

## Using Six Sigma Methodology In Solving The Critical Control Points Problems in (HACCP) System/ Case Study in Mosul Dairy Factor

Dr. Alaa Hasseb A. Aljalealy

Layla M. AL-Hameed

Omar A. Ismaeel

College Of Economic and Administration\University of Mosul

### Abstract

The HACCP concept is one of the developed and modern concept within food industries in recent year , the system is concern about food safety though determining critical hazard which may harm food safety in any manufacturing and distribution chains phases , so the HACCP is can be consider as a global system developed by food manufactures to raise standards of food safety and quality generally .

The HACCP system purpose is to providing an effective and practicable management tools for identifying food safety hazards and ensuring that adequate controls are in place which includes suppliers ,equipment makers , packaging , services providers farmers , food manufacturing process , and retailers organizations.

the importance of this research comes from its concerning with applying serene principles of HACCP system concept and identifying hazards which may harm production process in Mosul .

### استخدام منهجية Six Sigma في معالجة مشكلات النقاط الحرجة في نظام HACCP دراسة حالة في معمل الالبان في الموصل

المستخلص :

يعد نظام الـ HACCP أحد الانظمة المتقدمة والحديثة التطبيق في مجال الصناعات الغذائية ، ويعتمد مفهوم نظام الهاسب على اساس الحفاظ على سلامة ا لغذاء من خلال تحديد نقاط المخاطر الحرجة والمتحتمل ان يتعرض لها الغذاء في اي مرحلة من مراحل سلسلة تصنيع وتجهيز الغذاء، وبهذا فان نظام الهاسب باعتباره نظاما عالميا تم وضعه من قبل صناع الغذاء فهو يهدف الى تحقيق متطلبات الامن الغذائي من خلال سلسلة مزودي وموادي الغذاء .

ونظام الهاسب يهدف الى تزويد الشركات المصنعة للغذاء بالوسائل الالزمة لأخذ الخطوات الضرورية للتحكم بالمناطق الخطرة لامن الغذائي من خلال اعطاء الشركات المعنية ادوات السيطرة في سلسلة صناعة الغذاء ، وهذا يتضمن الموردين ، صناع المعدات ، مزودي مواد التغذية ، مزودي الخدمات ، المزارعين ، عمليات صناعة الغذاء ، منظمات تجارة التجزئة والبضائع المعلبة والجاهزة ، وبهذا فان الشركات تصبح قادرة على السيطرة لمعرفة النقاط الخطرة والحرجة في الصناعات الغذائية.

وتاتي اهمية البحث من خلال تركيزه على محاولة تطبيق المبادئ السبع للهاسب ومحاولة تحديد المخاطر التي يتعرض لها تصنيع المنتج في مصنع البان الموصل وذلك لأهمية هذا المعمل في انتاج منتجات متعددة تغطي حاجة السوق المحلية من جهة وخطورة تعرض مثل تلك المنتجات الى المخاطر المتمثلة بالتلف خلال مراحل التصنيع وحتى تسليم المنتج للزبائن . وباستخدام منهجية six sigma فان البحث يحاول ايجاد الحلول للنقاط الحرجة في سلسلة تصنيع المنتج في المعمل المذكور ، وذلك من خلال تحديد اهم المشكلات التي يتعرض لها المنتج وذلك باستخدام تقنية عظمة السمسكة ومن ثم اقتراح الحلول لمعالجة تلك المشكلات .

## Introduction

Amid the environmental instability that surrounds the contemporary food industry, there have been substantial changes in food industry operations, including significant developments in food quality and food activities. In its continual efforts to address the food quality and food safety requirements of government, customers, and consumers. The food embraced generic quality systems and quality programs similar to those used by other industries.

At the same time, it has adopted safety systems and programs that have been developed specifically for use within the food industry. Consequently, food quality and food safety requirements, and addressed through the use of systems and programs that include quality management, quality assurance, quality control, the hazard analysis critical control points (HACCP) system, and good manufacturing practices (GMPs). And since Six Sigma is a problem-solving technology that use data, measurements, and statistics to identify the vital few factors that will dramatically decrease waste and defects, while increasing predictable results, customer satisfaction, profit, and shareholder value. it has to deal with process performance to remove the unnecessary steps from the operations which cause the extra costs. one of the benefits of six sigma thinking is that it allows managers to readily describe the performance of the production's process in terms of its variability.

### Definitions and abbreviations:

**Critical control point (CCP):** A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level .The processing factors whose loss of control would result in an unacceptable food safety risk.

**Critical control point (CCP):** decision tree A sequence of questions to assist in determining whether a control point is a CCP.

**Critical limit:** A criterion that separates acceptability from unacceptability A maximum or minimum value to which a biological, chemical, or physical parameter must be controlled at a CCP to prevent, eliminate, or reduce to an acceptable level, the occurrence of a food safety hazard

**Hazard:** A biological, chemical, or physical agent in, or condition of, food with the potential to cause an adverse health effect A biological, chemical, or physical agent that is reasonably likely to cause illness or injury in the absence of its control.

**Hazard analysis:** The process of collecting and evaluating information on hazards and conditions leading to their presence to decide which are significant for food safety and, therefore, should be addressed in the HACCP plan .The process of collecting and evaluating information on hazards associated with the food under consideration to decide which are significant and must be addressed in the HACCP plan

**Hazard analysis critical control point (HACCP):** A system that identifies, evaluates, and controls hazards that are significant for food safety A systematic approach to the identification, evaluation, and control of food safety hazards. HACCP, which is recognized for its science-based approach, consists of a set of seven principles.

