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IMPLEMENTATION OF A HAZARD ANALYSIS CRITICAL CONTROL POINT (HACCP) SYSTEM IN A TOMATO CANNERY

BY

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DECLARATION

I hereby declare that this submission is my own work towards the M.Sc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This work is dedicated to my parents, Kingsley and Rosina Deteah. God richly bless you for your support.

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I am grateful to God for being with me throughout this program. I am also grateful to my supervisor, Dr. Herman Lutterodt for his mentorship. I wish to thank the staff and management of Nutrifoods Ghana Limited for allowing me to conduct this project using their facility. My deepest gratitude also goes to Richard Nyumuah, Isaac Donkor and Matthew Boakye for their immense assistance in coming up with this paper. My special thanks goes to my wife, Bernice and Francine my daughter as well as the entire Deteah family. The support was overwhelming. I hope this study becomes beneficial to other players in the tomato industry. I know this study would be the foundation of my future endeavours.

ABSTRACT

The main purpose of this study is to implement and validate the HACCP system in a tomato cannery. Every process step from the receipt of raw material to the packaging of finished goods underwent hazard analysis. After evaluation, five significant hazards points were identified at the raw material receipt, blending, pasteurizing, sieving and retort steps. At the end of the study, two (2) CCPs and one (1) control point were identified. The 1.25 mm sieve at the filling step ensuring physical hazards present in the paste were reduced to acceptable levels before being packed into the cans. It is the first CCP. The retort step with a water temperature and holding time of 90 °C and 40 minutes respectively for cans after they had been seamed is the second CCP. The pasteurizer with the minimum product retention time and temperature of two (2) minutes and 88 °C was established as a control point. The target pH of less than 4.6 for tomato paste inhibits the growth of spore forming organisms which might be present in the product. The temperature/ time regime of the pasteurizer and the retort steps coupled with the increasing acidity make up the multi hurdle effect which ensured all pathogens were eliminated or rendered harmless in the final product.

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ABBREVIATIONS

CCP	Critical control point
CODEX	Codex Alimentarius Commission
CP	Control point
FAO	Food and Agriculture Organization
FDA	Food and Drugs Authority of Ghana
FSIS	Food Safety and Inspection Services
FSIS	US Food Safety and Inspection Services
GLSS	Ghana Living Standard Survey
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis Critical Control Point
ISO	International Standards Organization
SSOP	Sanitation Standard Operating Procedures
TQM	Total Quality Management
USFDA	US Food and Drug Administration
WHO	World Health Organization

DEFINITIONS

Acceptable level: Acceptable level means the presence of a hazard which does not pose the likelihood of causing an unacceptable health risk.

Control point: This means any point in a specific food system at which loss of control does not lead to an unacceptable health risk.

Critical Control Point: means a point at which loss of control may result in an unacceptable health risk. (As defined in the USFDA Food Code)

Critical Limit: means the maximum or minimum value to which a physical, biological, or chemical parameter must be controlled at a critical control point to minimize the risk that the identified food safety hazard may occur (USFDA Food Code).

Deviation: This means failure to meet a required critical limit for a critical control point.

HACCP Plan: As defined in the Food Code, this means a written document that delineates the formal procedures for following the HACCP principles developed by The National Advisory Committee on Microbiological Criteria for Foods.

Hazard: This as defined in the Food Code means a biological, chemical, or physical property that may cause an unacceptable consumer health risk.

Monitoring: means a planned sequence of observations or measurements of critical limits designed to produce an accurate record and intended to ensure that the critical limit maintains product safety. Continuous monitoring means an uninterrupted record of data.

Preventive Measures: These mean an action to exclude, destroy, eliminate, or reduce a hazard and prevent recontamination through effective means.

Risk: Risk means an estimate of the likely occurrence of a hazard.

Sensitive ingredient: Sensitive ingredient means any ingredient historically associated with a known microbiological hazard that causes or contributes to production of a potentially hazardous food as defined in the Food Code.

Verification: Verification means methods, procedures, and tests used to determine if the HACCP system in use is in compliance with the HACCP plan.

CHAPTER ONE

INTRODUCTION

Food safety in the 21st century has become a global issue requiring close cooperation between countries in agreeing to standards and setting up transnational surveillance systems. In 2009, a Ghanaian local newspaper the *Daily Guide* investigations uncovered unsafe tomato paste products on the local market imported from China (www.ghanaweb.com, 28.10.2009). The general unease that the story generated was plain to see, emphasizing the increasing awareness of consumers on safety and health issues associated with the food they eat. In the developed countries including USA, Norway and the UK, consumers demand more information on food origin, specific production methods and composition (Lappo *et al*, 2013). This has contributed to the emergence of food safety and quality assurance tools in food production in these countries

The public alarm generated by the *Daily Guide* article was because tomato paste is widely consumed amongst the general populace of Ghana. The Ghana Living Standards Survey (GLSS, 2010) indicates that 25 percent of tomato consumption is of processed paste. The Ghanaian market is inundated with various processed tomatoes products, some produced locally, but most imported. The European Union is the biggest exporting market of tomato paste to Ghana, but lately, Chinese paste has grown in volumes traded as well.

Local production of processed tomatoes has been growing due to several reasons. Firstly, taxes on imported food products combined with deliberate policies such as tax holidays for local processors aimed at encouraging local manufacturing are gradually yielding some results. Secondly, the number of companies processing tomato paste has grown from 2 in 2010 to 4 in 2015 because regional trade agreement amongst West African countries have made free movement of goods and services within the sub-region possible (IFPRI, 2010).

Some companies that export processed paste to Ghana are taking advantage of these developments to site their business here.

Local manufacturing of food products is regarded as one of the most viable ventures and the expectation is that the number of companies, as well as, volume of total consumption of processed food products will continue to increase. Whilst these trends present opportunities in the labour market, they also present challenges in the areas food safety and quality management. This is especially so in the advent of lean product manufacturing practices where cost-minimization is a major consideration in the manufacturing sector. As Doeg (1995) commented, "No matter how professional and effective a company may be, there is always the possibility of a serious problem arising which is unforeseen and eventually develops into a major crisis. What is important however is the ability on the part of the company to think through the possible ramifications of such eventualities and preparing responses and scenarios to deal with it". This means that an effective food facility is one which always ensures that it is better prepared for the unexpected especially in food safety.

The Hazard Analysis Critical Control Point (HACCP) system developed by Codex Alimenatarius Commission in 1992 is acknowledged as the better intervention or quality measure to identify specific hazards and actions to control their occurrence by minimizing or eliminating them to ensure food safety and quality. HACCP is considered especially suitable for such delicate industries as food and health industries in preventing foodborne diseases (Arvanitoyannis and Kassaveti, 2009; Vela and Fernandez, 2003).

1.1. Problem Statement

Today, the country processes various kinds of food products such as dried pineapples and mangoes, fried plantains and canned tuna and tomato paste both for local consumption and for export.

Foodborne diseases are widespread, but increasingly, consumers are becoming more aware of the problem and have been demanding for safe and high quality foods. This is positive development because issues bordering on safety and consumer health associated with food are considered consumer-driven because of their associated cost (El-Hofi *et. al*., 2010). Food manufacturing companies consider food safety issues as important and but will implement cheaper means of addressing them. They often choose the minimalist approaches which have not always been proven to work

One of the most effective approaches to addressing food safety and quality issues is HACCP. A casual survey of most industries in Ghana indicates that the system (HACCP) is not employed in most industries, particularly, the indigenous local manufacturers and even amongst some international companies operating in Ghana because of the country's weak consumer influence on industry.

The 2009 tomato paste health alarm was followed by another story in the Daily Graphic (http://www.modernghana.com/thread/322679/245838/1) about some manufacturers of tomato paste deliberately adulterating their products with sugar and starch contrary to the country's legal provisions in the manufacturing of the said product. All the products found to contain these unauthorized products particularly starch; they were all of imported brands. Local companies demand for more action to combat the importation of cheap but possibly unsafe tomato products into the country. In today's global market, further taxation on imports may contravene WTO rules of fair competition. However, the country is better off if it demands specific food safety and quality standards from manufacturers exporting into the country. HACCP system presents one of such important tools in ensuring that food products manufactured in the country is safe and of high quality. With that, the country will have the

basis to demand for food products that proves to be of considerably safe manufacturing standards.

The only problem is that at the moment, none of the tomato paste companies processing locally employs the HACCP or related ISO22000 system.

1.2. Need for Study

Tomato paste is popular in the Ghanaian and West African cuisine and is estimated to be consumed in at least one diet per person pay week (GLSS, 2010). Any health-related incidence arising from consumption of tomato paste therefore, will, have wide-ranging repercussions. A system that ensures that hazards relating to tomato paste processing is controlled should be sought after. Developing a HACCP system for a tomato paste manufacturing line especially in the context that none exist in the 4 companies operating locally is therefore imperative. The study thence serves a practical purpose for the tomato paste processing industry.

Secondly, introducing HACCP to the local tomato paste manufacturing industry could be the starting point in doing same for other related sectors such as juice and palm oil industries and even in the meat processing sector which also pose serious health concerns. HACCP systems, having been proven resilient in preventing and mitigating food safety risks and hazards will be important in assuaging the fears of consumers and restore confidence in locally manufactured food products.

