

Quality Engineering In The Agri-Food Industries In Lebanon

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Abstract:

Industrial enterprises face varying quality objectives depending on the type of activity, justifying the adoption of quality engineering by such companies. This approach assists the company in organizing, optimizing, and supervising the means and processes in the production system of goods and services, meeting requirements for quality, quantity, safety, costs, deadlines, and the environment. A quantitative study was conducted to determine the factors that can encourage agri-food industries to implement or develop quality engineering in their work. A questionnaire is distributed to 360 employees working in these industries. The SPSS program is used to analysis the data obtained and the results showed that in Lebanon, agri-food industries are encouraged to implement quality engineering through the improvement of manufacturing and quality measures, increasing customer satisfaction and loyalty, and reducing the cost of non-quality. These industries encounter quality issues in their activities, such as a lack of organization, insufficient training, and a shortage of resources.

Key Word: Quality engineering, agri-food industries, quality objectives, cost reduction, improvement measures.

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I. Introduction

The organizations, regardless of their size, are faced with the increasing competition of global markets. Effective quality management helps businesses meet the needs of customers through their goods or services. It involves not only the core business, meaning home intervention, but also the culture and values of the entity, its management and organization, its strategy and positioning in the territory, and its human and financial resources (Martinez, 2019).

The tools and techniques of quality engineering are constantly evolving. They have both specialized and universal applications. If not used systematically, quality improvements may be random and spontaneous rather than comprehensive. Researchers Putri and Yusof (2009) summarize that quality practices found have focused on total quality management and the implementation of the ISO 9000 standard, technological learning, and research conducted in manufacturing organizations in general (Putri & Yusof, 2009). The need for a better understanding of the factors that encourage agri-food industries in the effective application and continual improvement of quality engineering is becoming increasingly important (Sahni, 2016).

Some individuals working in the manufacturing sector are familiar with a range of tools for applying and enhancing quality engineering. However, others within the same sector may not be acquainted with the implementation of these tools or are unfamiliar with quality engineering (Sahni, 2016).

This study will aim to identify the essential factors that can encourage agri-food industries in Lebanon to apply and improve quality engineering. It's worth noting that these industries can benefit from this engineering in enhancing product quality, increasing financial performance, and reducing waste.

The question that constitutes the problem statement of the study is as follows: What are the factors that encourage agri-food industries in Lebanon to apply and improve quality engineering?

To address this central question, this study will emphasize the objectives of quality engineering, the motivating factors for its application by agri-food companies, and subsequently highlight quality issues in this industry. This work will also present the adopted research methodology and the obtained results, concluding with a discussion of the main findings.

II. Literature Review

Quality engineering: definition and objectives

Quality engineering aims to ensure that goods and services are designed, developed, and manufactured to meet or exceed consumer expectations and requirements. It encompasses all activities related to analyzing the design and development of a product (Market Business News, 2021). By effectively using quality engineering,

the company ensures that the voice of the customer is heard in the product design (Shen, Xie, & Tan, 2001) (Danda, 2020).

Quality engineers also ensure that the company manufactures goods according to specifications. They focus not only on product quality and the production process but also on waste reduction. Quality engineers work in a variety of industries and play an essential role in addressing or rectifying defects. Some companies refer to them as quality assurance engineers, quality control engineers, or senior quality specialists (Market Business News, 2021).

Comparing quality assurance and quality engineering, it's clear that the former appears as a comprehensive process aimed at ensuring the manufacturing of good-quality products. Meanwhile, the latter designs the quality system, maintains it, and also enhances it (Market Business News, 2021).

The effective implementation of quality engineering methodologies and tools within an organization will improve communication between engineering and manufacturing teams and ensure that the voice of the customer is integrated into new or improved products or services. Quality engineering tools can enhance product quality and reduce costs through more efficient processes. Quality engineering can contribute to improving the financial performance of a company as well as production quality. Furthermore, proper implementation of quality engineering will result in producing high-quality products that meet or exceed customer desires, significantly impacting the company's bottom line. This gives the company a competitive edge in its operating market and enables access to new markets (Whelan, 2021).