**Process performance quality (PPQ) :** represented by four variables which are process outcomes, performance quality, process technology, people, this concept contrite on the process quality not just improving process performance.

### First: Research methodology

#### Statement of The problem:

The local factory of Dairy products in Mosul city have a serous problems in keeping the products fresh and valid to use, since this products have a direct contact with customers safety, so the researchers hopes through this research to determine the Critical Control Points in the production's process which expose the food to ruin

in order to maintain the product quality and safety through achieve (PPQ) by applying six sigma methodology.

### **Aims of the study:**

The goal of this research is to concentrate on the role of the (HACCP) and improving (PPQ) approach to improve food industrial organisations in Iraq. Taking in to consideration that Iraq has the potentials for development specially in Dairy industries in order to meet the quality and safety requirement of this products of the global market or at least regional market.

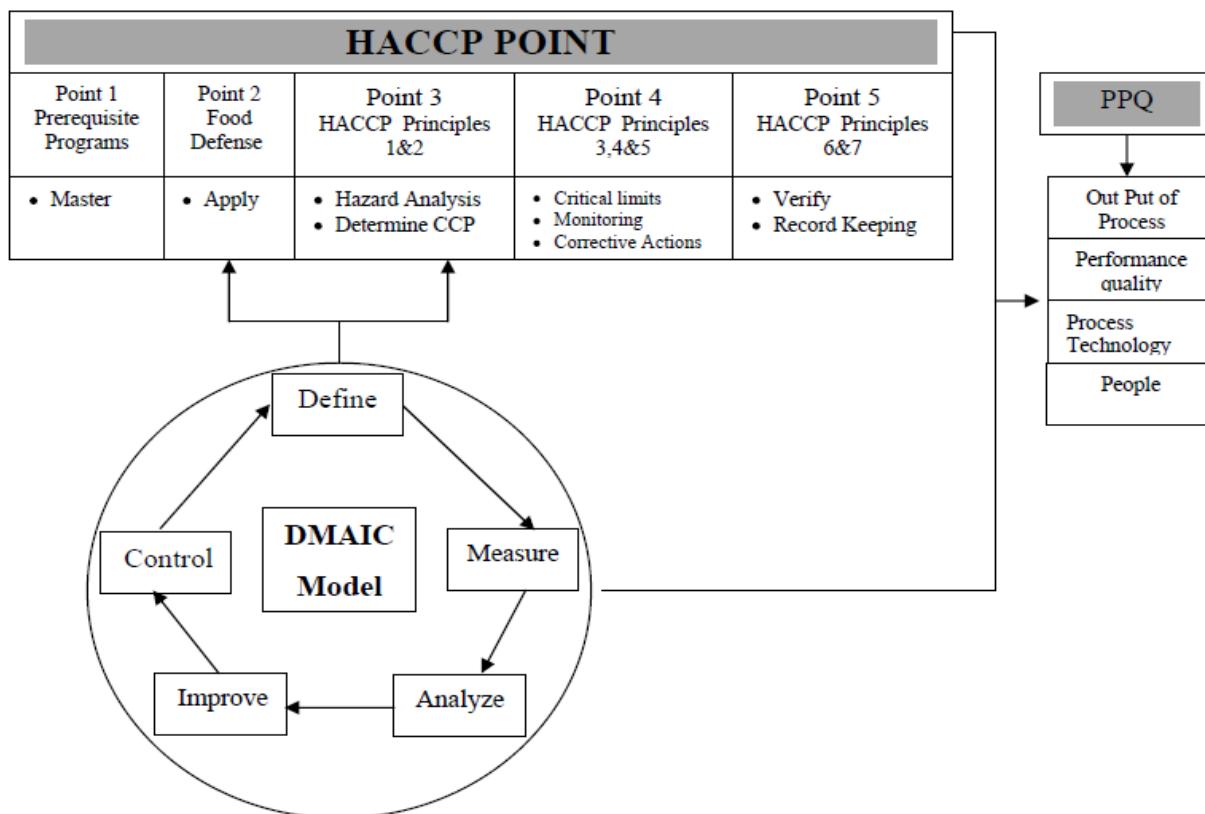
### **Significance of the research :**

Since Iraq has a big agricultural potential, and in the last few decades had witnessed a huge neglected duo to political ,economical and social factors.

Today we have the awareness to built our industry, and to built the quality in it, by that we could use our resources idly and make profits from the local production.

The results of this research will be useful to all Iraqi and development countries food Industries, and through this study we will be able to determine the critical point that affects the diary product quality and safety and then we will be able to adjust the process to reach PPQ. That will lead our dairy industries to be zero defects, and reduce the production failure cost.

### **The model:**



Source of the model: the model is designed by the researchers

## Second :Literature review

### A: Hazard analysis critical control points (HACCP)

#### What is the HACCP:

HACCP is an acronym used to describe the Hazard analysis and critical control point system. The HACCP concept is a systematic approach to food safety management biased on recognised principles which aim to identify the hazards that are likely to occur at any stage in the food supply chain and put into place controls that will prevent them from happening. HACCP is very logical and cover all stages of food production from the growing stage to the consumer, including all the intermediate processing & distribution activities.(Mortimer and Wallace, 2001: 2)

#### Advantages of HACCP:

The HACCP system can be applied throughout the food chain from the primary producer to the final consumer. Besides enhancing food safety, other benefits in applying HACCP include more effective use of resources and more timely response to food safety problems. In addition, the application of the HACCP

system can aid inspection by food control regulatory authorities and promote international trade by increasing buyer confidence in food safety.