1.3. Objectives of Study

The objective of this study is to design and validate a HACCP system in a commercial canned tomato paste factory in Ghana

1.4. Significance of Study

This study seeks to implement a HACCP system in a running tomato plant and evaluate its effectiveness in enhancing food safety. It will also serve as a baseline study to promote food safety in the tomato paste industry. In consideration of the population exposed daily to the health risk posed by consuming tomato paste products, it is believed that the study would be helpful in assuring and guaranteeing the health and safe usage of this most important food product in the Ghanaian populace.

It will serve as a novel product in the industry and as expected, as a benchmark, to significantly reduce the future cost of similar setups.

1.5. Limitations of Study

The first limitation of the study results from the tenets of HACCP itself, which is that, its usage should be considered in specific terms. Though a generic HACCP for the fruits and vegetable processing sector can be generated, the canned tomato paste sector is specifically considered in this study and therefore even though the study could be adapted for tomato puree or tomato chops it should not be directly transposed *in ditto*.

1.6. Organization of Study

The study is organized in 5 chapters. Chapter one briefly introduces the theme for the research and project work setting out the problem statement, the objectives and its importance. Chapter two reviews the body of work on the subjects of food safety, HACCP, its principles, planning and implementation setting the tone for chapter three which discusses the method employed specifically for the production of tomato paste for a particular company. Chapter four presents the results of the implementation of HACCP and the discussion of the results, recommendations and conclusion drawn in chapter five.

CHAPTER TWO:

2. LITERATURE REVIEW

2.1. The Hazard Analysis Critical Control Point System

2.1.1. History of HACCP

The Pillsbury Company first developed the concept of HACCP in the early 1960s. The firm worked cooperatively with NASA to develop this new system to ensure safety of the food consumed by the astronauts (Mathew, 2006). The first major development preceding HACCP is associated with the works of W.E. Deming whose theories of quality management are widely regarded as a major factor in turning around the quality of Japanese products in the 1950s culminating in what is called Total Quality Management (TQM) systems which according to Arvanitoyannis and Kassaveti (2009) emphasized a total systems approach to manufacturing that could improve quality while lowering cost. Prior to that time, most safety systems were based on end product testing usually referred to as quality control.

At the 1971 National Conference on Food Protection, the HACCP system was first presented. This new approach to food safety gained interest among food processors and was used as the basis for regulations regarding low-acid and acidified foods (Mathew, 2006).

However, after the initial excitement of the new system, interest in HACCP began to fade. According to Stevenson (1990) (cited by Kirby, 1994), only a few large companies continued to apply HACCP. The call for change was however galvanized again in the 1990s with a tragic outbreak of *Escherichia coli* foodborne illness in the United States related to the consumption of contaminated ground meat (Rocourt *et. al*., 2003; FDA,)The result of the outbreak was that the US Food Safety and Inspection Services (FSIS) developed a regulatory proposal known as the Pathogen Reduction-HACCP System Rule (Schlosser and Hulebak, 2002) and in 1997 HACCP principles were adopted worldwide as given in Codex

Alimentarius Commission (1997). Today, HACCP program is mandatory in many food processing industries especially in the European Union through its implementation as an element of the composite Global Food Safety Initiative, ISO 22000 (Regulation (EC) No. 852/2004). It is also a major requirement demanded of any country intending to export processed food products to the United States and European Union and some other countries including Japan.

There is a difficulty in implementing HACCP at its inception period particularly by businesses because of their size, lack of technical expertise, economic resources or the nature of their work encounter. This necessitated the commissioning of a joint initiative of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) through its platform the Codex Alimentarius Commission to develop guidelines for such small businesses (Corlett, 1998; Griffith, 2006).

A HACCP requirement in canned food industries is highly recommended. The major reason why some canning companies have implemented HACCP is to control Clostridium Botulinum (Ropkins and Beck, 2000; Mathew, 2006).

2.1.2. Purpose of a HACCP Program

The HACCP program serves several purposes. The main objective of HACCP is to produce a safe product. HACCP is therefore a hazard prevention program and not a finished product quality inspection. Microorganisms that cause illness and harmful chemicals are examples of some of the hazards that HACCP will attempt to reduce or eliminate (Swanson and Anderson, 2000). It is believed that no process would be absolutely safe, but there must always be a constant effort to achieve zero defects and eliminate health risks (Snyder, 1995). Ehiri *et al.*, (1997) indicated that to successfully implement HACCP, those in authority responsible for

ensuring food safety should recognize the need to move to that system rather than simply incorporating it as part of business-as-usual component.

Another function of HACCP is to reduce or even eliminate the need for endpoint testing. In a study conducted by El-Hofi *et al*., (2008) to implement HACCP system to UF white cheese production line in Egypt, the researchers determined that the successful implementation of the system completely eliminated the need to test for safety related issues on the final product as each sample completely passed safety checks. Before the HACCP concept was developed, many processors depended on endpoint testing to determine if their product was satisfactory. This testing can be very tedious and time consuming. Also, testing can lead to a loss of a portion of the product since some types of testing are destructive (Bachanan, 1990). HACCP attempts to reduce endpoint testing by conducting a series of checks throughout the process. At each step in the process, all possible hazards are considered in regards to how to prevent them and what actions will be taken if a significant hazard occurs (Mortimore, 2001). By the time the product reaches the end of the process, HACCP attempts to reduce hazards to an acceptable level (Mathew, 2006).

A third purpose of HACCP is to provide documentation to prove that the process is being conducted as written. Without documentation and records, there is no verification that anything has actually taken place. This is important in facilitating trade especially across borders (Mathew, 2006; Sarter *et al*., 2010).

2.1.3. Advantages of HACCP System

According to the FDA (1999) (cited by Mathew, 2006), the advantages of HACCP over other safety systems are that this preventative program:

- Focuses on identifying and preventing hazards from contaminating food
- Is based on sound science

- Permits more effective government oversight because record keeping allows investigators to determine how well a firm is complying with food safety laws over a period of time rather than how well it is doing on any given day
- Places responsibility for ensuring food safety appropriately on the food manufacturer or distributor

According to Jervis (2002) HACCP is the preferred risk management tool in total quality management because it focuses technical resources on critical parts of the process and provides a cost-effective control of food-borne hazards.

2.2. HACCP Components

2.2.1. Prerequisite Programs

Long before the implementation of HACCP system in the food industry, certain food safety programs had preceded it. The introduction of HACCP was not meant to be a replacement of these already existing programs but rather as an add-on to them. These programs in the context of HACCP implementation are collectively referred to as *prerequisite programs*. These programs, according to Sperber (2005) provide the basic conditions that are necessary for the production of safe food. Some examples of prerequisite programs are GMPs, SSOPs, letter of guarantee and pest control (NACMCF, 1999 cited by Untermann, 1999). As Quinn and Marriot, (2002) argues, prerequisite programs ensure the full functionality of the HACCP plan and thence a good HACCP plan is a reflection of well-maintained prerequisite programs.

Both prerequisite programs and HACCP are aimed at achieving food safety and quality. However, one striking difference between the two is that the former does so indirectly by tackling related issues affecting food safety whilst the latter focuses solely on food safety.

Secondly, prerequisite programs tends to be generic in its application across a processing plant but HACCP plans are only based on hazard analysis that are product or line specific (Mathew, 2006; Bernard *et al*, 1999 cited by Quinn, 2001).

Stier (1998) identifies Good Manufacturing Practices (GMPs) and Sanitation Standard Operating Procedures (SSOPs) are two of the most common prerequisite programs for HACCP. GMPs emphasize sanitary effectiveness and hygiene practices during food processing (Mathew, 2006). In the advanced economies, it is the norm with many companies to require that their supplier conduct regularly scheduled audits to assure that they are adhering to their GMPs (Quinn, 2001). Perhaps one of the earliest prerequisite programs still in use today is the SSOPs which describe all daily procedures that will be conducted to maintain sanitation, specify the frequency of the procedures, and identify those responsible for implementing the SSOP (Stier, 1998; Mathew, 2006). Both GMPs and SSOPs require that they are signed and dated by a qualified official and kept with all HACCP related documents (Mathew, 2006).

2.2.2. HACCP Team

In order for HACCP to function properly, it requires commitment from the entire plant where it is implemented. This starts with show of commitment from upper management. A HACCP team is set up in order to champion the operation of implementing the plan to the letter. The team is established of individuals who will execute the duties of implementing and maintaining the HACCP and as such should be interdisciplinary. It should not be a large group, usually 4 – 6 and its members could be:

- production manager
- head of analytical laboratory
- head of microbiological laboratory
- personal manager
- technical manager

- logistic manager

The HACCP team has to provide the production-specific expertise and experience which are necessary for the development of the HACCP plan (Untermann, 1999; Arvanitoyannis and Kassaveti, 2009). According to Arvanitoyannis and Kassaveti (2009) the responsibilities of the HACCP team are:

- organizing and documenting HACCP study
- reviewing deviation from critical limits
- internal auditing of HACCP plans
- communicating, educating and training employees in the operation of HACCP system
- understanding the stages of the process the team will be monitoring

It may be easier to keep the HACCP team internal for communication and availability purposes. Someone from research and development may be selected if new products and processes are being developed.

Training of HACCP team should not be done by HACCP practitioners but rather by academics, regulators or former hygiene trainers to avoid biases in the scope of attention and provide a more holistic approach to the system (Mortimore and Wallace, 1997).