A quality engineer focuses not only on product quality and the production process but also on waste reduction. Quality engineers design and control process quality. They work across various industries and play a crucial role in rectifying or repairing defects (Danda, 2020). Some companies refer to them as quality assurance engineers, quality control engineers, or senior quality specialists (Market Business News, 2021).

It's important to mention that the global food industry is expanding rapidly, especially as technology has led to new manufacturing methods that have enhanced this sector. Many risks can hinder the success of agri-food industries, such as shifting consumer tastes, the repercussions of expanding into new markets, product quality issues, and compliance challenges (Manisha, 2018) (Panorama Consulting Group, 2020).

Furthermore, implementing quality engineering brings several benefits to the company, such as cost savings, time efficiency, assurance of good quality of goods and services, enhancing planning, and improving communication (DeLiberis, 2020).

III. The Motivating Factors For Agri-Food Industries To Apply Quality Engineering

The application and improvement of quality engineering are linked to several factors. Among these, five have been identified: improving manufacturing and quality measures, customer satisfaction and loyalty, fostering a company culture with the staff, enhancing risk management, and reducing the cost of non-quality (Jawad, Kadhim, & Al Mansoori, 2020) (Owen, 2021) (Giesen, 2013) (Noyel, Zimmermann, Thomas, & Thomas, 2016) (Manisha, 2018).

Improvement of manufacturing and quality measures

Productivity is affected by quality engineering. The application and improvement of the latter guide personnel to work in a professional manner, which involves critical thinking, teamwork skills, honesty and sincerity, developed interpersonal and communication skills, and a thirst for knowledge and continuous training. This ultimately leads to increased productivity in the workplace. For the improvement of manufacturing process management, quality engineering works within a team whose overall goal is to ensure that finished products are safe, reliable, and meet customer expectations while maintaining the manufacturing process as efficient and cost-effective as possible. Additionally, quality engineers collaborate with various stakeholders at each stage of the manufacturing process (Lussier, 1990) (Jawad, Kadhim, & Al Mansoori, 2020).

Regarding quality improvement, quality engineering aims to enhance quality measures through the application and improvement of main objectives such as quality assurance, which focuses on processes and aims to eliminate process variation by strictly creating and implementing a set of precisely defined quality procedures ensuring the final product's quality, such as the ISO 9001 standard, quality control, and the Six Sigma approach¹ (Owen, 2021).

The application and improvement of quality engineering have a particular impact on the agri-food industry, resulting in enhanced feedback that allows for better visibility across the entire industrial process. This means that quality engineers will be able to suggest corrective and preventive actions in earlier stages and with

¹ A set of techniques and tools for process improvement. It aims to enhance the quality of a process's production by identifying and eliminating the causes of defects and minimizing variability in manufacturing processes. It can also involve reliability engineering, which utilizes engineering and analysis techniques to improve the reliability of a product, process, or system.

greater accuracy. They will be able to identify new correlations and implement new mechanisms to ensure quality at each stage of production (Giesen, 2013).

Improving the proactive prevention of data collected by connected machines will assist quality engineers in preventing non-conformities and enable operators to repair machines and streamline processes before disruptions occur. Accelerating stress tests, real-time process monitoring, and sophisticated modeling tools will make quality engineering more proactive than reactive. They also impact root cause analysis with more information and a connected factory. Consequently, it will be easier for quality engineers to separate the signal from the noise to identify the root cause of problems (Misra, 2008).

A well-implemented quality engineering, therefore, instills confidence in all stakeholders, convincing them that the organization will improve over time and that product quality will remain consistent (Khan, Iqbal Khan, Sheeraz, & Mahmood, 2017).

Customer satisfaction and loyalty

In the competitive market, the application and improvement of quality engineering aim to continually encourage agri-food industries to develop new products. At times, they succeed in gaining market share with a range of products in the market. To achieve this, manufacturers must deliver products of superior quality that exceed consumer expectations and present them in the market with competitive prices (Box & Woodall, 2012).

