, which indicates that there is no statistically significant relationship between DM and AR with the implementation of SPC.

These results support what was obtained from some previous studies such as Bjerke & Hersleth (2001) and Gauri (2003) and other studies that have been conducted where the implementation of such tools requires administrative approval and continuous administrative support.

Chapter Six

Conclusions and Recommendations

6.1 Overview

In this chapter, the results of the study are completed and summarized. Moreover, the recommendations for food factories in order to activate and implement SPC in future days are highlighted. This chapter also presents the study's limitations and offers suggestions for future research.

6.2 Conclusions

This study supported the results of previous studies and proved the role and effectiveness of SPC implementation in various sectors, especially the food industry sector. Based on extensive literature reviews, a set of relevant hypotheses have been formulated and a new model for evaluating the application of SPC has been developed. According to the analysis of data collected from a sample of Palestinian food companies, this study makes several key disclosures.

- This study is the first of its kind in Palestine in this field and was limited to the food industries sector in Palestine due to the importance of this sector in supporting the Palestinian economy.
- The study proved that there is a significant positive impact of both audit and review on SPC practices and decision-making on the implementation of SPC tools, which requires companies to focus and pay attention to these two factors to obtain the best results.
- The study showed that the implementation of SPC in the food industry is related to obtaining quality certificates and not only for quality control and improvement, but also for quality assurance purposes.
- Quality obstacles in companies such as old technology of machines, poor maintenance and handling of machines, and the absence of a culture of quality as a supreme value in the work environment play a key role in the failure to implement such tools, which in turn also affect the success of companies.

6.3 Recommendations

In light of the achieved results, several recommendations are presented to Palestinian food companies.

- The Federation of Food Industries should increase the awareness about quality as a supreme value in the work environment and encourage senior management to adopt the responsibility of implementing SPC and provide the necessary support. Considering that SPC tools have the potential to improve the quality of the company's products, top management should be aware about the impact of SPC implementation in the organization. SPC requires changes in leadership style in order to use SPC to increase process quality and SPC it is a technique to control and reduce process variance.
- Forming quality improvement teams consisting of employees from the quality department, production and laboratory who have consistent training in to plan for SPC implementation in food industries.
- Continuous planning for SPC training, the company is in dire need to provide consistent training, so it is highly suggested that SPC implementation training be provided at every level within the organization to all employees, and includes SPC training on other quality tools and techniques to improve process and product quality. Continuing training courses help to raise awareness for all employees and can help the company to achieve the goals through which to increase the competitive advantage.
- Palestinian food companies are advised to address the obstacles and constraints facing the implementation of SPC, especially on the development of new machines.
- Permanently checking out the quality of raw materials before they are accepted and do not accept raw materials that do not comply with the standards (the quality of raw materials is the main factor for changing product standards).
- Continuous calibration of production machines and quality control during a regular period should be conducted.

6.3 Research Limitations and Future Researchs

This study faced several limitations. First, most respondents did not have full knowledge of all SPC tools as they are considered advanced. Second, not all licensed Palestinian food companies applied SPC tools. Therefore, the target sample for collecting results and knowing the importance of SPC and its benefits in the food industries for this study was small. Third, this study developed a conceptual framework for examining the relationship between SPC implementation and product improvement in certain circumstances. Thus, verifying and retesting it in other situations is necessary. Ultimately, future research may investigate moderating factors influencing this relationship such as company size, company age, company experience implementing SPCs, etc. Meanwhile, this study only followed the quantitative approach, where the qualitative approach and interviewing the respondents were difficult due to confidentiality and non-disclosure of food industry secrets. Therefore, future research may follow quantitative and qualitative methods to enrich the results.

Moreover, most companies use SPC tools only in analyzing surveys to measure customer satisfaction and to follow up on complaints about product improvement.

Finally, the scope of this study is the food industry. Thus, the results do not apply to other sectors. Therefore, more work can collect comprehensive data and extend the research to other industrial sectors.

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Appendices

Appendix (1): Questionnaire in English language



الجامعة العربية الأمريكية
ARAB AMERICAN UNIVERSITY
FACULTY GRADUATE

Dear Participant,

The researcher Ali Jebreen from the Department of Quality Management at the Arab American University is conducting a study entitled “**Assessing the Statistical Process Control Implementation in Palestinian Food Industries: An Empirical Study.**” Knowledge of productivity improvement techniques using SPC tools in the food industry.