2.2.3. Product Description and its Intended Use

Another requirement of a HACCP plan is to develop a product description and intended use of this product. A complete description involves providing information about ingredients, processing methods, retail, packaging and storage conditions aimed at identifying any possible hazards occurring to the product and that which the product may cause (Arvanitoyannis et. al., 2004). Furthermore, information giving description of target a group that may consume the product is also required (Ababouch, 2000). Product description is not

exhaustive. However, USDA (1999) mandates that the following questions should be answered in describing the product:

1. What is the common name of the product?
2. How is the product to be used?
3. What type of packaging encloses the product?
4. What is the length of shelf life of the product, and at what temperature?
5. Where will the product be sold? (Who is the intended consumer and what is the intended use?)
6. What labelling instructions are needed?
7. Is special distribution control needed?

The purpose of the product description is to help familiarize the HACCP team with the products and technologies being utilized. The intended use consists of information on whether the product has to be prepared prior to consumption e.g. by heating or whether it can be consumed directly (Untermann, 1999).

2.2.4. Process Flow Diagram

Prior to conducting a hazard analysis, a process flow diagram must be created. It is a flow chart that represents the process starting with receiving of materials to shipping of the end product (Mathew, 2006). The flow diagram should be constructed by the HACCP team which should be fully familiar with the process (Arvanitoyannis et. al., 2004). It should cover all steps of the operation. The flow diagram should include time and temperature profiles for each stage of production. It does not necessarily have to be an extensive drawing of the facility. According to FDA recommendations a block type flow diagram will suffice. (Fig. 1)

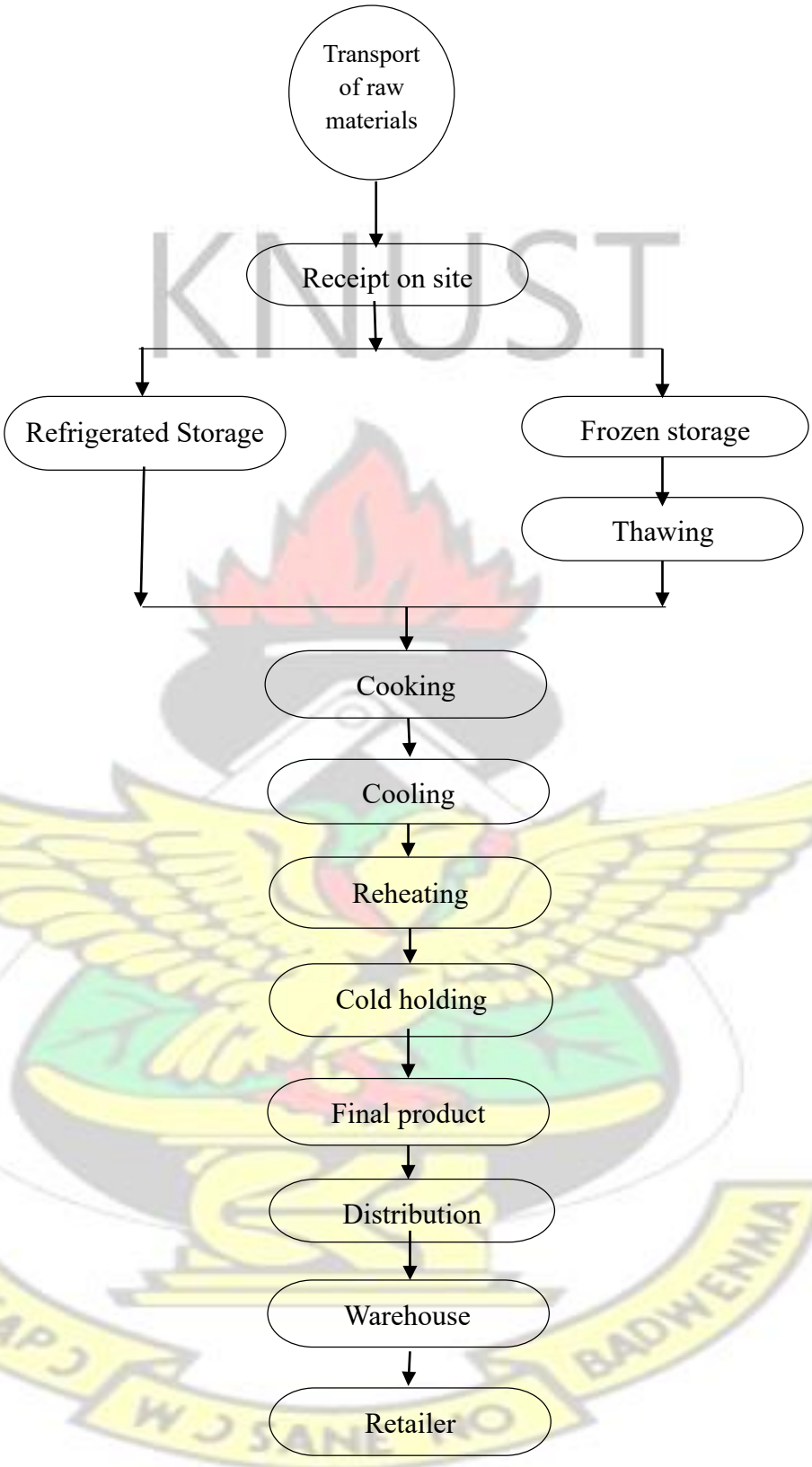

Figure 1 Generalized flow diagram of typical production process (Arvanitoyannis and Hadjiscostas, 2001; FDA, 1999)

2.3. Principles of HACCP

HACCP principles are developed after preliminary steps of the HACCP components have been completed. In theory, the only way of ensuring that every can of tomato paste from a given production line is safe from any contamination, is to test every can. Obviously, such an endeavour is totally impractical, so that instead, a representative group of cans is withdrawn against a sampling plan appropriate for the product and the history of the plant. However, whilst such an approach is essential to confirm that pre-set standards of hygiene are being met and that potential contaminants are at a low level or absent, the procedure can never prevent some spoiled packages from reaching the consumer. The concept of HACCP becomes even more useful in shifting the emphasis in quality assurance from mitigation to that of preventative (Jervis, 2002). As a consequence, the system identifies seven aspects of production that merit constant attention and these aspects are enshrined in seven principles (Tamime and Robinson, 2007).

First – any potential hazards associated with canned tomato paste production from the collection of raw materials through to manufacture and distribution must be identified and an assessment made of the likelihood that a given hazard will arise; and the preventative measures that are necessary to reduce any inherent risks. When determining the likelihood of a hazard, the HACCP team must research each hazard and identify any trends. The team indicates for example that the likelihood of a particular occurrence is low if the available literature indicates that hazard does not occur often (Mathew, 2006). Another important aspect when assessing hazard is to inquire about its severity in a scenario that it is not properly controlled. This is so because hazards differ in their severity. Mathew (2006) classifies hazards that can lead to chronic illness or death as very severe compared with those less severe types that may only result in small side effects.

Second – the precise points in the identified sequence that can be controlled in order to eliminate a hazard or minimize the risk of occurrence must also be identified. This is achieved by going over the flow diagram (Sohrab, 1999). If failure to control a particular hazard is a risk to public health, then the step in the process is regarded as a critical control point (CCP). CCP hazard must be eliminated or reduced to acceptable level. However, if no major risk is involved, the step may be identified as a control point (CP). For example a pasteurizer in a milk industry is a CCP because contamination with a pathogen could present a direct risk to the consumer. According to Alli and Weddig (1999), CCPs require a lot of careful development and extra documentation and that is why they should be limited to only those that are truly critical. The shotgun approach is one of the most widely used methods in determining CCPs/CPs. However, this method is subjective, relying mostly on the opinions of team members. Tompkin (1994) avers that rather than this approach which may lead to excessive numbers of CCPs, a more accurate and feasible method that can reduce the number of CCPs is the decision tree method (Mathew, 2006). This approach attributed to Tompkin (1994), asks several questions about each processing step where a hazard is significant. The questions are in a "yes" and "no" format, and will eventually determine whether that step is a CCP (Fig. 2).

Third – set of targets – critical limits, attainments of which, will gain control over a CCP/CP must be established. A critical limit is a maximum or minimum value to which a specific parameter must be controlled at each CCP. Common critical limits are temperature, time, moisture, pH and salt concentration.

Fourth – a monitoring procedure must be established to record the particular aspects of production that are under control. Critical limits can be monitored continuously or noncontinuously. Continuous monitoring is ideal when a particular parameter tends to have

more variation than normal (Tompkin, 1994). If non-continuous monitoring is utilized, a member of the HACCP team must be assigned to conduct checks are regular intervals.

Fifth – however, if the monitoring procedure indicates that a CCP/CP is not under control, then an agreed program of corrective action must be capable of immediate implementation.

Sixth – there must be procedures for verification that the HACCP system is working throughout the factory, e.g. the introduction of supplementary checks to ensure that the principal components of the system are operating to the required standard.

Seventh - introduction of a documentation system that takes into account all processes and records in accordance with the principles and their application. Such a system should assign responsibilities of the individual operators associated with that specific section of the process.

HACCP is designed as a structured approach, and the proper sequencing of activities is crucial to obtain an effective output. Jervis (2002), in his seminal work "*Application of Process Control in Dairy Microbiology Handbook*" identifies 14 sequential stages in the preparation of HACCP system in the manufacture of yoghurt. It is important to note however, that, in as much as sequence of activities may differ amongst production processes, proper sequencing is key in setting up an effective system.