A HACCP plan is specific to a particular food and processing application. The HACCP system is capable of accommodating change, such as advances in equipment design, processing procedures or technological developments.

The successful application of HACCP requires the full commitment and involvement of management and the workforce. It also requires a team approach.

The application of the HACCP system is compatible with the implementation of quality management systems, such as the International Organization for Standardization's ISO 9000 series, and is the system of choice in the management of food safety within such systems.(Whitehead and Orriss ,[www.fao.org](http://www.fao.org))

### **HACCP principles:**

HACCP is a systematic approach to the identification, evaluation, and control

of food safety hazards based on the following seven principles:([www.fao.org](http://www.fao.org))

Principle 1: Conduct a hazard analysis.

Principle 2: Determine the critical control points (CCPs).

Principle 3: Establish critical limits.

Principle 4: Establish monitoring procedures.

Principle 5: Establish corrective actions.

Principle 6: Establish verification procedures.

Principle 7: Establish record-keeping and documentation procedures.

### **CCPs Decision tree:**

Important considerations when using the decision tree:

The decision tree is used after the hazard analysis.

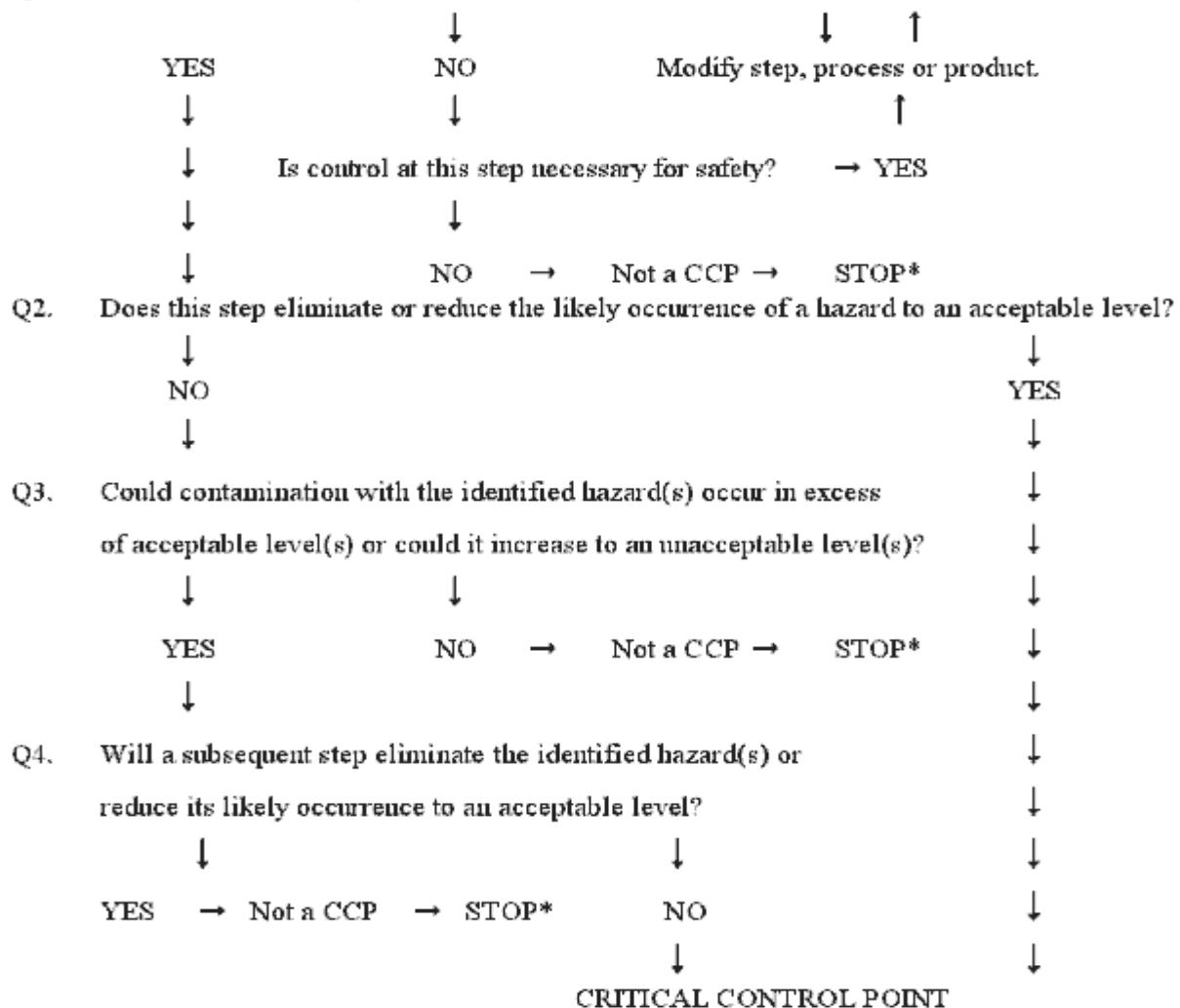
The decision tree then is used at the steps where a hazard that must be addressed in the HACCP plan has been identified.