The application and improvement of quality engineering impact quality control, which is performed on the product and involves testing a sample from a manufacturing process to ensure it meets design specifications or required quality standards, resulting in customer satisfaction and loyalty (WFQ Inc, 2020). Customer orientation is a source that encourages businesses to identify, understand, and satisfy customer needs, striving to exceed their expectations (Danda, 2020).

Improving quality increases the company's market share, which, coupled with a cost optimization strategy, can positively impact its revenue and profit. The application and enhancement of quality engineering processes thus lead to an increase in the company's market share, optimization of production costs, and consequently an improvement in its financial performance (O'Neil, Sohal, & Teng, 2016).

Developing a corporate culture with the staff

The adoption of quality engineering can enhance the organization's performance and establish a culture of quality and continuous improvement within the organization. Well-implemented quality engineering provides all stakeholders with the certainty that the organization will improve over time and that product quality will be maintained (Khan, Iqbal Khan, Sheeraz, & Mahmood, 2017).

Additionally, the application and improvement of quality engineering have an impact on the importance of employee engagement in the manufacturing process. Therefore, employees need to be aware of the importance of implementing the Quality Management System (QMS). This requires staff involvement in the company's culture, which consists of beliefs, values, attitudes, conditioned reflexes, and shared behavioral patterns among the organization's members. The culture of quality must permeate every aspect of the project and be supported by all stakeholders. This foundation can only be achieved through support and guidance towards quality improvement (Danda, 2020).

Development of risk management

Many food industries face quality issues when trying to speed up or slow down production to adapt to the market. Particularly for brands with multinational clienteles, it's challenging to consistently provide fresh products while being reliable, efficient, and cost-effective (Panorama Consulting Group, 2020). This is why the application and improvement of quality engineering have an impact on risk management, defined as the process of weighing policy alternatives in light of risk assessment outcomes and, if necessary, selecting and implementing appropriate control options, including regulatory measures. The primary goal of food risk management is to protect public health by controlling these risks as effectively as possible through the selection and implementation of suitable measures (Manisha, 2018).

Quality control integrated into the industry will enable the quality engineer to effectively monitor quality in machines and processes. Artificial intelligence, in particular, will assist quality engineers in designing validation systems and quality assurance during production, thereby becoming more efficient and precise with each iteration (Khan, Iqbal Khan, Sheeraz, & Mahmood, 2017).

Reducing the cost of non-quality

The term "non-quality" is used to describe a situation where there is no capability to develop a product right the first time, in line with customer specifications and expectations. In other words, it refers to the observed gap between the targeted quality and the obtained quality. Assessing the cost of non-quality is quite challenging, yet essential work for the company to maintain its overall performance. In addition to the product, it's crucial to

ensure the quality of delivery, safety, maintenance, and warranties. However, the application and improvement of quality engineering impact the reduction of non-quality costs by ensuring proper equipment operation, avoiding downtime, regularly assessing customer complaints and production quality non-conformities, planning internal audits, minimizing waste, establishing progress action plans (zero defects), and anticipating malfunctions that may generate non-quality (Noyel, Zimmermann, Thomas, & Thomas, 2016).

There will be less waste and fewer produced scraps because the product will be manufactured in accordance with specific requirements and expectations, leading to customer satisfaction right from the first time. There will be fewer touch-ups and repairs needed on the finished product and fewer rejected goods. These organizations have a broad vision, with all stakeholders and customers in sight. Every movement, product, and process is well-documented, and all records are kept. Any deficiency in performance is regularly identified and rectified (Khan, Iqbal Khan, Sheeraz, & Mahmood, 2017).

IV. Quality Issues In The Agri-Food Industries

Agri-food industries often encounter quality issues that can hinder the effectiveness of applying and improving quality engineering. Among these issues, notable factors include lack of organization, inadequate training, insufficient discipline, resource scarcity, time constraints, and weak production processes (Jardine, 2021).