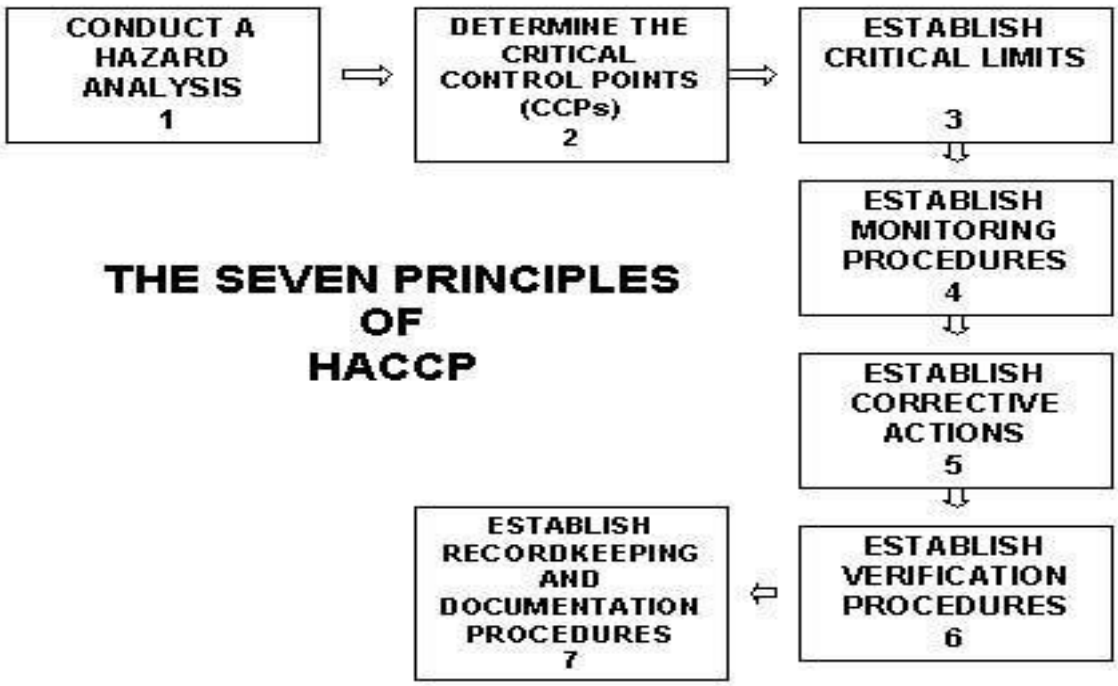

Figure 2. The seven principles of HACCP (adapted from FDA, 1999)

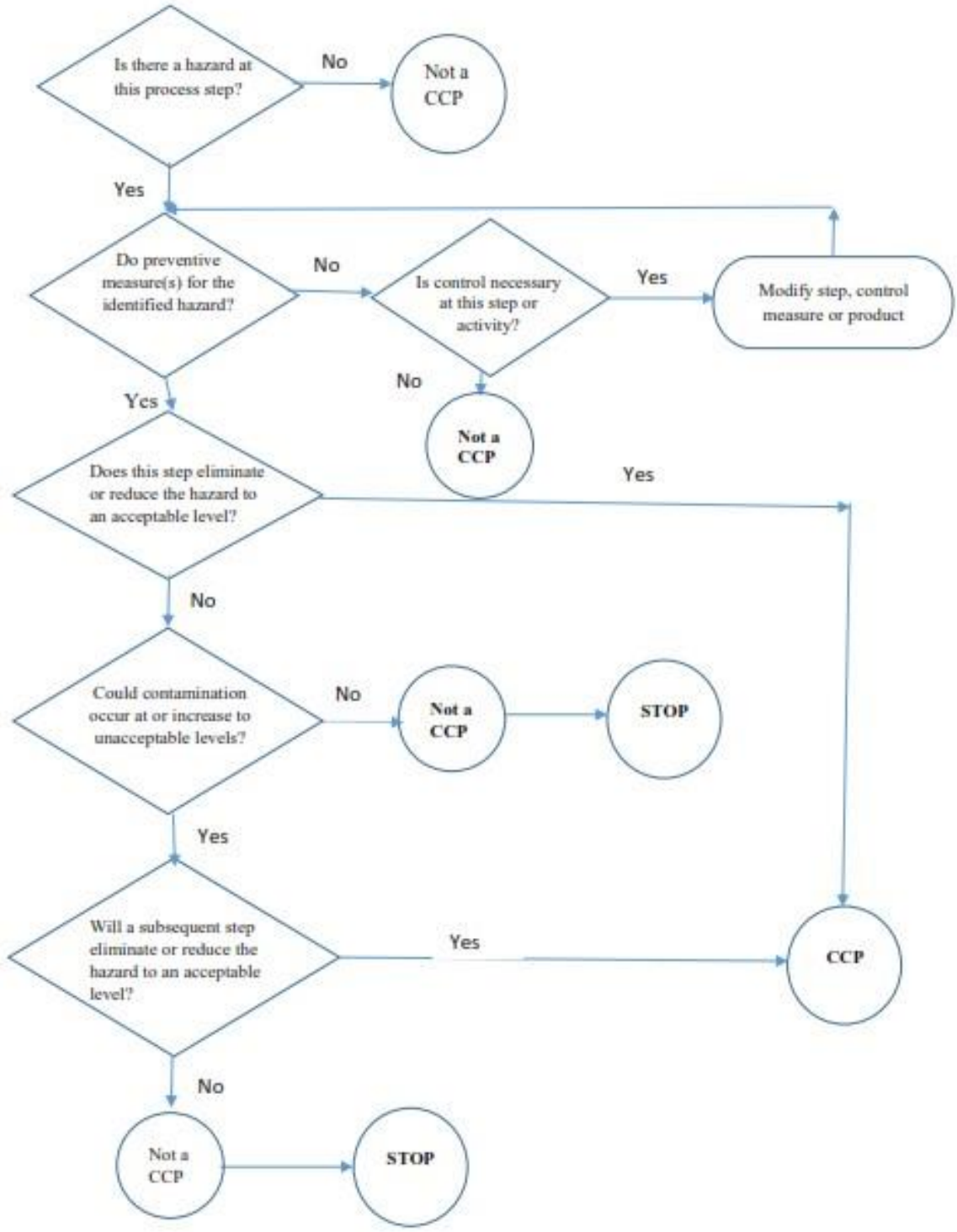

Figure 3: Process step CCP decision tree (Adapted from Corlett, 1998; Arvanitoyannis et. al., 2001).

CHAPTER THREE:

3. MATERIALS AND METHODS

3.1. Application of HACCP System

The steps used in applying HACCP system in the production of Tasty Tom® tomato paste is described by El-Hofi *et al.* (2010) in the implementation of the system in a white cheese production line in Egypt. Their system, in addition to drawing up a HACCP plan considers a post-HACCP evaluation of the effectiveness of the system and therefore, provides a more comprehensive preventive oriented approach in addressing food safety concerns.

Tasty Tom® canned tomato paste is produced by Nutrifoods Ghana Limited, a subsidiary of Olam International and Sanyo Foods. The company's production line is situated in Tema; in the Greater Accra Region of Ghana with a daily capacity of 250MT. Nutrifoods Ghana employs about 280 staff in administration, production, quality management, marketing and logistics.

3.1.1. Assembly of HACCP Team

The first step employed in this project was to assemble the Company's HACCP resources having obtained approval from top management to proceed with developing the system and permitting specific employees to be part of the team. Management took overall responsibility of the project. The HACCP team consisted of 6 members including:

- Production Manager
- Quality Manager
- Quality management specialist
- Warehouse Manager
- Engineering/Maintenance Manager
- HACCP consultant

The advantage of the team was that all the members with the exception of the HACCP consultant were conversant with the technology and equipment used in the processing lines. The consultant was briefed accordingly and together with the other members appraised with the practical aspect of food production as well as, the applied aspect of microbiology. The consultant took the rest of the team through the principles and techniques of HACCP application.

3.1.2. Final Product Description

The second step in developing the HACCP system was to provide a complete and comprehensive description of the final product, Tasty Tom® Tomato Paste and how it is intended to be used. In doing so a Process Description form was developed adapted from the FSIS Generic Models in product description. Table 1 provides headings developed for Tasty Tom® Tin Tomato Paste.

Table 1: Product Description Form 1 – Process Description

Please answer the following questions in developing Product
1. Full name of products
2. Common name (s)?
3. How is it to be used?
4. Type of primary package?
5. Type of secondary package?
6. Length of shelf life?
7. At what temperature?
8. Where will the product be sold?
9. Labeling instructions?
10. Special Distribution control needed?

Source: Self, adapted from FSIS Generic Model for Tomato Past

The second form was designed to collect further information on the ingredients used in producing the final product. This was essential in identifying which of these ingredients is

associated with hazards and such hazards affect the final product's quality and safety (See Table 2).

Table 2: Product Description Form 2 – Ingredient List

Product Line		
Primary ingredient	Non-primary ingredients	Binders/extenders
Spices/flavourings	Restricted ingredients	Preservatives/acidifiers

Source: Self; adapted from FSIS Generic Model

3.1.3. Construction and Verification of Process Flow Diagram

The process of constructing the process flow diagram involved outlining each step in the production process in sequence from reception of raw materials at the factory through processing, packaging and storage. The flow considered the cyclical order that process follows in the event of product recall and reconstitution. The HACCP team did a walkthrough of the production facility to verify the accuracy of the information contained in the drawn process diagram. The end product of this step is a schematic sketch of how the final product is attained.

3.1.4. Regulatory Requirements for SSOPs and GMPs

In order to demonstrate commitment and resources of management to successfully implement the HACCP plan, the team outlined and considered the implementation of all prerequisite programs; both mandatory and voluntary regulations including SSOPs and GMPs. A written recall plan describing how a recall event will be handled was also developed.