All information collected through the questionnaire will be used to contribute to knowledge only, so please make sure to mark (X) on all submitted data otherwise incomplete responses will not meet the requirements of the researcher, to this end please kindly answer the following short questions regarding the objective Advertiser, It will not take you more than (8) minutes of your time, your response is extremely important to me, so the real, honest and prompt response is the input available to the quality of the project, and if you have any inquiries please send me the following email: a.jebreen@student.aaup.edu

Thank you very much for your kind cooperation.

Researcher: Ali Jebreen

DI07	Age of the firm (in years): <input type="checkbox"/> ≤5 <input type="checkbox"/> (6-10) <input type="checkbox"/> (11-20) <input type="checkbox"/> (30-21) <input type="checkbox"/> more than 30
DI08	Quality certificates obtained by the company: <input type="checkbox"/> ISO 9001:2015 <input type="checkbox"/> ISO22000 <input type="checkbox"/> PSI. <input type="checkbox"/> HACCP <input type="checkbox"/> ISO 14001 <input type="checkbox"/> None <input type="checkbox"/> Others, specify them (please):
DI09	Products produced by the company (you can choose more than one option if there is more than one): <input type="checkbox"/> Production and preservation of meat <input type="checkbox"/> Milk and dairy <input type="checkbox"/> Processing and preservation of vegetables and fruits <input type="checkbox"/> Pasta <input type="checkbox"/> Vegetable and animal oils and fats <input type="checkbox"/> Wheat and grain products <input type="checkbox"/> Soft drinks <input type="checkbox"/> Ice cream and Ras al-Abed <input type="checkbox"/> Bottled water <input type="checkbox"/> Cocoa and chocolate products <input type="checkbox"/> Chips and snacks <input type="checkbox"/> Juices and gels <input type="checkbox"/> Others, specify them (please):

Section Three: Study Variables

This section consists of 6 parts, please answer all of them, by placing a circle around the number that represents the best description, so that the degree is divided from (1-5) as shown below, noting that the higher number indicates the higher degree of approval while the lower number indicates at the lowest degree of approval. Please put an "X" under the option that applies to your company.

1- Managerial Actions

Code	Clause	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
MA01	There is a clear plan from the top management to implement the control schemes.					
MA02	Top management regularly defines quality improvement efforts.					
MA03	The information of planning control schemes is used by top management.					

MA04	Senior management provides clear support for the use of control schemes throughout the company.					
MA05	Top management is ready to accept any suggestions, comments and complaints from the employee.					
MA06	Senior management provides the necessary financial support for training programs to develop the knowledge and skills of employees.					
MA07	Top management is concerned with removing obstacles to the application of control schemes.					
2- Process Approach						
Code	Clause	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
PA01	The company uses statistical methods to adjust operations according to the required specifications.					
PA02	Processes are designed to ensure the application of quality at all stages of production, starting from raw materials, through production, and ending with packaging, storage and distribution.					
PA03	The company documents all operations in a clear and understandable manner for all employees.					
PA04	There are work procedures that clarify the responsibilities and powers of the employees.					
PA05	The company has a monitoring and control system in the operations.					

PA06	The company uses statistical methods to compare the results of laboratory tests for foodstuffs during the production stage.					
3- Decision Making						
Code	Clause	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
DM01	The decision is made based on the available data and statistics.					
DM02	Decisions made in the company are applicable.					
DM03	Data is checked and analyzed for accuracy before relying on it.					
DM04	The company has approved methods for data collection and analysis.					
DM05	The company's decisions depend on the variance that appears from SPC tools in the results of food laboratory tests.					
4- Statistical Method Implementation						
Code	Clause	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
SMT01	All employees in the quality department receive training in building quality schemes.					
SMT02	All the employees in the control department have received training to apply various tools on the production line to improve the quality.					
SMT03	Everyone in the quality control department can describe what the control chart says about the product's process performance/characteristics.					

SMT04	Technical staff experts are able to answer technical questions arising from the use of control charts.					
SMT05	We have the ability to solve problems arising from the application of control charts.					
SMT06	Technical staff experts have sufficient knowledge of food safety laws to ensure that no deviation from the specifications limits.					
SMT07	The company requires suppliers of its production inputs to apply SPC methods in order to be certified as suppliers by the company.					
SMT08	The company requires its suppliers to obtain quality certificates such as ISO, PS, HACCP and others in order to be approved by the company for supply.					

5- Audit and Review SPC Practice

Code	Clause	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
AR01	The company continually documents the capability of its manufacturing process.					
AR02	The limits of the control charts for parameters associated with the manufacturing process are updated as the process changes.					
AR03	Easy to update information about the manufacturing process.					
AR04	SPC implementation is periodically audited to identify process improvement opportunities.					