The lack of organization results in a breakdown in communication between departments and employees within the company. Additionally, undefined responsibilities lead to confusion among employees regarding tasks to be accomplished, subsequently jeopardizing the assurance of achieving an adequate final product.

Insufficient employee training can hinder the achievement of the company's goals. In such cases, employees lack competence or have no understanding of the work processes and measures, resulting in the company offering goods and services that do not sufficiently meet customer expectations.

A lack of discipline can create tensions and generate employee discouragement. Additionally, rigid systems within the company may limit innovation and the ability to respond to the issues they face. In such cases, customer feedback may not be adequately acknowledged, leading to a breakdown in customer relationships.

A lack of financial resources limits investments in research aimed at improving the quality of offered products and even investments in launching new products that better meet consumer expectations. Human resources are also vital in quality management within a company, as it's the personnel who must ensure the company's production and perform quality audits or implement quality engineering. If the number of employees is insufficient, certain tasks may be abandoned.

Excessive workloads, unrealistic promises to customers, and irresponsible attitudes are among the factors that weaken relationships with customers and sometimes diminish the quality of goods or services offered in the market.

In some companies, the quality issue is directly linked to the management, where there are leaders who sometimes don't truly understand the importance of quality control and improvement. Moreover, poor time management can limit the work of individuals responsible for quality management, such as cases where these leaders are more concerned with solving problems than with their anticipation and management. Consequently, the weak production process negatively affects the quality of the products offered (Jardine, 2021).

V. Research Methodology

Based on the literature review, five hypotheses have been developed in this study, as follows:

- Hypothesis H1: The application and improvement of quality engineering have a significant impact on the improvement of manufacturing and quality measures in the agri-food industries in Lebanon.
- Hypothesis H2: The application and improvement of quality engineering have a significant impact on the development of a corporate culture with the staff in the agri-food industries in Lebanon.
- Hypothesis H3: The application and improvement of quality engineering have a significant impact on customer satisfaction and loyalty in the agri-food industries in Lebanon. Hypothesis
- H4: The application and improvement of quality engineering have a significant impact on the development of risk management in the agri-food industries in Lebanon.
- Hypothesis H5: The application and improvement of quality engineering have a significant impact on reducing the cost of non-quality.

Testing these hypotheses is done using the quantitative method, where a questionnaire is distributed within the agri-food industries across all Lebanese regions. The obtained results are processed using descriptive analysis and multiple linear regression through the statistical software SPSS.

The agri-food businesses represent the largest portion of industrial establishments in Lebanon, accounting for 21.8% of businesses in 2016. This sector is predominantly made up of small family-owned enterprises, employing an average of 6 people (IDAL, 2018).

The population for this research is composed of employees working in different companies operating in the Lebanese agri-food industrial sector. These companies are spread across various Lebanese regions and manufacture products such as cereals, canned goods, oils, condiments, starch, and spices. The study sample is random, where the questionnaire is distributed to 360 employees in 25 industries. These companies were selected based on geographic diversity and size.

The questionnaire for this research consists of 18 questions divided into two themes. The first theme consists of 5 questions, while the second theme comprises 13 questions based on the Likert scale. The questionnaire is administered in two ways: face-to-face and online via the Google Forms platform to create, distribute, and collect responses. This cost-effective technique helps minimize geographical barriers. The distribution of questionnaire takes place from May 1st to the end of June 2022.

The data collected is filtered to develop relevant and valid information, forming the basis for analysis. This information will validate the hypotheses and inform new managers about the importance of applying and improving quality engineering in industries. It's noteworthy that the total number of respondents is 300, meaning 300 observations have been conserved. 24 persons didn't respond, and the 36 other didn't answer all the questions, so they are eliminated.