3.2. Implementation of Principles of HACCP

The seven principles of HACCP were applied at this stage in a step-by-step approach to develop the plan. The external consultant having appraised members of the principles assigned specific tasks that especially utilizes the special expertise of each member in production of the product

at the facility. The focus of the entire hazard analysis is in identifying the microbiological, chemical and physical hazards that may occur at each step of the production process.

3.2.1. Conduct of Hazard Analysis

Prerequisite programs (PRPs) which are features of the production environment are required to be in place by the HACCP plan. An audit was carried out utilizing ISO 22000:2005 (E) Section 7.2 as the primary document. Once the team had assured itself that the prerequisite programs were in place, an evaluation of the operation for hazard was then carried out using the first principle. The following steps based on the USDA HACCP Manual were duly followed:

- Review of the production process description developed in pre-HACCP step 2 to determine how the information could influence the hazard analysis.
- All product(s) ingredients and incoming materials for the product(s) were looked at to determine how they influence the process.
- Each step in the process flow diagram was determined for existence of biological, chemical or physical hazard(s).

In order to identify the hazards, the following steps were taken:

1. Observing operations: each product preparation process was observed for receipt of raw materials, storage, heat treatment, cooling and packaging. During the observation stage, specific question were asked at each processing step as described in USDA Manual (See bibliography for information).
2. Measuring operations: time and temperatures applied during the production and storage of tomato paste were measured and recorded on the flow diagrams.

Once a hazard was identified, a full assessment and description of the significance of the hazard were provided based on scientific literature. An evaluation of the likelihood and severity of

occurrence of the hazard is then assessed and as a final step preventive measures for each of the hazard are identified.

3.2.2. Identification of CCPs

The HACCP team having identified and assessed hazard types and their respective preventive measures, the next step was to apply principle two of HACCP; identifying points in the process steps where the hazards could be prevented, eliminated or reduce to acceptable levels. The team utilized the decision tree approach in identifying the CCPs (Corlett, 1998; Arvanitoyannis *et al*., 2001).

3.2.3. Establishment of Critical Limits

The HACCP regulation defines critical limit as:

"The maximum or minimum values to which a physical, biological, or chemical hazard must be controlled at a critical control point to prevent, eliminate, or reduce to an acceptable level the occurrence of the identified food safety hazard."

The critical limits for tomato paste are expressed as numbers or specific parameters based on visual observations such as:

- Organoleptic
- Concentration (brix)
- Consistency by Bostwick
- Colour values on the Gardner colour scale
- pH
- Acidity

Table 3 provides the full list of compulsory tests and their recommended values required in the determination of critical limits in the production of Tasty Tom® tin tomato paste.

Table 3: List of Compulsory Tests and recommended values in Determining Critical Control

Limits

No.	Specifications	Recommended value
1.	Organoleptic	Normal/typical taste and odor. Absence of burnt taste, fermented taste and smell.
2.	Concentration(brix)	28% minimum
3.	Consistency by Bostwick (at 12.5 Brix, at 25 °C)	4-11 cm/30s
4.	Colour (at 12.5 Brix)	2 minimum Gardner Color Scale
5.	pH	4.5 maximum
6.	Acidity	7% maximum
7.	Sugar (at dry matter)	42% minimum
8.	Salt	2% maximum
9.	Total coliform	10 cfu/g maximum
10.	Escherichia Coli	Absent
11.	Yeast	500 cfu/g maximum
12.	Staphylococus aureus	Absent
13.	Lysteria monocytogenes	Absent
14.	Bacillus cereus	50 cfu per g maximum
15.	Howard mould count	60% maximum

Source: Adapted by Nutrifoods from WFP Technical Specifications for Tomato Paste

3.2.4. Establishment of CCP Monitoring Procedure

Monitoring was then planned to assess whether a CCP is under control and to produce an accurate record for future use in verification. The monitoring system was also to warn of any trend towards loss of control in order to take action to bring the process back into control before a critical limit is exceeded. Continuous monitoring was preferred because it results in permanent record that could be reviewed and evaluated to ensure that the CCP is under

control.

Two employees of the process line were trained in CCP monitoring ; testing procedures; critical limits established; methods of recoding test results and actions to be taken when critical limits are exceeded. A HACCP team member was assigned to supervise the employees doing the monitoring.

Table 4: Monitoring Form for Critical Control Limits

Process Step/CCP	**Critical Limits**	**Monitoring Procedure Who/what/when/how**	**Corrective Action**
Date:		**Approved By:**	

3.2.5. Establishment of Corrective Action

The HACCP regulations defines corrective action thus as,

"Procedure to be followed when a deviation occurs; where deviation is a failure to meet a critical limit"

A plan to correct potential deviations from established critical limits were planned in advance and when it did occur, the 4-step approach of USDA generic HACCP manual was followed by:

1. Determining the disposition of non-complying product;
2. Correcting the cause of the non-compliance to prevent a recurrence;
3. Demonstrating that the CCP is once again under control (This means examining the process or product again at that CCP and getting results that are within the critical limits.);

4. Maintaining records of the corrective actions. Not all deviations can be anticipated, therefore, it is recommended that the statement "other actions as appropriate" be included with the specific corrective action.

3.2.6. Establishment of Record Keeping Procedure

In accordance to the HACCP principles the following record keeping forms were designed as follows:

1. Prerequisite Programs
2. Product Description
3. List of Incoming ingredients
4. Process Flow Diagram
5. Process Hazard Analysis Worksheet
6. HACCP Master Plan (HACCP worksheet)
7. HACCP Deviation Report

3.2.7. Establishment of Verification Procedure

The final step in setting up a HACCP system for Nutrifoods Ghana Limited tomato paste product line was to verify that the system is operating as intended and whether there is a need to fine-tune any aspect of the system.

3.3. Summary of the Approach

The terms of reference for this project is to set up a HACCP Plan for Nutrifoods Ghana Limited in its Tasty Tom® tin tomato paste production line. The company has not received any adverse report bordering on safety and quality and thence a quantitative approach could not be used in this study. Qualitative method of research methodology was used as the objective of the study was to implement HACCP plan in anticipation of preventing potential food-borne hazard in the future.

The research approach is summarized as follows:

1. Prerequisite programs
2. Assembly of the HACCP team
3. Description of final product and intended use
4. Production process flow diagram
5. Hazard Analysis
6. HACCP Master Plan

CHAPTER FOUR:

4. PRESENTATION OF RESULTS

4.1. Results of Audit of Prerequisite Programs

Based on the approach explained in Chapter 3, an audit was carried out at the production facility of Nutrifoods Ghana Limited to ascertain the application of its prerequisite programs in order to prepare for the development of a HACCP system.

4.1.1. Premises

The premise of Nutrifoods Ghana Limited was found to be suitable for the production of canned tomato paste based on the results of the PRP audit conducted. The facility fulfils the requirements of a typical food factory which includes the food processing and packaging lines, the buildings and exterior landscaping, and the utility-supply and waste-treatment facilities. The layout of the facility is displayed on notice boards at vantage points outside the immediate environs of the production area, clearly showing the various units and production lines as well as, emergency points and exits. The premise is connected to the national utilities services including water and electricity and has made satisfactory provisions for those utilities in cases of delivery failures.

The Company is duly registered with the local government agencies to operate from where it is located and has all documents to that effect in place. The external areas around the facility are well-maintained in a clean and tidy manner such that it does not pose any risk to the products via cross-contamination. The design and layout of the premises has been constructed in such a way to ensure that there is no cross contamination from raw material reception to final product dispatch. Importantly, an appropriate segregation is maintained between areas of low risk, medium risk and high risk.

The building walls of the premises are well-painted in bright colours to improve visibility and are smooth and impervious to water. The lighting system in and around the facility is acceptable. The factory floors are tiled but not slippery and are easy to clean. The laboratory floors require constant cleaning due to the materials used in the flooring. The facility has satisfactory drainage system and provides good means of sewage and waste disposal.

4.2. Good Manufacturing and Hygiene Practices

4.2.1. Food Safety Policy

The Company has a Food Safety Policy in place and has been duly signed by the senior executive manager stating the Company's commitment and objectives for the supply of safe products that meet:

i. Customer expectations ii. Legal requirements iii. Continuous improvement iv. Suitable for consumption in the country of manufacture and country of sale

The Company organizes staff durbar every quarter solely to emphasize and remind them of the safety policy. Additionally, employees in direct responsibility in ensuring safety are routinely taken through safety check readiness. These checks are documented showing how well the policy is operationalized.

4.2.2. Personal Hygiene

The company has developed, implemented and documented a personal hygiene policy and procedure that covers the following criteria as a minimum:

i. Hand-washing requirements ii. Clothing requirements iii. Sneezing, coughing, blowing of nose iv. Staff movement

v. PPE storage – to ensure no cross contamination between low and high PPE vi. Eating, drinking and smoking restrictions

vii. Cuts, wound and bandage requirements

viii. Control of personal items including medications and mobile phones

The Company conducts regular staff hygiene compliance checks on a weekly basis and spot checks are done in between.

4.2.3. Supplier Quality Assurance

Nutrifoods produces its final product from imported concentrated tomato paste, supplied in large aseptic bags stored in wooden bins and metals containers which are received at the reception station. Prior to this the Company has no direct control on the manufacturing of this raw material. A supplier quality assurance system is the only means to ensure the safety and quality of the raw materials it processes. The Company has a formal SQA system documented. Suppliers are required to institute and provide proof of QMS verified via annual supplier appraisal agreed between the two parties. The Company however, has an approved vendor list.