AR05	A periodic review of SPC activities in the company is made.					
AR06	The company conducts a periodic audit through field visits on the system of applying SPC methods in the facilities of suppliers					
AR07	The company conducts statistical tests for the materials supplied by the suppliers and decides to accept or reject them (return them to the supplier).					
6- Major Quality Obstacles						
Code	Clause	Strongly agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly disagree (1)
MQO01	Failure of senior management to improve quality in the company.					
MQO02	The absence of a culture of quality as a supreme value in the work environment.					
MQO03	The company does not plan to improve its operations.					
MQO04	The technology used in machinery and equipment is outdated.					
MQO05	Insufficient training for production process operators.					
MQO06	Lack of awareness of SPC tools by operators.					
MQO07	Poor maintenance and handling of machinery and equipment in the company.					

➤ **Any other comments or additions that you would like to express:**

.....

Thank you for your cooperation

Appendix (2): Questionnaire in Arabic language



الجامعة العربية الأمريكية

ARAB AMERICAN UNIVERSITY

FACULTY GRADUATE

السيدات / السادة المحترمين:

يجري الباحث علي جبرين من قسم إدارة الجودة في الجامعة العربية الأمريكية دراسة بعنوان " تقييم تطبيق ضبط العمليات الإحصائية (SPC) في الصناعات الغذائية الفلسطينية: دراسة تطبيقية"، والبحث الجاري هو جزء من دراستي لاستكمال درجة الماجستير وأجري لأغراض أكاديمية بحثية، والغرض من هذا البحث هو معرفة تقنيات تحسين الإنتاجية باستخدام أدوات (SPC) في الصناعات الغذائية.

سيتم استخدام جميع المعلومات التي تم جمعها من خلال الاستبيان للمساهمة في المعرفة فقط ، لذا يرجى التأكد من وضع علامة (×) على جميع البيانات المقدمة وإلا فإن الردود الغير مكتملة لن تفي بمتطلبات الباحث ، ولهذه الغاية يرجى التفضل بالإجابة عن الأسئلة الآتية القصيرة فيما يتعلق بالهدف المعلن، لن يستغرق الأمر منك أكثر من (8) دقائق من وقتك ، رداً في غاية الأهمية بالنسبة لي ، لذلك فإن الاستجابة الحقيقية والصادقة والسريعة هي المدخلات المتاحة لجودة ورقة بحث المشروع وإتمامها بنجاح ، وإذا كان لديكم أي استفسار يرجى مراسلتي على البريد الإلكتروني الآتي:

a.jebreen@student.aaup.edu

ولكم جزيل الشكر والاحترام على حسن تعاونكم.

الباحث: علي جبرين

القسم الأول: أهلية المشاركة في الاستبيان:	
M01	هل تطبق الشركة مراقبة العمليات وضبط الجودة الاحصائي (SPC)؟ <input type="checkbox"/> نعم <input type="checkbox"/> لا
	إذا كانت إجابتك ب (لا) على السؤال السابق فيرجى إكمال الاستبيان للتعرف على المعوقات التي تحول دون تنفيذ (SPC) ، أما إذا كانت إجابتك ب (نعم) على السؤال السابق فيرجى تحديد الأدوات المستخدمة في التنفيذ ومن ثم استكمال الاستبيان للتعرف على عوامل النجاح.
M02	الأدوات المستخدمة في مراقبة العمليات وضبط الجودة الاحصائي (SPC) <input type="checkbox"/> الرسم البياني (Histogram) <input type="checkbox"/> مخطط باريتو (Pareto chart) <input type="checkbox"/> المخططات المبعثرة (Scatter charts) <input type="checkbox"/> مخططات التدفق (Flow charts) <input type="checkbox"/> مخططات السيطرة (Control charts) <input type="checkbox"/> Check sheet <input type="checkbox"/> مخطط هيكل السمكة (Cause and effect diagram) <input type="checkbox"/> العمليات الإحصائية الأساسية (الوسط الحسابي، الوسيط، الانحراف المعياري...) <input type="checkbox"/> أخرى، حدد:

القسم الثاني: المعلومات الديموغرافية: (Demographic Information)	
الرمز	السؤال
DI01	الجنس: <input type="checkbox"/> ذكر <input type="checkbox"/> انثى
DI02	المؤهل العلمي: <input type="checkbox"/> ما دون التوجيهي <input type="checkbox"/> توجيهي <input type="checkbox"/> دبلوم <input type="checkbox"/> بكالوريوس <input type="checkbox"/> ماجستير <input type="checkbox"/> دكتوراة فأعلى
DI03	الوظيفة: <input type="checkbox"/> موظف إداري <input type="checkbox"/> رئيس قسم <input type="checkbox"/> مدير فني <input type="checkbox"/> مراقب جودة <input type="checkbox"/> مدير الجودة <input type="checkbox"/> المدير العام <input type="checkbox"/> غير ذلك، حدد؟
DI04	عدد سنوات الخبرة: <input type="checkbox"/> $5 \geq$ <input type="checkbox"/> (10-6) <input type="checkbox"/> (15-11) <input type="checkbox"/> (20-16) <input type="checkbox"/> أكثر من 20
DI05	مكان المنشأة: <input type="checkbox"/> القدس <input type="checkbox"/> بيت لحم <input type="checkbox"/> رام الله والبيرة <input type="checkbox"/> الخليل <input type="checkbox"/> نابلس <input type="checkbox"/> سلفيت <input type="checkbox"/> قلقيلية <input type="checkbox"/> طولكرم <input type="checkbox"/> طوباس <input type="checkbox"/> جنين <input type="checkbox"/> أريحا والأغوار
DI06	حجم المنشأة (عدد الموظفين): <input type="checkbox"/> (10-1) <input type="checkbox"/> (50-11) <input type="checkbox"/> (250-51) <input type="checkbox"/> أكثر من 250
DI07	عمر المنشأة (بالسنوات): <input type="checkbox"/> $5 \geq$ <input type="checkbox"/> (10-6) <input type="checkbox"/> (20-11) <input type="checkbox"/> (30-21) <input type="checkbox"/> أكثر من 30
DI08	شهادات الجودة الحاصلة عليها الشركة: <input type="checkbox"/> ISO 9001:2015 <input type="checkbox"/> ISO 22000 <input type="checkbox"/> PS <input type="checkbox"/> HACCP <input type="checkbox"/> ISO 14001 <input type="checkbox"/> لا يوجد <input type="checkbox"/> أخرى، حددها (رجاء)
DI09	المنتجات التي تنتجها الشركة (بإمكانك اختيار أكثر من خيار في حال كان هناك أكثر من منتج): <input type="checkbox"/> إنتاج وحفظ اللحوم <input type="checkbox"/> الحليب والألبان <input type="checkbox"/> تجهيز وحفظ الخضار والفواكه <input type="checkbox"/> الزيوت والدهون النباتية والحيوانية <input type="checkbox"/> القمح ومنتجات الحبوب <input type="checkbox"/> المعكرونة

<input type="checkbox"/> المشروبات الغازية	<input type="checkbox"/> البوظة ورأس العبد	<input type="checkbox"/> المياه المعبأة
<input type="checkbox"/> منتجات الكاكاو والشكولاتة	<input type="checkbox"/> الشيبس والمسليات	<input type="checkbox"/> العصائر والجل
<input type="checkbox"/> أخرى، حددها (رجاء):		

القسم الثالث: متغيرات الدراسة "Study Variables"

يتكون هذا القسم من 6 أجزاء يرجى الإجابة عنها جميعها، بوضع دائرة حول الرقم الذي يمثل أفضل وصف، بحيث أن الدرجة مقسمة من (1-5) كما هو موضح أدناه، مع الإشارة إلى أن الرقم الأعلى يدل على درجة الموافقة الأعلى بينما الرقم الأقل يدل على درجة الموافقة الأقل. يرجى وضع إشارة X تحت الخيار الذي ينطبق على شركتكم.

1- الإجراءات الإدارية "Managerial Action"

الرقم	البند	موافق بشدة (5)	موافق (4)	محايد (3)	غير موافق (2)	غير موافق بشدة (1)
MA01	توجد خطة واضحة من الإدارة العليا لتطبيق مخططات التحكم.					
MA02	تتولى الإدارة العليا بانتظام تحديد جهود تحسين الجودة.					
MA03	تستخدم الإدارة العليا معلومات مخططات التحكم في التخطيط.					
MA04	توفر الإدارة العليا دعماً واضحاً لاستخدام مخططات التحكم في جميع أنحاء الشركة.					
MA05	الإدارة العليا مستعدة لقبول أي اقتراحات وتعليقات وشكاوى من الموظف.					
MA06	تقوم الإدارة العليا بتوفير الدعم المالي اللازم للبرامج التدريبية الخاصة بتطوير معارف ومهارات العاملين.					
MA07	تهتم الإدارة العليا بإزالة العقبات أمام تطبيق مخططات التحكم.					