Using the statistical software SPSS to analyze the collected data required coding of the questions and responses. The multiple linear regression method aims to identify a relationship between a dependent variable (the variable to be explained) and one or more independent variables (explanatory variables). It helps create a predictive model for the relationship that exists between these two types of variables. In this study, the dependent variable (Y) is linked to the application and improvement of quality engineering in the agro-food industries in Lebanon, while the independent variables (Xn) consist of factors that may encourage agro-food industries in Lebanon to apply and enhance quality engineering. The multiple linear regression model is as follows: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p + \epsilon$ Where β is an assumed constant parameter and ϵ is the error term.

VI. Result

This section aims to present the statistical results obtained through the research. It outlines the various profiles of the survey respondents. Additionally, it identifies the quality issues faced by the agri-food industries in Lebanon. Finally, it presents the factors that have a significant impact on the implementation and improvement of quality engineering by agri-food industries in Lebanon.

Profile of the survey respondents

According to the obtained results, regarding the age of the studied industries, approximately half have been in existence for 4 to 10 years, and 32% are aged over 10 years. The years of experience for half of the respondents in the industry range from 1 to 5 years. Nearly one-third of the respondents have experience ranging from 6 to 10 years.

Factors Encouraging Agri-food Industries in Lebanon to Implement and Improve Quality Engineering

To identify the factors motivating agri-food industries to apply and enhance quality engineering, a multiple linear regression method is adopted. The results of this regression are outlined below. An "Output" is generated by the SPSS program encompassing the results of this regression.

Table 1: Descriptive statistics

	Mean	Std. Deviation	N
Application and improvement of quality engineering	4.50	.839	300
Improvement of manufacturing and quality measures	4.50	.707	300
Development of a corporate culture with the staff	4.46	.613	300
Improving customer satisfaction and building customer loyalty	4.30	.763	300
Improvement of risk management	4.54	.838	300
Reduction of non-quality costs	4.50	.863	300

(SPSS)

Table 2 indicates that the number of observations used in the multiple linear regression test is equal to 300 (N=300). This implies that all the responses obtained from the questionnaire are utilized in this test. The dependent variable is the application and improvement of quality engineering by agri-food industries. Meanwhile, the independent variables include the improvement of manufacturing and quality measures, the development of corporate culture with the staff, customer satisfaction and loyalty, the development of risk management, and the reduction of non-quality costs.

Table 2: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.701 ^a	.491	.420	.639

a. Predictors: (Constant), Application and improvement of quality engineering, Improvement of manufacturing and quality measures, Development of a corporate culture with the staff, Improving customer satisfaction and building customer loyalty, Improvement of risk management, Reduction of non-quality costs.

(SPSS)

It is essential to consider both coefficients R and R Square as presented in the above table. The value of R is equal to 0.701, indicating that the regression model has an acceptable level of prediction. Furthermore, the value of R Square is equal to 0.491. It is worth mentioning that R Square is referred to as the coefficient of determination and represents the proportion of variance that can be explained by the independent variables. The significance of the R Square value is based on the work of Chin (1998), where a value greater than 0.33 indicates a moderate effect of the explanatory variables on the dependent variable (Chin, 1998). The results of the ANOVA analysis are presented in the following table.

Table 3: ANOVA

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.935	6	2.822	6.910	.000 ^b
	Residual	17.565	143	.408		
	Total	34.500	149			

a. Dependent Variable: Application and improvement of quality engineering

b. Predictors: (Constant), Improvement of manufacturing and quality measures, Development of a corporate culture with the staff, Improving customer satisfaction and building customer loyalty, Improvement of risk management, Reduction of non-quality costs.

(SPSS)

The result of the ANOVA test is presented in the above table. It indicates that the value of F is 6.910. The significance of this figure is shown in the last column, "Sig.". As the value of Sig is equal to 0.000, i.e., < 0.05, the model as a whole fits the data well. Therefore, the independent variables (factors) significantly predict the dependent variable (the application and improvement of quality engineering by agri-food industries in Lebanon). After confirming the significance of the prediction model and its effectiveness, it is now important to move on to the next table to identify which factors have a significant impact on the application of quality engineering by agri-food industries in Lebanon.