4.2.4. Other GMP and GHP Programs

Apart from the specific programs reported on above the Company also has the following programs relating to good manufacturing and hygiene practices maintained by the Quality Assurance Manager:

i. Receiving inspections ii. Management of purchased materials (storage and transportation, handling,

disposal etc.)

iii. General plant GMPs iv.

Equipment maintenance

v. Regulatory inspections vi.

Employee training

vii. Pest control

The Company keeps a plan of verification of all PRPs in accordance with the terms of ISO 22000:2005 Section 7.8 and has records of verifications and modifications.

4.3. Preliminary Steps in HACCP Analysis

4.3.1. Food Safety Team

In accordance with Section 6.2 of ISO 22000:2005, a HACCP team was appointed taking note of the competence, skill, training and experience of the members and how their responsibilities impact of food safety. The HACCP team consisted of 7 members including:

- Product line manager
- Quality Manager
- Warehouse Manager
- Quality management specialist
- One line supervisor
- Engineering manager
- HACCP consultant

All records on the members of the team are maintained demonstrating the experience and knowledge of the team.

4.3.2. Product Characteristics

The final product conforms to the product characteristics regulated by the National standards regulatory body, the Ghana Standard Authority and verified by the Ghana Foods and Drugs Authority. It also conforms to international code practice for the processing of tomato paste.

Table 5: Product Characteristics of Tasty Tom(R) Tomato Paste

Product Description

Full name of products	Tasty Tom® Tomato Paste
Common name (s)?	Tasty Tom
How is it to be used?	Finished product for culinary purposes
Type of primary package?	3 piece tin can
Type of secondary package?	Corrugated paper boxes
Length of shelf life?	2 years from date of manufacture
What storage condition?	Store in a cool and dry place away from water and sunlight
Where will the product be sold?	In the Ghanaian market
Labeling instructions?	Product Name/Ingredients/Net Weight/Batch Code/Dates of Production and Expiry
Special Distribution control needed?	Carrier must be clean, free from contaminants and protect from rain and direct sunlight

4.3.3. Raw materials, ingredients and product contact materials

The raw material used in the production of Tasty Tom ® Tin Tomato paste is tomato concentrate of twenty-eight (28) per cent natural tomato soluble solids, potable water and salt. Tin can and paper box are the primary and secondary contact materials used in packaging. All the possible microbiological (M), chemical (C) and Physical (P) contamination or hazards are listed and discussed in Table 6.

Table 6: Ingredient List in the Production of Tasty Tom® Tomato Paste

Product Line		
Primary ingredient	**Non-primary ingredients**	**Binders/extenders**
Concentrated paste	Water in accordance with GS 175 – 1:2009. Salt in accordance with GS 153: 2004	Not permitted
Spices/flavourings	**Restricted ingredients**	**Preservatives/acidifiers**
Not permitted	N.A	Citric acid (single strength or concentrated) as acidulant.

4.3.4. Characteristics of end product and intended use

Table 7 presents the results of analytical parameters that Nutrifoods Limited employs in the production of its tomato paste intended for its final market. These parameters are guided by the regulations of the Ghana Standards Authority (GSA) for processed fruits and vegetables and specifically for tomato paste and tomato puree (GS 246:2013). Other reference methods which the Company has documented include AOAC 981 for pH; ISO 3634:1979 for salt; AOAC 965.41 for Howard mould count.

Table 7: Analytical Parameters used at Nutrifoods in the Processing of Tomato Paste

Parameter	**Characteristic**
Organoleptic	Normal/typical taste and odour. Absence of burnt taste, fermented taste and smell.
Concentration (Brix)	28 %
Consistency by Bostwick	4 – 11 cm/30s
Colour (at 12 Brix)	Colour characteristics consistent with concentrate diluted with 7 % natural total soluble solids.
pH	4.6 maximum
Acidity	7 % maximum
Sugar (at dry matter)	42 % minimum
Salt	2 % maximum
Sandy matter	Not exceeding 0.1 % of the natural total soluble solids content
Howard mould count	60 % maximum

4.4. Flow Diagram and Process Steps

A summary of the manufacturing process for Tasty Tom® Canned Tomato is presented in Figure 4. The process is summarized in 7 steps: Raw materials receipt, batching and suction; blending and evaporation; pasteurization; sieving and filling; sterilization and packing; incubation/storage and dispatch and re-processing.

1. Raw Material Receipt, Batching and Suction

The raw material comes in an aseptic bag kept in metal drums or wooden bins. On receipt, these drums/bins are inspected to ensure that they are in good condition. They are then kept in storage until they are due for processing. Processing begins with the transfer of the raw materials to the processing unit where the lids of the drums are removed and the aseptic bags cut open. Once the drums are opened, samples of the raw materials are checked for organoleptic, colour, brix, pH, acidity and bostwick specifications. Batching is done after checks for the various specifications are completed. The product is then weighed and conveyed to the unit where suction into blending tanks is carried out. Potable water is then pumped into the blending tank as specified.

2. Blending and Evaporation

In the blending tank, the raw material is dosed with salt and blended together. When blending parameters have been achieved, the resultant product is transferred into holding tanks from where it is pumped to the evaporator unit. The product in the 8 MT evaporator receives condensed vapour to achieve a maximum temperature of 65 ºC. The brix, colour and pH specifications are checked again before product is pumped into a second holding tank.

3. Pasteurization

Pasteurization is applied to eliminate the most resistant pathogenic bacteria of public health concern that is reasonably likely to be present in the food for as long as the shelf life of the product. Before it is pasteurized, the product is passed through a sieve to further reduce unwanted particles as a percentage of the total soluble solids content. The sieve is calibrated at 4mm. The product passes through the sieve into the pasteurizer where it is held at a minimum temperature and time of 88 °C and 2 minutes respectively. The product is then pumped into a temperature-controlled holding tank.

4. Sieving and Filling

The primary packaging material is de-palletized, coded and conveyed for sterilization in time for filling. Microbiological analyses of can swabs are also carried out. The product is transferred from the holding tanks onto the filling line at temperature of 87.5 °C minimum. Before the product is filled into cans, it passes through a 1.25 mm sieve. The can is seamed after filling. Brix, colour, Bostwick, pH and net weight are checked at this stage.

5. Sterilization and Packing

Post-filling sterilization or retorting is carried out using the principle of conduction to achieve a high degree of temperature within the shortest possible time. The required temperature is determined by the microbiological organisms of concern, measured with thermocouples. The resultant product is then cooled using water in an over-pressurized environment to prevent the internal pressure inside the package from buckling and thence destroying the integrity of the package.

The canned products are air-dried and filled into carton, sealed and batch-coded before they are palletized. Afterwards, the sealed cartons are dispatched to floor storage area for incubation and final dispatch.

6. Incubation, Storage and Dispatch

Initial grade quality assurance check by visual inspection and analysis are carried out at first dispatch floor before transfer to the incubation/storage unit. A final grade quality control is carried out by visual inspection and positive release after 7 days of incubation. The product is then transferred to the final dispatch area.

7. Re-processing Paste

Product rework is carried out for products that do not meet the conformity criteria for the final grade. An assessment of the rework for conformity to specification is done, whereupon the

product is transferred into the rework bin for onward transportation to the emptying station for the process to begin again.

Figure 4: Process flow diagram for the production of tomato paste

4.5. Hazard Analysis and CCP Determination

For each step of the process flow diagram, hazard analysis was done. For each hazard identified, control measures were recommended. These control measures when put in place help reduce the hazard to acceptable levels, prevent them from occurring or eliminates them when they occur. Effective machine maintenance, effective cleaning routine, good hygiene practices as

well as a good Supplier Quality Assurance (SQA) are some of the control measures implemented.

Table 8: Hazard Analysis Chart

Process Step	Class of Hazard	Description of hazard	Source of hazard	Hazard Identification/Assessment				Justification	Control measure	Responsible	Record
				Likelihood	Severity	Risk	Sig.				
Raw material Receipt, batching and suction	P	Presence of Foreign matter	Manufacturer	1	1	1	No	Source from approved suppliers only	1.SQA 2.Sieving step downstream	Supplier	Supplier list
	C	Agrochemical residue	Manufacturer	1	2	2	No	Source from approved suppliers only	SQA	Supplier	Supplier list
			Inherent in Concentrate	1	3	3	Yes	Source from approved suppliers only	1. SQA (COA) 2. Further processing during pasteurization	Supplier	1. Supplier list 2. CoA
	B	Clostridium, Staphylococcus, Bacillus, Yeast, Moulds, E. Coli	Personnel	1	2	2	No	Implement GHP	GHP	Supervisor	Lab records of hand swabs
			Suction tube	1	2	2	No	Effective sanitization of pipe	GMP	Supervisor	1. Cleaning records 2. Lab records of swabs

Process Step	Class of Hazard	Description of hazard	Source of hazard	Likelihood	Hazard Severity	Risk	Sig.	Control Responsible	Justification	measure	Record
Blending	P	Introduction of Foreign matter	Water	1	1	1	No	Water house	Water is treated	Water treatment supervisor	Utility in	Water analysis records
	P	Introduction of Foreign matter	Salt	1	1	1	No	Source approved	from SQA	Supplier	suppliers only	Supplier list
	C	None										
	B	Aerobic bacteria , Staphylococcus, E. Coli, coliforms	Water	2	3	6	Yes	Water treatment in house	1.Chlorination 2.Further processing during pasteurization and retort	Utility supervisor		Water analysis records
Evaporation	P	Introduction of foreign matter	pumps	1	2	2	No	Sieving particles	of			
	C	None										