2- نهج العملية "Process Approach"

الرقم	البند	موافق بشدة (5)	موافق (4)	محايد (3)	غير موافق (2)	غير موافق بشدة (1)
PA01	تستخدم الشركة الأساليب الإحصائية لضبط العمليات وفق المواصفات المطلوبة.					
PA02	يتم تصميم العمليات بحيث تضمن تطبيق الجودة في كل مراحل الإنتاج بدءاً من المواد الخام مروراً بالإنتاج وانتهاءً بالتغليف والتخزين والتوزيع.					

					توثق الشركة جميع العمليات بشكل واضح ومفهوم لكل الموظفين.	PA03
					توجد إجراءات عمل توضح المسؤوليات والصلاحيات للموظفين.	PA04
					يتوفر في الشركة نظام رقابة وتحكم في العمليات.	PA05
					تستخدم الشركة الأساليب الإحصائية في مقارنة نتائج الفحوصات المخبرية للمواد الغذائية أثناء مرحلة الإنتاج.	PA06

3- اتخاذ القرارات "Decision Making"

الرقم	البند	موافق بشدة (5)	موافق (4)	محايد (3)	غير موافق (2)	غير موافق بشدة (1)
DM01	يتم اتخاذ القرار بناء على البيانات المتوفرة والإحصائيات.					
DM02	القرارات التي يتم أخذها في الشركة قابلة للتطبيق.					
DM03	يتم فحص وتحليل البيانات لمعرفة مدى دقتها قبل الاعتماد عليها.					
DM04	توجد في الشركة طرق معتمدة لجمع البيانات وتحليلها.					
DM05	تعتمد قرارات الشركة على اختلاف التباين الذي يظهر من أدوات SPC في نتائج الفحوصات المخبرية للأغذية.					

4- تطبيق الأدوات الإحصائية "Statistical Method Implementation"

الرقم	البند	موافق بشدة (5)	موافق (4)	محايد (3)	غير موافق (2)	غير موافق بشدة (1)
SMT01	يتلقى جميع العاملين في قسم الجودة تدريباً على بناء مخططات الجودة.					
SMT02	تلقى جميع العاملين في قسم مراقبة تدريباً على تطبيق مختلف الأدوات على خط الإنتاج لتحسين الجودة.					
SMT03	يمكن للجميع في قسم مراقبة الجودة وصف ما يقوله مخطط التحكم عن أداء عملية/خصائص المنتج.					
SMT04	خبراء الطاقم الفني قادرون على الإجابة عن الأسئلة الفنية الناتجة عن استخدام مخططات التحكم.					

					لدينا القدرة على حل المشاكل الناتجة من تطبيق مخططات التحكم.	SMT05
					خبراء الطاقم الفني لديهم المعرفة الكافية بقوانين السلامة الغذائية التي تضمن عدم الخروج عن حدود المواصفات.	SMT06
					تتشرط الشركة على الموردين لمدخلات الإنتاج لديها تطبيق أساليب SPC لكي يتم اعتمادهم كموردين من قبل الشركة.	SMT07
					تتشرط الشركة على مورديها الحصول على شهادات جودة مثل ISO, PS, HACCP وغيرها لكي يتم اعتمادهم من قبل الشركة للتوريد.	SMT08

5- التدقيق ومراجعة ممارسات SPC: "Audit and Review SPC Practice"

الرقم	البند	موافق بشدة (5)	موافق (4)	محايد (3)	غير موافق (2)	غير موافق بشدة (1)
AR01	تقوم الشركة بتوثيق قدرة عملية التصنيع باستمرار.					
AR02	يتم تحديث حدود مخططات التحكم للمعلومات المرتبطة بعملية التصنيع مع تغيير العملية.					
AR03	من السهل تحديث المعلومات حول عملية التصنيع.					
AR04	يتم تدقيق تنفيذ SPC بشكل دوري لتحديد فرص تحسين العملية.					
AR05	يتم عمل مراجعة دورية لأنشطة SPC في الشركة.					
AR06	تقوم الشركة بعمل تدقيق دوري من خلال زيارات ميدانية على نظام تطبيق أساليب SPC في منشآت الموردين.					
AR07	تقوم الشركة بعمل فحوصات بطرق إحصائية للمواد الموردة من الموردين وتقرر قبولها أو رفضها (إرجاعها للمورد).					