A subsequent step in the process may be more effective for controlling a hazard and may be the preferred CCP.

More than one step in a process may be involved in controlling a hazard.

1. More than one hazard may be controlled by a specific control measure.

Q1. Do control measure(s) exist for the identified hazard?



\*Proceed to next step in the described process

## Figure (1) CCPs Decision tree

**Source:** Vasconcellos. J. Andres 2005. Quality Assurance for the Food Industry A Practical Approach, CRC PRESS Washington. USA.

## HACCP Costs

HACCP cost estimates can be viewed as measures of the opportunity cost to society of implementing HACCP rather than using resources for other purposes. They are partial cost estimates because both ignore increased government monitoring costs and either ignore or underestimate process modification costs.

The HACCP implementation required each plant to (a) develop and maintain sanitation standard operating procedures (SOP); (b) maintain carcasses and raw material at specified temperatures during handling, holding, and shipment; (c) apply antimicrobial treatments to carcasses prior to treatment; (d) perform microbiological testing for processed material on each day; and (e) develop and maintain a HACCP plan for each process of each animal species. (Roberst and others, 1996:1299)

### **Implementation challenges**

Probably the most important benefits from implementing a HACCP system into a business are the lessons learned from the challenges encountered during implementation. If your business is in the middle of implementing a HACCP system or believes that a HACCP system is already implemented, these challenges may still be out there waiting to be corrected. (Kaliher, 2003: 130)

Challenge 1 getting commitment at all levels in the organization

Challenge 2 estimating time required to implement HACCP

Challenge 3 employee involvement

Challenge 4 communication

Challenge 5 training

Challenge 6 corrective action

Challenge 7 production ownership

Challenge 8 documentation

### **B: Six Sigma (6 ) in HACCP**

The need for statistical quality control principles are still required to meet a producer's needs for other critical food characteristics not included in the HACCP regulations (flavor, color, etc). Considerable publicity for the six-sigma quality control system has suggested that conventional statistical quality control procedures are outmoded. This might be true in hardware manufacturing industries where warranties, returns, and repairs are part of the system, but certainly not in the food industries. However, there are some parts of the six sigma approach which might be of value to the food industry as well. In this we will use the methodology of Six Sigma in the principle 2 and principle 3 of HACCP.

### **Six Sigma (6 ) Problem Solving Process**

According to (Pande & Holpp, 2002, 29-30) improvement, problem-solving, and process-design teams, are the most visible of a Six Sigma effort. These teams,

led by Black Belts or Green Belts are formed to solve problems and/or improve processes, the life cycle of this process in terms of six phases: (Kaliher,2003,20)

Phase 1: Identifying and Selecting the Project(s).

Phase 2: Forming the Team .

Phase 3: Developing the Charter .

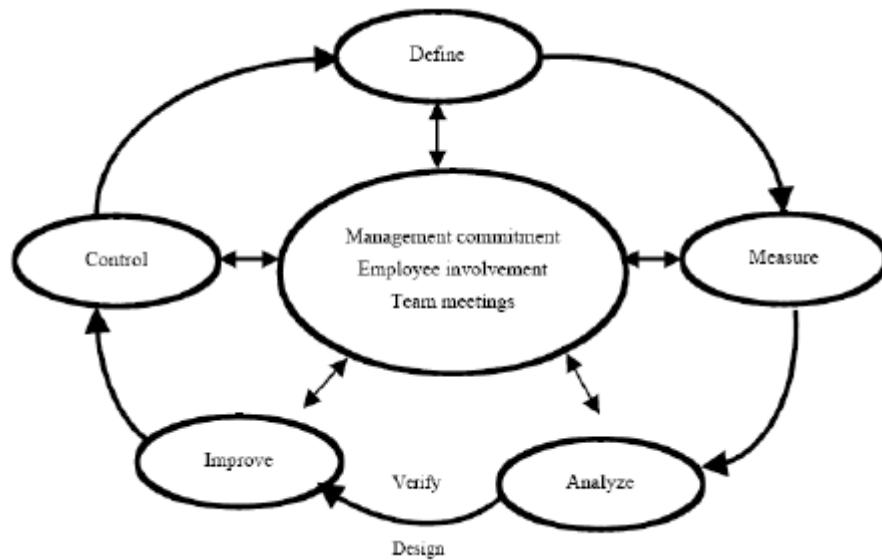
Phase 4: Training the Team .

Phase 5: Doing DMAIC and Implement Solution .

Phase 6: Handing OFF the Solution .

### DMAIC Process

The problem solving process that Six Sigma uses is called DMAIC, , it is an acronym for the five phase processes of define, measure, analyze, improve and control. DMAIC is the backbone of Six Sigma and is considered as such because it provides the fundamental structure and processes from which all Six Sigma activity is to emanate and evolve. Like most TQM processes or tools, Six Sigma is practiced typically in teams of diverse backgrounds and different organizational areas. In bringing a diverse team together to work a problem or initiative across a large enterprise, it is critical to have a common process or model that all members can follow. This process for Six Sigma is DMAIC.