Process Step	Class of Hazard	Description of hazard	Source of hazard	Hazard Evaluation/Assessment				Justification	Control measure	Responsible	Record
				Likelihood	Severity	Risk	Sig.				
	B	Aerobic bacteria, yeast and mould	Evaporation tank	1	2	2	No	Cleaning and sanitization	1.CIP 2.Further processing during pasteurization and retort	CIP supervisor	CIP records
	P	None									
	C	None									
Pasteurization	B	Clostridium, Staphylococcus, Bacillus, Yeast, Moulds	Survival	2	3	6	Yes	Clostridium toxicity can lead to severe illness	Monitoring of pasteurization time/temperature	Pasteurizer operator	Pasteurizer time/temperature records

Process Step	Class of Hazard	Description of hazard	Source of hazard	Likelihood	Hazard Identification/Assessment Severity	Risk	Sig.	Justification	Control measure	Responsible	Record
Sieving	P	Inherent foreign matter	Pumps	2	2	4	Yes	Pore size of sieve effectively removes potential foreign matter	Sieve integrity	Supervisor	Maintenance records
	C	None									
	B	None									
Filling and seaming	P	Dust particles	Tin can and lid	2	1	2	No	Cans are steam rinsed	Rinsing of tin		
	C	Heavy metals	Tin	1	2	2	No	Effective coating of tin with lacquer	Coating of tin with lacquer	Tin Supplier	Copper sulphate test records

Process Step	Class of Hazard	Description of hazard	Source of hazard	Likelihood	Hazard Identification/Assessment Severity	Risk	Sig.	Responsible Justification	Control measure	Record

	B	1.Staph 2.Bacillus 3. Yeast 4. Moulds E. Coli	1.Recontamination before seaming 2.Contamination from tin can and lid	1	2	2	No	Microbial survival in paste reduces during processing	1. Steam rinsing of tin but tin and lid 2. Retort as may re-introduce microbes into product		Boiler maintenance records
	P	None									
	C	None									
Retort	B	Staphylococcus, Bacillus, Yeast, Moulds, E. Coli	Recontamination by tin lids and food handlers	2	3	6	Yes	There is a chance of recontamination from tin lids	1. Retort time/ temp 2. Good hygiene practices	Retort operator	Time/ time records
Incubation, Storage and Dispatch	P	None									
	C	None									

Process Step	Class of Hazard	Description of hazard	Source of hazard	Likelihood	Hazard Evaluation/Assessment Severity	Risk	Sig.	Justification	Control measure	Responsible	Record
Reprocessing paste	B	None									
	P	None									
	C	None									
	B	Staphylococcus, Bacillus, Yeast, Moulds, E. Coli	Recontamination by food handlers	1	2	2	No	Paste for reprocessing are handled by authorized personnel	1.GHP 2.Further processing at pasteurizer	Supervisor	Hand Swab records

Using the hazard evaluation matrix, five hazards considered to pose a high food safety risk were identified in five processing steps. These are presented in the table below;

Table 8: Hazard Identification

	Process step	Hazard
1	Raw material Receipt	BH: *C. Botulinum* inherent in concentrate
2.	Blending	BH: Contamination product with micro-organism found in water
3.	Pasteurization	BH: Contamination with micro-organism inherent in concentrate
4.	Sieving	PH: Inherent foreign matter from worn out pumps
5.	Retort	BH: Recontamination by food handlers and tin lids

The high risk hazards which were identified to be significant for food safety were subjected to the decision tree. The outcome of this process established two (2) process steps as CCPs. These were sieving and retort. Pasteurization was also established as a Control Process. The raw material receipt and blending steps were also identified as PRP and OPRP respectively.

Table 10: Results of the CCP determination using the Decision Tree

			Q1a: Do control preventive measure (s) exist at this step? **YES:** Go to Q2. **NO:** Go to Q1b						
				Q1b: Is control at this step necessary for safety?					
					Q2: Is this step specifically designed to eliminate or reduce the likely occurrence of the hazard to an acceptable level?				
						Q3: Could contamination with identified hazard (s) occur in excess of acceptable level (s) or could these increase to unacceptable levels?			
							Q4: Will a subsequent step eliminate identified hazard (s) or reduce likelihood of occurrence to an acceptable level?		
Activity	Class of hazard	Hazard description	Q1a	Q1b	Q2	Q3	Q4	CCP/PRP/OPRP	Control Measure
Raw material Receipt	B	C. Botulinum inherent in concentrate	Yes		No	Yes	Yes	PRP	Effective Supplier Quality Assurance
Blending	B	Contamination product with micro-organism found in water	Yes		No	Yes	Yes	OPRP	Ensure effective chlorination of water used
pasteurization	B	Contamination with micro-organism inherent in concentrate	Yes		Yes		Yes	CP	Effective temperature/time monitoring
sieving	P	Inherent foreign matter from worn out pumps	Yes		Yes		No	CCP 1	1. Effective monitoring of sieve integrity 2. Effective maintenance of pumps
Retort	B	recontamination by tin lids and food handlers	Yes		Yes		No	CCP 2	1. Effective temperature/time monitoring

2. Effective implementation of good hygiene practices

4.6. Establishing Critical Limits, CCP Monitoring, Verification and Corrective Actions

Critical limits set for the pasteurizer and retort is based on views sourced from experts in the industry. That of the sieve was set to enable easy passage of paste for filling. In table 11 below, the various control measures and their critical limits for each CCP are listed.

Table 11: CCPs and Critical Limits

Process step	CCP No.	Control Measure	Critical Limit
sieving	CCP 1	Effective monitoring of sieve integrity	1.25 mm sieve
Retort	CCP 2	Effective temperature/time monitoring	90 °C/40 minutes

4.7. Validation of CCPs

The various CCPs undergo validation and the results of which are presented below: At CCP 1, the 1.25 mm sieve is validated by monitoring the sieve integrity. The sieve integrity is checked to ensure there is no breach. The nature of the particles present is described as well as their weight. In table 12 is listed results from 4 weeks of monitoring.

Table 12: Weekly Sieve Monitoring Record

	Is sieve intact?	Are there particles present?	Weight of particles present /g	Description of particles if any
Week 1	Yes	Yes	1.2	Pieces of material from pumps
Week 2	Yes	Yes	0.4	Pieces of material from pumps
Week 3	Yes	No	N/A	N/A
Week 4	Yes	Yes	0.8	Pieces of material from pumps

A smear test is also done using the microscope to observe the presence of other particles other than tomato. This is done by observing 50 fields per sample under the microscope.

Fields which contain foreign particles are labeled as positive fields. The percentage is then calculated. A percentage of less than four (< 4 %) is preferred. In table 13 is listed the results of smear test done on 10 samples that have gone through the sieves.

Table 13: Smear test using a microscope

Sample	Positive fields	Total no of fields observed	% Positive
Sample 1	0	50	0
Sample 2	0	50	0
Sample 3	0	50	0
Sample 4	0	50	0
Sample 5	0	50	0
Sample 6	0	50	0
Sample 7	0	50	0
Sample 8	0	50	0
Sample 9	0	50	0
Sample 10	0	50	0

At CCP 2 which is the retort, the objective is to ensure that the product microbial load is low. Preferably less than ten (<10). In table 14 is listed the results of aerobic bacteria, yeast and mould analysis done on products from the retort. The pH obtained for each product analyzed is also recorded

Table 14: Aerobic bacteria, yeast and mould results of products from retort

Sample	pH	APC (cfu/g)	Yeast(cfu/g)	Mould (cfu/g)
Sample 1	4.17	<10	<10	<10
Sample 2	4.17	<10	<10	<10
Sample 3	4.18	<10	<10	<10
Sample 4	4.17	<10	<10	<10
Sample 5	4.18	<10	<10	<10

4.8. Establishing the HACCP Plan

The methodology explained below was used to conduct the Hazard Analysis:

-Identification of distinct process steps for each product cluster based on the flow diagrams.

For each process step:

-Identification of all potential hazards associated with that process step.

-Classification of hazard based on type (whether physical, biological, chemical or allergen) and category (into which part of the PRP does this hazard fall).

-A description of the hazard.

-The likely occurrence (Probability of occurrence) of the identified hazard, evaluated quantitatively, in terms of not likely, likely and very likely.

Table 15: Probability of occurrence of hazard

Probability of occurrence of activity/aspect	
Not likely (1)	A hazard that has a very low probability of occurrence due to effective control measures in place. Usually once in a year.
Likely (2)	A hazard that has reasonable frequency of occurrence or probability of occurrence usually on a half yearly basis
Very likely (3)	A hazard that has a very high probability of occurrence due to its nature or control measures in place usually monthly.

The severity of the hazard's adverse health effects evaluated quantitatively in terms of Low Impact, Moderate Impact and Critical impact are as follows:

Table 16: Explanation to the Hazards rating scales

Severity of impact	
Low Severity (1)	This is a hazard that has no or mild health effects on consumers.
Moderate Severity (2)	Hazards with moderate impact on health effects which might be severe or chronic in nature.
Critical/ High Severity (3)	A hazard which has the potential to affect consumers' health which will be life threatening / fatal/ serious injury.

The food safety hazard ratings explained by multiplication as shown in table 17. These were used in determining the ranking of each food safety hazard.