6- المعوقات الرئيسية المتعلقة بالجودة في الشركة: "Major Quality Obstacles"

الرقم	البند	موافق بشدة (5)	موافق (4)	محايد (3)	غير موافق (2)	غير موافق بشدة (1)
MQO01	عدم التزام الإدارة العليا بتحسين الجودة في الشركة.					

					غياب ثقافة الجودة كقيمة عليا في بيئة العمل.	MQO02
					لا تخطط الشركة لتحسين عملياتها.	MQO03
					التكنولوجيا المستخدمة في الآلات والماكينات قديمة.	MQO04
					التدريب غير كافي لمشغلي عملية الإنتاج.	MQO05
					قلة الوعي بأدوات SPC من قبل المشغلين.	MQO06
					ضعف الصيانة والتعامل مع الآلات والماكينات في الشركة.	MQO07

➤ أي تعليقات أو إضافات أخرى تودون التعبير عنها:

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شكراً لتعاونكم

Appendix (3): Official Letter to Food Companies

Arab American University
Ramallah Site



الجامعة العربية الأمريكية
موقع رام الله

May 16, 2022

To Whom It May Concern

The Faculty of Graduate Studies at Arab American University certifies that **Mr. Ali Mohammad Yusuf Jebreen** holding a student No. of (202011960) is a student in the master's program Quality Management.

Mr. Jebreen is conducting her master thesis entitled:

" Evaluation of the application of statistical process control in the Palestinian food industries- an empirical study ". under the supervisor of Dr. Yahya Ahmed Hafez Salahat, for your kind actions to help her to obtain the necessary information for the study, noting that the information will be used for the purpose of research only and will be dealt with the utmost confidentiality.

This certificate was given upon her request.

Dean of Graduate Studies

Dr. Nouar Qutob



Appendix (4): Companies participating in the survey

NO.	Company name	Company products
1-	Siniora Food Industries Company.	Meat production and preservation
2-	Al Hamouda Company for Food and Agricultural Products.	Dairy products
3-	Bon Rashid Mills Company.	Coffee
4-	National Beverage Company – Jericho..	Water
5-	Arab Construction Project Association.	Dairy products
6-	Bin Azhiman Stores Chain Company.	Coffee
7-	Khalil Rahman Pasta and Foodstuff Company.	Pasta and tea
8-	Noman Al-Junaidi Company for Food Industries and Investment / Vivien Water.	Water
9-	Asia Mineral Water Company.	Water
10-	Soft Drinks Company – Pepsi.	Soft drinks
11-	Zadona Agricultural Manufacturing Company.	Processing and preservation of vegetables and fruits
12-	The National Beverage Company Coca-Cola.	Soft drinks
13-	Al-Pinar Dairy Products Factory.	Dairy products
14-	Land Company for Agricultural Products.	Dates preservation
15-	Al-Arz Ice Cream Factory Company.	Ice cream
16-	Sinokrot Food Products Company.	Cocoa and chocolate products
17-	Modern Group Co. For Bottling Soft Drinks.	Soft drinks
18-	Al Ghosoun Islamic Company.	Meat production and preservation
19-	Al Salam Refrigeration Company.	Processing and preservation of vegetables and fruits

20-	Abu Khreshiq Trading Company.	Ice cream
21-	Petra Ice Cream Factory and Ras Al-Abed Company.	Ice cream, chips and snacks
22-	Al Safi Dairy Company.	Dairy products
23-	Al Nasr Industrial Company.	Juices and chips
24-	Al-Zahraa Factory Company for Food and Drink Products.	Juices
25-	Al Saadi Industrial Trading Company.	Water, juices and chips
26-	AL-Sanaoubar Factory for Salads and Foodstuffs.	Salads
27-	National Dairy Company.	Dairy products
28-	Al-Zaytouna Foodstuff Company.	Tahina and Halawa
29-	Pal Gardens Agricultural Company.	Dates and vegetables
30-	Ardy Crops Company.	Juices
31-	Rawafed Foodstuff Company.	Juices
32-	Al-Hejaz Chocolate Company.	Chocolate product
33-	Hebron Snacks Company.	Chips and snacks
34-	Nice Foodstuff Company.	Salads
35-	Mr. El-Telbani Company for Food Industries.	Biscuit
36-	Al-Qasrawy Industrial Trading Company.	Chips and snacks
37-	Al-Jebrini Dairy and Foodstuff Company.	Dairy products
38-	Al Salwa Food Products Company.	Meat production and preservation
39-	Islamic Corporation for Food Products.	Meat production and preservation
40-	Zarefco Company for Manufacture and Trade of Foodstuffs.	Processing and preservation of vegetables and fruits