**Figure 3 : The DMAIC base model**

**Source :** Hutton, Thomas C., 2004 , *ACE vs. Six Sigma* , Master OF Business Administration, at the Massachusetts Institute OF Technology.:18

According to (Park , 2003, 38) The most important methodology in Six Sigma management is perhaps the formalized improvement methodology Six Sigma Framework characterized by DMAIC process. This DMAIC process works well as a breakthrough strategy. Six Sigma companies everywhere apply this methodology as it enables real improvements and real results.

The methodology works equally well on variation, cycle time, yield, design, and others. The critical aspects of the corporate-level preparation for the Six Sigma methodology include establishing key business performance measurements, ensuring organizational effectiveness, readying the organization for Six Sigma, and establishing goals for improvement. These goals and opportunities are then aligned with other business initiatives and filtered into projects. The project level implementation relies on the DMAIC methodology to capitalize on opportunities for improvement. Extensive training is conducted for champions and sponsors, Black Belt and Green Belt candidates, and employees. The Black Belt and Green Belt training programs include various tools and techniques to apply the DMAIC methodology(described below).( GUPTA, 2004 , 24)

### **Define Phase**

The intent of the define phase is to clarify the goals and value of a project. Teams and champions use the appropriate tools necessary to assess the magnitude of the opportunity in a given value stream, the resources required, and an overall design of the problem-solving process. (Munro, 2002)

### **Measure Phase**

In the measure phase the team will assess the amount of variation within the variables. Teams are expected to identify and measure both input and output process variation. The measurement tools used, and in particular the variation associated with them, are considered critical. Therefore, a critical and early step in the measure phase is to determine how much variation exists in the measurement tool. (Pande & Holpp, 2002).

### **Analyze Phase**

In this phase, computer software tools such as Microsoft Excel often aid teams. Tools such as Excel assist teams in reducing and organizing large quantities of data and thereby better understanding trends and relevant factors. (Pande & Holpp, 2002).

### **Improve Phase**

The improve phase is where many teams are tempted to go right at the very start of the DMAIC process. One of the key attributes and benefits of Six Sigma is the rigor that it employs in keeping teams from rushing immediately to the improve

phase. The final solution must be approved by the team champion and generally the cognizant leadership of the subject process. (Pande & Holpp, 2002).

### **Control Phase**

The team's objective in the control phase is to identify and implement a control plan that will successfully monitor the process and will readily indicate to the appropriate personnel when the process degrades or goes off track. An appropriate control plan will identify the process owner(s) and will include a flow chart and standard operating procedure that contains the previously determined improvements. An appropriate control plan will also include a response plan for dealing with problems that may arise.(Pande & Holpp, 2002).

### **C: Process Performance Quality PPQ:**

In the food industry, quality is a requirement for consumer acceptance. Total quality, or integral quality, means that all industrial operations, manufacturing, and the final product are subjected to acceptable processing and conformance with requirements. The successful operation of any production, manufacturing, or formulation process is dependent upon the degree of control that can be exerted on the process. .( Vasconcellos,2005: 2) , process control has been embraced as part of a system of total quality management (TQM), which includes dimensions of senior management commitment, training, business culture, and continuous improvement, among others. The principle cause of quality problems is viewed as variability in processes, whether these processes are manufacturing operations, purchasing, logistics, or other related tasks. The function of HACCP systems is to direct the use of scientific methods to monitor performance and identify points of high leverage for performance improvement. (Mazzocco, 1996: 770)

Quality programs recognize elements such as quality in production and control of production as being essential aspects. These principles require that a producer or manufacturer plan the production or manufacturing process in such a manner that the process can be carried out under controlled conditions. This process control element is now recognized as being critical for the successful operation of a manufacturing industry in order to ensure that quality targets can be consistently achieved. To obtain quality results, therefore, the initiative must be taken at the highest managerial levels.( Vasconcellos,2005: 2)

Much of work within an organization can be looked upon as a process, which means a repetitive sequence of activities. The goal of the process is to produce product or services, which should satisfy the customer, the process generates data that indicates how well the process is satisfying its customer, which can give

information about how well the process is working and how it can be improved, the process orientation and focus has become even more focused on the currently dominating improving program Six Sigma.(Hansson, 2003: 14)

Process management is indicated by " use of statistical techniques", "reduce of cycle time", process performance charts", and "continuous improvements" In this research the variable of Process Performance Quality that we aim to achieve by implementing HACCP through Six Sigma methodology, PPQ is include (process outcome, performance quality, process technology, people

### **Process outcome:**

There is an overlap between the variables that represent the performance quality and process outcome which can be presented in ( product reliability, customer satisfaction, profitability).

### **performance quality:**

performance quality may be represented by { time to market (responsiveness of the process), productivity, process reliability}.

### **process technology:**

All competitive priorities have the potential to be affected by the decision of the process technology which is a strategic decision. Cost reduction is a frequent objective of technology in the production of product and services, cost reduced by appropriate technological innovation include labor cost, cost of waste, cost of carrying too much inventory, and utility cost. Technology can also provide the controls necessary to reduce product defect and service failures, eliminating waste at the same time.

Process technology can also be used to improve the quality of goods and services. The process are controlled so that variability is reduced are inherently better quality.