Table 4: Coefficients

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.138	.825		.167	.868
	Improvement of manufacturing and quality measures	.140	.189	.102	.740	.043
	Development of a corporate culture with the staff	.071	.180	.065	.397	.693
	Improving customer satisfaction and building customer loyalty	.662	.166	.558	3.997	.000
	Improvement of risk management	-.031	.191	-.028	-.163	.871
	Reduction of non-quality costs	.141	.177	.145	.796	.030

a. Dependent Variable: Application and improvement of quality engineering

(SPSS)

Table 7 indicates the variables that have a significant impact on the application and improvement of quality engineering in agri-food industries in Lebanon. It is worth noting that a Sig value < 0.05 implies that the independent variable has a significant impact on the application and improvement of quality engineering. Therefore, among the six independent variables, three have a significant impact on the dependent variable. These three variables are the improvement of manufacturing and quality measures (Sig = 0.043), customer satisfaction and loyalty (Sig = 0.000), and the reduction of non-quality costs (Sig = 0.030).

After identifying these three independent variables, it is important to analyze the B value for each of them. For the reduction of non-quality costs, the B value is 0.141, for customer satisfaction and loyalty, it is 0.662, and for the improvement of quality measures, it is 0.140.

The regression equation is as follows:

$$Y = 0.138 + 0.14 \text{ Improvement of manufacturing and quality} + 0.622 \text{ Customer satisfaction and loyalty} + 0.141 \text{ Reduction of non-quality costs}$$

According to these results, the "customer satisfaction and loyalty" factor has a higher impact on the application and improvement of quality engineering in the agri-food industries in Lebanon than the other two

independent variables. It is essential to study the direction of the impact of these three independent variables on the dependent variable. Since the B value is positive for all three selected independent variables, the direction of the impact is positive, meaning that an increase in the independent variable contributes to an increase in the probability of the application and improvement of quality engineering in the agri-food industries in Lebanon.

Quality Issues in Agri-food Industries

The theoretical section presented six quality issues faced by agri-food industries. The study results regarding these issues are presented in the figure below.

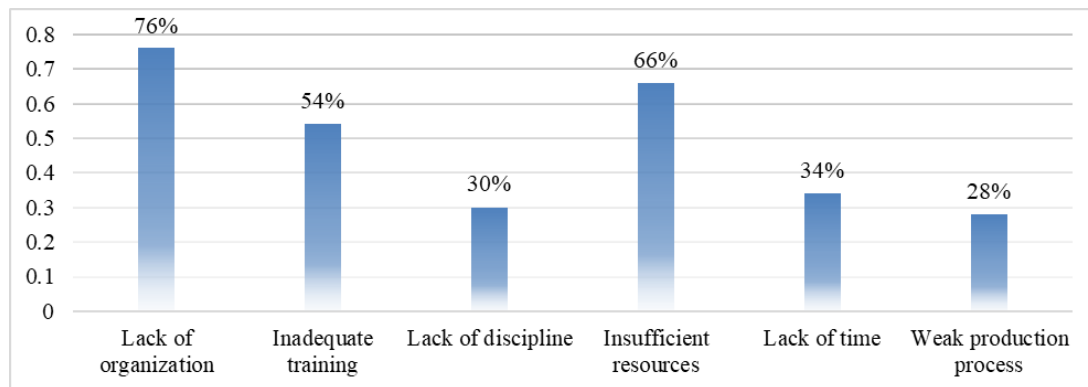


Figure 1: The quality issues in the agri-food industries in Lebanon (Author)

The figure above indicates that the respondents consider a lack of organization (76%) and insufficient resources (66%) as the most significant problems they face in their quality management. Additionally, inadequate training is a concern for 54% of the respondents.

While not deemed as critical, other issues should not be overlooked. These include a lack of time (34%), a lack of discipline (30%), and a weak production process (28%).