41-	Turkish Palestinian Food Industries Company.	Processing and preservation of vegetables and fruits (pickles)
42-	National Beverage Company – Capy.	Juices
43-	Al Taif Dairy and Foodstuff Company.	Dairy products
44-	Vegetable Oil Factories Public Shareholding Company Limited.	Vegetable and animal oils and fats
45-	Al Ghazal Food Products Company and Factory	Vegetable and animal oils and fats
46-	Al Sanabel Food Products.	Meat production and preservation
47-	Nakheel Palestine Investment Company.	Dates preservation
48-	Al-Hedmy Food Industries Company.	Dairy products
49-	Sharif Factory for Industry and Trade.	Juices
50-	Al- Asyl for Drink and Food Industries.	Juices
51-	Al Shunnar Foodstuff Factory.	Juices
52-	Al-Furate Water Company.	Water
53-	Tayibat Al Emarat Company.	Salads
54-	Al-Kurd Brothers Company for Beverages and Foodstuffs.	Ice cream
55-	Abu Aita Pasta Company.	Pasta
56-	Rukab Ice Cream Factory Company.	Ice cream
57-	Al-Buraq International Company for Trade and Industry.	Vegetable and animal oils and fats
58-	Ghosheh Food Industries Company.	Meat production and preservation
59-	Near East Company for Industry and Trade.	Vegetable and animal oils and fats
60-	Salah Trading Company.	Chips and snacks
61-	Arab Growers Company.	Dates

62-	Ten Pros Food Industries Company.	Chips and snacks
63-	Al-Qaisi Dairy Company.	Dairy products
64-	Rummana Food Products Company.	Vegetable and animal oils and fats
65-	Sinokrot Import and Export Company.	Wheat and grain products

Appendix (5): Descriptive Statistics

Indicator	Items	Mean	Standard deviation
MA01	There is a clear plan from the top management to implement the control schemes.	4.077	0.664
MA02	Top management regularly defines quality improvement efforts.	4.292	0.696
MA03	The information of planning control schemes is used by top management.	4.062	0.605
MA04	Senior management provides clear support for the use of control schemes throughout the company.	4.092	0.650
MA05	Top management is ready to accept any suggestions, comments and complaints from the employee.	4.215	0.734
MA06	Senior management provides the necessary financial support for training programs to develop the knowledge and skills of employees.	4.123	0.813
MA07	Top management is concerned with removing obstacles to the application of control schemes.	4.031	0.632
PA01	The company uses statistical methods to adjust operations according to the required specifications.	3.892	0.611
PA02	Processes are designed to ensure the application of quality at all stages of production, starting from raw materials, through production, and ending with packaging, storage and distribution.	4.538	0.584
PA03	The company documents all operations in a clear and understandable manner for all employees.	4.354	0.567
PA04	There are work procedures that clarify the responsibilities and powers of the employees.	4.431	0.495
PA05	The company has a monitoring and control system in the operations.	4.338	0.770

PA06	The company uses statistical methods to compare the results of laboratory tests for foodstuffs during the production stage.	4.246	0.657
DM01	The decision is made based on the available data and statistics.	3.800	0.769
DM02	Decisions made in the company are applicable.	4.015	0.447
DM03	Data is checked and analyzed for accuracy before relying on it.	4.123	0.691
DM04	The company has approved methods for data collection and analysis.	3.985	0.734
DM05	The company's decisions depend on the variance that appears from SPC tools in the results of food laboratory tests.	3.677	0.843
SM01	All employees in the quality department receive training in building quality schemes.	3.769	0.855
SM02	All the employees in the control department have received training to apply various tools on the production line to improve the quality.	3.877	0.713
SM03	Everyone in the quality control department can describe what the control chart says about the product's process performance/characteristics.	3.892	0.767
SM04	Technical staff experts are able to answer technical questions arising from the use of control charts.	3.877	0.775
SM05	We have the ability to solve problems arising from the application of control charts.	3.954	0.773
SM06	Technical staff experts have sufficient knowledge of food safety laws to ensure that no deviation from the specifications limits.	4.431	0.841
SM07	The company requires suppliers of its production inputs to apply SPC methods in order to be certified as suppliers by the company.	3.477	0.962