Dependability of delivery can be affected by process technology decision because technology can make process less variable, which makes them easier to predict and much more consistent. (Finch, 2006:93)

### **people experience( Quality at the Source)**

This process puts the production worker in the driver s seat of controlling the product quality. Some of the principles are: ( Vasconcellos,2005: 9)

1. Every worker becomes a QC station.

2. Every worker is responsible for inspecting his or her own work, identifying any defects and repairing the products.
3. Each worker is given the right to stop the line to avoid producing defective parts in this part of PPQ we obtain to earn the people (workers) multiskills with variety of experience which will achieve the variety and accumulation in knowledge of the organisation human capital.

### **Discussion and Conclusions:**

#### **Discussion:**

Mosul dairy factory have been established in 1976, the of the employees (161), the factory produce (yogurt, cream, cheese), and all these product did not contain preservatives marital m this factory is a bunch of the general state for dairy product in Abu-gareab. It is worth mentioning that all the equipments in the above mentioned factory were manufactured in the 1970s and some of them belong to the 1950s. Since 2003 till now the factory had the plane of replacing the production lines with automatic one, However the factory is still running taking into consideration the demand in the local markets. The factory depends in finance on auto-financing.

The production process depends upon the manual work not automation. Hence and an attempt to solve the problem of the CCP that encounter food industry and one of which is Mosul dairy factory, the researches has made a number of field visits to take an overview of the production line and the marketing department in the factory. Solving the CCP problems makes indispensable taking the following steps:

1. Assembling HACCP team

**Table No(1) of the HACCP Team in Mosul dairy factory**

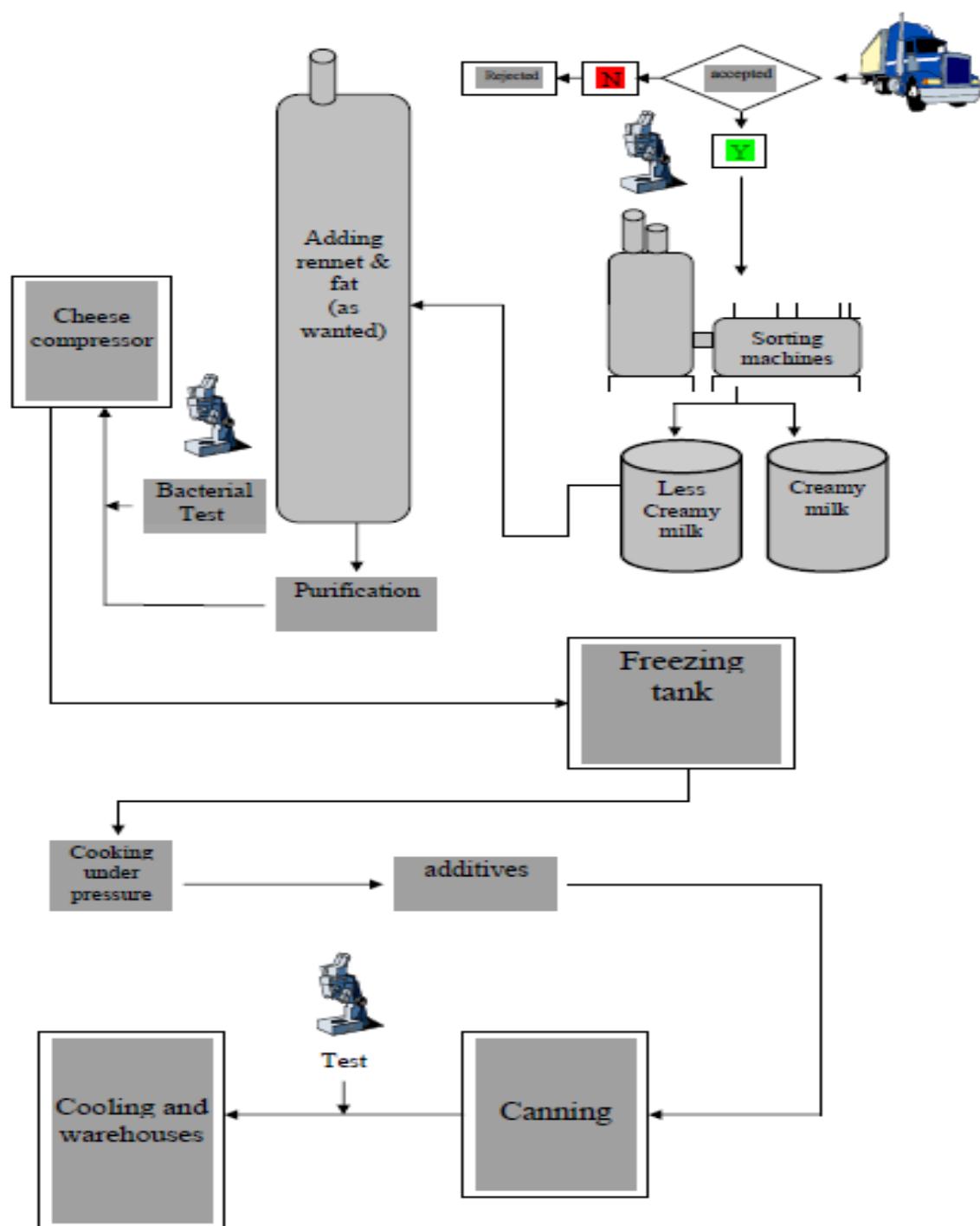
<b>Job</b>	<b>Required Major</b>	<b>Current Major</b>
<b>Engineer</b>	<b>Agricultural engineer</b>	<b>Agricultural engineer</b>
<b>Production</b>	<b>Production management</b>	<b>Chemical</b>
<b>Quality assurance</b>	<b>Quality assurance</b>	<b>Chemical</b>
<b>Health safety</b>	<b>Medicine</b>	<b>Not available</b>
<b>Nutrition techniques</b>	<b>Nutrition techniques</b>	<b>Nutrition techniques</b>
<b>Environmental health</b>	<b>Environmental techniques</b>	<b>Geological sciences</b>
<b>Chemical</b>	<b>Chemical</b>	<b>Chemical</b>
<b>Physical</b>	<b>Physical</b>	<b>Physical</b>