Table 17: Ranking of Food safety hazard – Matrix

		Severity of impacts		
		Low Severity		
Moderate Severity				Critical/ High Severity
		(1)	(2)	(3)
Probability of occurrence	Not likely (1)	1(Not Critical)	2(Not Critical)	3(Critical)
	Likely (2)	2(Not Critical)	4(Critical)	6(very critical)
	Very likely (3)	3(Critical)	6(very critical)	9(very critical)

The risk rating, in quantitative terms (arrived at by multiplying the probability of occurrence of identified hazard with the severity of hazard in case of occurrence), and the classification of the control measures based on the risk rating. If the multiplication of Probability x Severity (Risk) is more than 2, then Control Measure is required to control the identified hazard. If risk is ≤ 2, then the routine PRPs are sufficient to control the hazard at hazard analysis. An explanation / justification for the risk rating arrived at, together with the general control measures in place for that risk. While conducting the HACCP Analysis, practical experiences, experimental data, and professional literature have been taken into account.

Table 18: Scale /Matrix Weights

Ratings scores	Weights
Scores 1, & 2 = Not Critical (NC)	A hazard that has no food safety implication on final consumer though it may be related to quality issues. These hazards have very low probability of occurrence and impact
Scores 3 & 4 = Critical (C)	A hazard with moderate impact and fairly regular in occurrence but with economic effect on food production, loss of quality. This hazard also has no adverse health implication on consumers as there are other controls before it gets to the customer.
Scores 6 and 9 = Very Critical (VC)	These are hazards rated very critical because of adverse effect on human health and implications on food safety.

In the monitoring plan, the various CCPs are listed and the hazards described. CCP 1 has the integrity of the sieves as the target. This is monitored weekly by the machine operator. Samples

are also analyzed every four hours using a smear test for particles to determine if there's been a breach in sieves before the weekly monitoring when the sieves are taken out, washed and examined. CCP 2 monitors time and temperature of the water in the retort. This is done hourly by the operators as the cans pass through. Both CCPs have their critical limits established. The various corrective actions to be taken in the event the critical limits are exceeded are also listed. The plan also describes the records to be used. CCPs are verified by reviewing monitoring records on a monthly basis.

Table 19: CCP Monitoring Plan

CCP N°	Activity	Hazard description	Monitoring Parameters	Target	Critical Limits	Monitoring: Procedure	Monitoring: Frequency	Corrective actions	Responsible	Records	Verification
CCP 1	Sieving	Inherent foreign matter from worn out pumps	Sieve integrity	Sieve integrity	25 mm	Visual weekly Checks Smear test	Every 4 hours	Inform maintenance to effect sieve change	Operator Lab Analyst	Sieve monitoring record	Review monitoring records
CCP 2	Retorting	survival of microbes	Time and temperature	Water temperature	°C for 40 minutes	on the monitor	Hourly	Re-adjust settings reading Inform HACCP team leader if deviation persists	operator	Time/temp record sheet	Review monitoring records

CHAPTER FIVE:

5. DISCUSSION AND CONCLUSION

5.1. Discussion

According to Shewfelt (2016) processed foods are a safer alternative to fresh horticultural products. This is because it is expected that the processor might have put in place special care has been taken to eliminate all possible food safety hazards that could come with the raw material as well as could be associated with the processing process.

Tomato paste is, however noted to be associated with *C. Botulinum*, a spore forming microorganism (Efiuvwevwere *et al*, 1998). In dealing with *C. Botulinum*, other quality control measures comes in to act in synergy with heat treatment to control *C. Botulinum*. In this study, control of pH and temperature are noted to prevent *C. Botulinum* from forming spores. The practice of adjusting the pH of tomato paste coupled with the appropriate temperature control prevents spore formation. These quality parameters therefore ensure that no spore generates into vegetative form by exposing them to destruction by the heat treatment processes. The practice where multiple control measures acts in synergy in the control of a specific food safety hazard is referred to as a multi-hurdle effect (Leistner *et al*, 1995)

The hazard analysis shows that all physical and chemical hazards that are potentially associated with Tomato processing can be controlled with an effective PRP.

As a general rule, the first stage in the control of hazards comes with the implementation of adequate pre-requisite programs at the manufacturing premise. This study identified the following as major sources of food safety hazards to canned tomato processing;

1. Implementation of an adequate and verifiable Supplier Scheme by putting in place a Supplier Quality Assurance system (SQA) for the tomato paste, which in this case

become the raw/stating material. Tomato paste could come with all the three categories of food safety hazards, namely chemical hazards (from pesticide residue

and processing chemicals, physical hazards (from paste processing line) and biological hazards (survival and growth of microorganisms). According to Vasconcellos (Dec, 2003), before a HACCP plan is developed, the supplier quality program should be in place. This means that raw materials should be purchased from accredited suppliers who have either implemented HACCP themselves or have a verifiable food safety management system based on the principle of HACCP to control potential hazards. SQA should be verified through supplier audits or certificates issues by credible third party audit. Each supply of raw materials should also be packaged and transported under conditions that will not expose the bulk purchased paste to re-contamination. Besides, each supply should be accompanied by credible Certificate of Analysis (COA) authenticating the safety of the products. A sure guarantee that the incoming raw material is safe is the beginning of producing a safe product. The mantra, "garbage in, garbage out", ensures the input of safe raw materials thereby putting less stress on the HACCP being implemented at the cannery. SQA therefore become the foremost recommended PRP for tomato processing

2. The second source of hazards identified by this study is hygiene from personnel and equipment. The food handlers can easily contaminate in-process foods especially with microorganisms. The recommendation is to implement and enforce a strict personal hygiene regime in the factory. Enforcement of dress code, washing and hand sanitization, regular medical screening and training are essential in ensuring that the food handler does to pose food safety risk to the product and by extension the consumer.

Again, food processing equipment can contribute all categories of hazards to consumer. First, the food contact surfaces such as pipes and processing/holding tanks should be contracted with materials (stainless steel) that allows for easy washing and sanitization. It must also avoid L-Shaped pipes and right edges/joints to help eliminate microbial niches and formation of biofilms. Smooth surfaces made from stainless materials also help in eliminating physical hazard risk associated with wear and tear of materials. The risk of chemical hazards from cleaning in place (CIP) is also much reduced with smooth surfaces.

3. Process flow and separation of risk areas. The design of the reference plant used for the study adequately ensures that high risk and low risk areas are well separated. This minimizes that cross flow of personnel and equipment, a major factor in controlling cross contamination risk in food processing.
4. Equipment maintenance. Maintenance is also very critical in ensuring that the CCP of time/temperature achieves desired limits. Results of the hazard analysis above indicate that equipment maintenance is essential in controlling physical and biological hazard risk in tomato processing. According to Stier (2012), improper machine maintenance was responsible for majority of foreign objects contamination. He states that preventive maintenance is the best way to protect equipment as well as extend its life while enhancing its operation efficiency. Preventive maintenance starts with proper inventory. That together with regular risk assessments ensure that loose bolts and nuts are prevented from falling into in-process food. It is also essential in ensuring that joints are well tightened and maintained to eliminate microbial niche and the formation of biofilms.

The study identified two (2) CCPs and one control point. The CCPs involve the removal of foreign materials by a sieve and heat treatment to control biological hazards.

The paste from the pasteurizer passes through a sieve when the can is being filled. CCP1 which is the 1.25mm sieve ensures that any foreign material which happened to pass through the 4mm sieve before the pasteurizer is removed. These sieves are cleaned once a week, the particles present weighed and recorded. The integrity of the sieve is also monitored and recorded. In addition to this, a smear test is done every 4 hours on product samples to ascertain there has been no breach in the sieves. The CCP is verified by reviewing the monitoring records.

CCP2 which is the Retort step involves heat treatment of canned paste. Retort is very critical in the control of microbial hazards in canned tomato processing as the process sterilizes both the product and the packaging. The canned product undergoes a minimum water temperature and time of 90 °C and 40 minutes respectively before product is cooled, dried and packed into cartons. The pasteurizer performs a similar function and its sterilization is limited to only the product. The product from the holding tank undergoes a minimum temperature and time of 88 °C and 2 minutes respectively in the pasteurizer before being discharged to the filling line. Arguably, both pasteurization and retort process steps have a common target which is the elimination of microbial hazards in the paste and therefore both should be considered as CCP in line with question 2 of the CCP decision tree. However, if question 4 of the decision tree is applied, there is a subsequent step required to eliminate the same hazards as the pasteurizer which is the retort. This effectively renders the pasteurizer as a control point and not a critical control point. Having too many CCPs can make the HACCP plan's implementation burdensome (Schmidt and Newslow, 2007). Hence the need for question 4 of the decision tree to be answered before a process step is established as a CCP. This also ensures that emphasis are placed on the proper establishment of Prerequisite Programs.

Hence the hazards identified can be considered not likely to occur due to these programs.

5.2. CONCLUSION AND RECOMMENDATION

A modified CCP Tree was used in the final determination of the hazard classification. There were two (2) CCPs identified in the HACCP study. These are CCP1 at sieving step and CCP2 at the retort step. A weekly monitoring of the sieve integrity of the sieves at CCP 1 as well as a daily smear test ensure that physical hazards present in the product are significantly reduced. The time/ temperature monitoring of water done at CCP 2 also ensure effect elimination or reduction of microbiological hazards present in the product. In order for the HACCP plan to be effectively implemented, validation was done for all CCPs.

Answering of question four (4) of the decision is recommended in the determination of CCPs in order to reduce the number of CCPs for a particular process system. This ensures that the Prerequisite Programs are thoroughly thought of and effectively established. This leads to a successful HACCP implementation.

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