SM08	The company requires its suppliers to obtain quality certificates such as ISO, PS, HACCP and others in order to be approved by the company for supply.	3.662	1.071
AR01	The company continually documents the capability of its manufacturing process.	4.215	0.794
AR02	The limits of the control charts for parameters associated with the manufacturing process are updated as the process changes.	3.969	0.764
AR03	Easy to update information about the manufacturing process.	4.092	0.738
AR04	SPC implementation is periodically audited to identify process improvement opportunities.	3.677	0.946
AR05	A periodic review of SPC activities in the company is made.	3.508	0.979
AR06	The company conducts a periodic audit through field visits on the system of applying SPC methods in the facilities of suppliers	3.369	1.016
AR07	The company conducts statistical tests for the materials supplied by the suppliers and decides to accept or reject them (return them to the supplier).	3.692	.943
MQO01	Failure of senior management to improve quality in the company.	2.292	1.224
MQO02	The absence of a culture of quality as a supreme value in the work environment.	2.477	1.360
MQO03	The company does not plan to improve its operations.	2.338	1.224
MQO04	The technology used in machinery and equipment is outdated.	2.769	1.433
MQO05	Insufficient training for production process operators.	2.769	1.134
MQO06	Lack of awareness of SPC tools by operators.	3.200	1.084
MQO07	Poor maintenance and handling of machinery and equipment in the company.	2.677	1.204



الجامعة العربية الأمريكية – جنين

كلية الدراسات العليا

تقييم تنفيذ ضبط العمليات الإحصائية في الصناعات الغذائية الفلسطينية:

دراسة تطبيقية

إعداد

علي محمد يوسف جبرين

إشراف :

د. يحيى صالح

تم تقديم هذه الرسالة استكمالاً لمتطلبات درجة الماجستير في تخصص

إدارة الجودة

تموز/2022

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الملخص

تقيم الدراسة درجة تطبيق رقابة العملية الإحصائية (SPC) في صناعة الأغذية الفلسطينية بعد عمل بحثي تحليلي وصفي. تحتل الصناعات الغذائية مكانة حيوية في القطاع الصناعي الفلسطيني وتعتبر ركيزة للنمو الاقتصادي المحتمل. تم توثيق فوائد تنفيذ أدوات SPC جيداً في الأدبيات ؛ ومع ذلك ، لا يُعرف الكثير عن تنفيذ SPC بين المصنعين الفلسطينيين. لتحقيق الغرض من هذه الأطروحة فيما يتعلق بمدى تطبيق أدوات SPC في مصانع الأغذية الفلسطينية ، نقوم بتحليل البيانات التي تم جمعها من عينة مكونة من 65 شركة أغذية فلسطينية وفقاً لاتحاد الصناعات الغذائية الفلسطينية حيث تعمل 75 شركة رسمياً في الضفة الغربية وتمثل مجتمع البحث، منتجاتهم هي أساسا المواد الغذائية والمشروبات . تم استخدام طريقة نمذجة المعادلات الهيكلية للمربعات الصغرى الجزئية (PLS-SEM) لتحليل البيانات الكمية التي تم جمعها.

تكشف الدراسة عن عدة نتائج أساسية ؛ والمثير للدهشة أن 55٪ فقط من الشركات المستهدفة لا تطبق أدوات SPC. تواجه شركات الأغذية الفلسطينية عدة تحديات في نشر وتنفيذ SPC. وتشمل هذه المعوقات ثقافة الجودة الرديئة كقيمة عليا في بيئة العمل ، وانتشار الآلات القديمة ، وقلة التدريب بناءً على الأدبيات ، يقترح النموذج المقترح أربعة محركات لتنفيذ SPC: الإجراءات الإدارية ، والتدقيق والمراجعة ، ونهج العملية ، واتخاذ القرار، تُظهر النتائج أن وظائف التدقيق والمراجعة واتخاذ القرار هي عوامل مهمة لتحسين تنفيذ SPC ضمن إعدادات الدراسة.

في هذه الدراسة تم التوصل إلى العديد من التوصيات التي يوصى اتحاد الصناعات الغذائية الفلسطينية برفع مستوى الوعي بفوائد SPC بين الأعضاء، قد يركز المديرون على تدريب الموظفين الفنيين على SPC ، ومعايرة الآلات باستمرار ، وفحص المواد الخام قبل استلامها، تحسين المدخلات يزيد من احتمالية المطابقة للمواصفات . أخيراً ، أوضحت الدراسة قيود هذا العمل البحثي ، وأهمها أن المشاركين اعتبروا SPC كأداة متقدمة، تستخدم هذه الأطروحة طريقة كمية وفهماً أفضل وتستكشف العوامل المؤثرة التي يمكن تحقيقها عند إجراء البحوث النوعية في البحث المستقبلي.