VII. Discussion

After presenting the results in the previous section, the figure below illustrates the final model of the research.

According to this figure, three factors out of the five studied have a significant impact on the application and improvement of quality engineering in agri-food industries in Lebanon.

Jawad et al. (2020) state that quality engineering helps industries effectively manage manufacturing processes, ensuring that finished products are safe, reliable, and meet customer expectations (Jawad, Kadhim, & Al Mansoori, 2020). Quality improvement is achieved by enhancing quality measures through the application and improvement of quality assurance, focusing on process orientation and the elimination of process variation (Owen, 2021).

According to statistical results, the application and improvement of quality engineering by agri-food industries aim to develop and enhance new products that meet customer expectations by offering higher-quality products. This drives agri-food industries in Lebanon to focus on the product, encouraging them to test a sample of a manufacturing process to ensure it meets design specifications or required quality standards, resulting in improved product quality.

Therefore, Hypothesis H1, *positing that the application and improvement of quality engineering have a significant impact on the improvement of manufacturing and quality measures in agri-food industries in Lebanon*, is validated.

Box and Woodall (2012) argue that the application and improvement of quality engineering contribute to continuously developing new products to increase market share by offering products that meet customer expectations (Box & Woodall, 2012). Customer-centric focus encourages industries to identify, understand, and satisfy customer needs, striving to exceed their expectations (Danda, 2020).

The study results indicate that customer satisfaction and loyalty are among the most important factors driving agri-food industries in Lebanon to apply and improve quality engineering. This factor encourages these industries to work within a team of professionals with the overall goal of ensuring that finished products are safe, reliable, and meet customer expectations, while maintaining an efficient and cost-effective manufacturing process. These companies define appropriate tests and acceptable result parameters to ensure the effectiveness of quality tests throughout the manufacturing process, understanding problems to develop effective solutions and modifying practices as necessary to maintain standards, resulting in satisfied and loyal customers.

Thus, Hypothesis H3, *stating that the application and improvement of quality engineering have a significant impact on customer satisfaction and loyalty in agri-food industries in Lebanon*, is also validated.

According to Noyel et al. (2016), quality engineering helps companies reduce non-quality costs. In this case, the company can reduce equipment malfunctions, avoid downtime, and effectively communicate quality non-conformities (Noyel, Zimmermann, Thomas, & Thomas, 2016). By applying and improving quality engineering, industries can reduce waste and produce goods in compliance with specific requirements and expectations. Consequently, there will be fewer rejected goods (Khan, Iqbal Khan, Sheeraz, & Mahmood, 2017).

According to the statistical results, the reduction of non-quality costs is one of the important factors that drive agri-food industries to apply and improve quality engineering. According to Isaac and Nkoi (2018), cost reduction involves ensuring the proper functioning of equipment, avoiding downtime, conducting regular reviews of customer complaints and quality non-conformities in production, planning internal audits, limiting waste, setting progress action plans (zero defects), and anticipating malfunctions that may generate non-quality. Furthermore, this cost reduction can improve the financial performance of industries (Isaac & Nkoi, 2018).

Regarding Hypothesis H5 concerning *the application and improvement of quality engineering having a significant impact on the reduction of non-quality costs*, it is validated.

According to Danda (2020), agri-food industries can engage employees in the manufacturing process through quality engineering, involving them in the company culture. The quality culture should permeate every aspect of the project and be supported by all stakeholders on the ground (Danda, 2020).

However, the empirical results of the study did not indicate the importance of this factor (involvement in company culture) in the application and improvement of quality engineering in agri-food industries in Lebanon. Therefore, Hypothesis H2, stating that *the application and improvement of quality engineering have a significant impact on the development of a corporate culture with the staff in agri-food industries in Lebanon*, is not validated.

Additionally, according to Manisha (2018), quality engineering makes risk management more effective. The primary goal of food risk management is to protect public health by controlling these risks as effectively as possible through the selection and implementation of appropriate measures (Manisha, 2018).