**Source:** designed by the researchers

## 2. Product Description :

**First: The Product:** the researchers adopted the processed cheese product of which it consists of ( cheese, salt, emulsifying salt), 43% total solids, 30% fat in dry material. Canned in a plastic sealed can, this can contain the expiry date, the product description and the company name without mentioning the nutrition facts.

**Second: production process:** the factory contains a single production line for producing various types of cheese including processed cheese. The figure (4) will explain the production process and the process layout.



### Distribution methods:

Through out the meeting held with the head of the marketing dep., it was obvious that the production process is controlled by the local market demand of Mosul city

without the surround regions, the product distributing condition should be cold storage in 5c , it is worth to mentioned that the factory has no wholesalers in Mosul instead the deals with random retailers.

### **Usage of the products:**

the processed cheese is terminal product, which means that it will not be a part of another production process. The range of this product is Mosul city exclusively due to the poor distribution capabilities.

### **Hazard Analysis :**

Through out the fields visits and the observations, the hazard occurs in four points of the production process, these points are

**The first Hazard:** milk is most critical raw material because containing melon of bacteria, the temperature degree of the received milk should be 2-4c, in the Mosul dairy factory the temperature degree reaches 8-10c some times, due to the poor transports conditions. But the factory still use it for the production, depending on the tests results that takes samples from the milk tanks, these tests includes (temperature, methyl blue , fat, Hp, physical characteristics) and the results will determine the designs of accepting or rejecting the milk, also the results will determine the kind of the products that will produced. By applying the decision tree of CCP this point dose not represent CCP.

**The second Hazard:** the bacteriological test point between the compressing cheese stage and friezing stage is a CCP according to CCP decision tree, the bacteriological test includes (yeast and mold growth, fat hydrolyzing bacteria, protein decomposing bacteria, and physical characteristics ), the purpose of this test is to confirm the product safety to consumer health and measure the quality level to determine the sigma that factory working according to. Through applying the six sigma methodology to this point as CCP, the results will be:

#### **1) Quantity of the good and defect product at each point :**

$$200 \text{ Kg} - 180 \text{ Kg} = 20 \text{ kg}$$

#### **2) Good product percentage :**

$$180 \text{ Kg} / 200 \text{ Kg} = 90 \%$$

#### **3) Defect product percentage :**

$$1 - 90 \% = 10 \%$$

#### **4) Defect average et each point : Defect occurring average et each point**

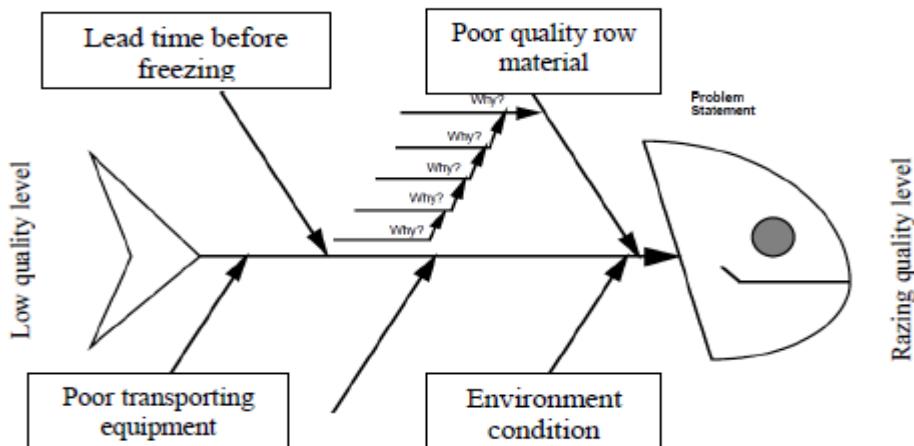
$$10\% / 4 = 0.025$$

## 5) Defect per million opportunities (DPMO):

$$1000000 * 0.025 = 25000$$

6) (DPMO) to Six Sigma tables : Sigma level is =  $3.4\sigma$ 

## Analyze the Problem :



**The Third Hazard:** the terminal test (after canning ) which includes (physical characteristics, bacterial pollution), the Hazard will increasing for using (canes) which could be contaminated, by applying CCP decision tree at this point, we find out that this is a CCP, the imported thing at this point that the quality level should be 6 ( zero defect) due to the high risk on the customers health and safety, and by applying 6 methodology to this point as a CCP, the results will be:

## 1) Quantity of the good and defect product at each point :

$$200 \text{ Kg } 195 \text{ Kg } = 5 \text{ kg}$$

## 2) Good product percentage :

$$195 \text{ Kg } / 200 \text{ Kg } = 97.5 \%$$

## 3) Defect product percentage :

$$1 - 97.5 \% = 2.5 \%$$

## 4) Defect average et each point :

## Defect occurring average et each point :

$$2.5\% / 4 = 0.00625$$

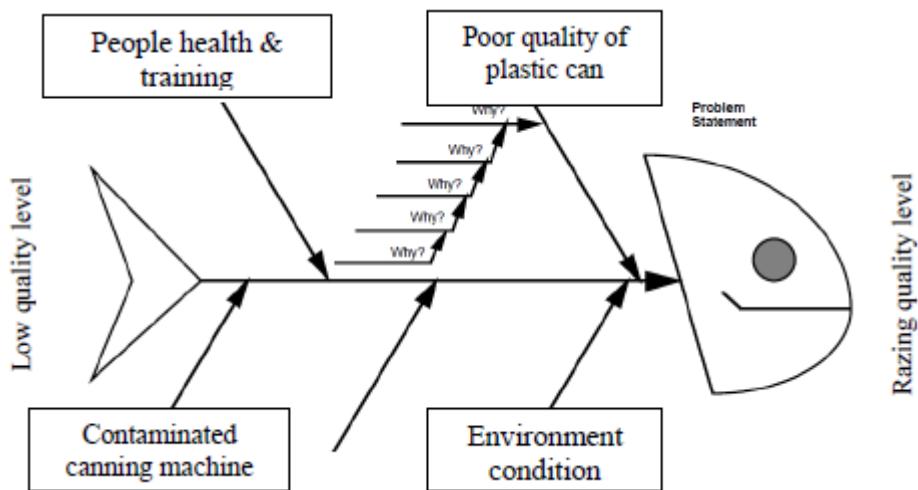
## 5) Defect per million opportunities (DPMO):

$$1000000 * 0.00625 = 6250$$

## 6) (DPMO) to Six Sigma tables :

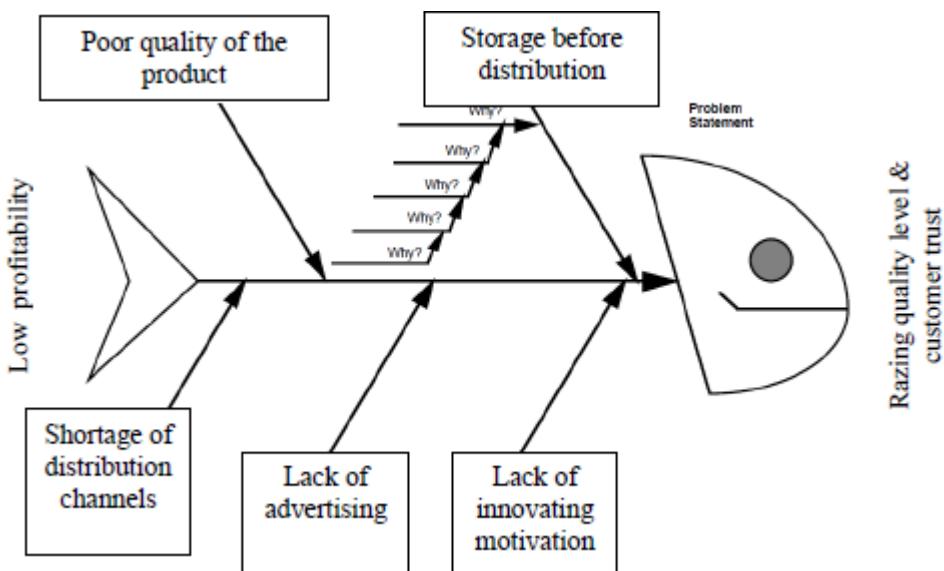
Sigma level is  $4\sigma$ 

## Analyze the Problem :



**The fourth Hazard:** Hazard will occur after distribution stage, when the product reached to retailer, the Hazard will occur and increased duo to the poor preservation of the product. By applying the CCP decision tree we find out that this is a CCP, because of the poor capabilities to control the surrounded conditions of distribution and keep the product, we can't compute the quality level at this stage.

## Analyze the Problem :



**Conclusions:**

1. the quality level of the second CCP is ( 3.4 ) which can be analyzed to the environmental conditions, lead time before freezing, poor quality of the raw material, poor transporting equipment. the improving procedure is control the environmental conditions inside the factory, reducing lead time before freezing stage, increasing the suppliers numbers, replace the transporting equipment with the an effective modern one.
2. the quality level of the third CCP is (4 ) which can be analyzed to the poor quality of the plastic can, people health and training, contaminated canning machine, environmental conditions the improving procedure is dealing with more than one supplier so the factory could choose the best material, giving more attention to people health and training, cleaning the canning machine or replies it be full automatic one, controlling the environmental pollution inside the factory.
3. the first and the fourth Hazard points will need establishing monitoring procedure and correction actions, and that will be in the first Hazard point, increasing the range of the raw marital suppliers, which will promote the responsiveness, productivity, and process reliability when the factory don t have to accept what they offered to, and have the ability to choose. It is worth mentioning that there is a huge lack of quality awareness in the food industry, despite of the ISO department in the general state center.
4. in order to enhance process reliability, we need to increase the people ability to be a QC stations in every process and replace the production line with automatic line with emphasizing on the quality training to all the levels that have a direct contact to the production process.
5. one of the HACCP implementation necessities in Mosul dairy factory is process technology that will enhance the product quality, productivity and customer trust in factory products.

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