For agri-food industries in Lebanon, this factor (risk management) has not been a motivator for applying and improving quality engineering. In this case, Hypothesis H4, positing that *the application and improvement of quality engineering have a significant impact on the development of risk management in agri-food industries in Lebanon*, is not validated.

In Malaysian's and Indonesian's automotive industries show that quality engineering helps to meet customer requirements, improve the existing product or process, find the main reason of the problem and eliminate it. Quality engineering is considered as tool for continuous improvement (Yusof & Putri, 2009). For (Hassan & Shaharoun, 2000) The implementation of quality engineering enhances the tools and techniques used to suit new challenges in manufacturing and to satisfy the emerging quality paradigm.

According to Jardin (2021), agri-food industries face various quality issues such as a lack of organization, insufficient training, a lack of discipline, a lack of resources, a lack of time, and a weak production process (Jardine, 2021). While in the automotive industries there are some difficulties faced such as lack of education, resources, training, cooperation (Yusof & Putri, 2009).

According to the study results, the most significant quality issues faced by agri-food industries in Lebanon are a lack of organization (76%) and insufficient resources (66%). The importance of insufficient training is also notable for half of the respondents (54%). Other problems were also encountered by the study respondents, albeit to a lesser extent, including insufficient training, a lack of time, a lack of discipline, and a weak production process.

To address these problems, several solutions can be adopted, involving processes such as defining the problem to be addressed, identifying causes, searching for a solution, initiating actions (implementing the chosen solution), and monitoring the effectiveness of the solution and its implementation according to agri-food industries in Lebanon (WFQ Inc, 2020).

VIII. Conclusion

This study focuses on the importance of implementing and improving quality engineering in the agri-food industries, adhering to regulations to achieve performance development in product quality, employee productivity, and industry culture. This ensures that goods and services are designed, developed, and manufactured in industries to meet or exceed consumer expectations and requirements, prompting industries to evolve and progress in their work.

Quality engineering in agri-food industries in Lebanon seeks to highlight its strengths and emphasizes its importance in improving products manufactured by agri-food industries. For this reason, agri-food industries in Lebanon tend to apply and improve quality engineering driven by several factors such as the improvement of manufacturing and quality measures, customer satisfaction and loyalty, and the reduction of non-quality costs. This allows agri-food industries to remain competitive in the market.

Agri-food industries in Lebanon identify certain quality problems, including a lack of organization, insufficient training, and a lack of resources. For these industries, these problems can be addressed through various

processes, including defining the problem to be addressed, identifying causes, searching for solutions, initiating actions, and monitoring.

Based on this study, recommendations can be made. Industries are encouraged to provide training to their employees on the importance of quality engineering in the competitive world to meet and exceed customer requirements. Additionally, they are urged to implement continuous monitoring processes for the improvement of quality engineering, characterized by a basic problem-solving system, allowing these processes to proceed more quickly and systematically. To achieve this, allocating a budget to adopt and improve quality engineering is essential.

The Lebanese government is encouraged to facilitate access to necessary sources of funding for investment in agri-food industries, such as subsidized bank loans (which is currently challenging due to the Lebanese economic crisis) or loans from financial institutions supported by non-governmental organizations. Furthermore, the government can offer tax exemptions to motivate entrepreneurs to invest in the agri-food industry.

However, several limitations posed obstacles to the study, including:

- The sanitary crisis and the Lebanese government's decisions to impose a prolonged lockdown, have made it challenging to visit more agri-food industries.
- The economic crisis in the country and the high fuel prices made it difficult to visit agri-food industries and reduced the availability of infrastructure such as electricity and the internet.
- The total population number is unknown due to the lack of statistics in the Lebanese field.
- A larger sample could have improved the validity of the results.

After discussing quality in the private sector, specifically in agri-food industries in Lebanon, a new perspective emerges, focusing on studying the quality of services provided by Lebanese public administrations and the possibility of implementing quality engineering in the public sector to ensure good quality of public services.

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