KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA
COLLEGE OF SCIENCE
DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

DEVELOPING A GENERIC HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) SYSTEM FOR THE PALM CREAM CONCENTRATE CANNING INDUSTRY IN GHANA

A THESIS SUBMITTED TO THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN FOOD QUALITY MANAGEMENT

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Science (M.Sc.) and that, with the exception of references to the work of other researchers in the same area of study, which has been duly recognized and acknowledged, this research is the result of my own investigations and that this work contains no material previously published by another person nor material which has been accepted for the award of another degree of the University.

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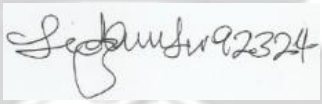
Christian Kwashiga DEDZO		.....
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(Head of Department)	**Signature**	**Date**

DEDICATION

I dedicate this thesis to my Heavenly Father whose fathomless grace, unfailing love and unmerited favour has brought me this far in life. 'Soli Deo Gloria' - to wit: 'To GOD alone be the Glory'.

To my dad and mum, I appreciate you for all that you have done for me and to my aunt, Akuvi Tsigbey, uncle Mr. Godwin Agbleze and late uncle Dr. E.K. Fiamavle whom I am eternally grateful to for their tender loving care for me during my undergraduate studies.

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Last but not the least, I will like to thank the Managing Director of Praise Export Services Limited, Mr. Godwin Adordie who allowed me to use his factory and resources for this study. May the Lord bless him and the workers of his company richly.

ABSTRACT

A typical indigenous Ghanaian small and medium-sized enterprise (SME) engaged in palm cream concentrate canning was selected for HACCP study and the generic HACCP system

was developed which can be adapted for the entire palm cream concentrate canning industry in Ghana. To manufacture canned palm cream concentrate, fresh and ripen palm fruits are inspected, received, weighed and sorted for their quality. The quality palm fruits are washed, cooked at a temperature of 100°C for 30 minutes, de-pulped into paste, fiber and kernels. The paste with the fiber is squeezed and strained to obtain palm cream. The fine cream is collected and blended with 0.5% salt and heated to a temperature ≥ 70°C for 15 minutes. Empty cans are washed, filled with the hot cream, seamed, washed to get rid of stains and loaded into retort baskets and then hoisted into a vertical retort for sterilization. Retorting is done at 121°C for 60 minutes and then cooled to a temperature of 40°C and the product are removed from the retort and incubated at ambient temperature for 7 days. After which labelling is done and the product are cased and palletized ready for sale. The 14 stages of HACCP implementation including the 7 preparatory steps and the 7 principles of HACCP recommend by (Campden BRI, 2009) were applied to the palm cream concentrate canning process. Each processing step was correctly captured in the process flow diagram and subjected to hazard analysis to identify all potential food safety hazards that are associated with each step. The identified hazards were classified as either physical, chemical or biological and subjected to risk assessment process using a quantitative scoring method to determine the likelihood and severity of each potential hazard which helped to determine significant hazards with each step. The significant hazards were then subjected to critical control point determination using the codex decision tree. Three steps of microbiological significance were identified in the process as CCPs. These are can seaming (CCP# 1), retorting (CPP# 2) and retorted can cooling (CCP# 3). Critical limits were established for these limits as follows: CCP# 1 – can seaming (body hook butting (BHB) > 75%, thickness rating (TR) > 75% and actual overlap (AO) > 1.1mm), CCP# 2 – retorting
(120 -122°C for 60 minutes at a pressure of 1bar must be achieved during sterilization) and CCP# 3 – can cooling (incoming cooling water into the retort must be chlorinated to 3 - 4 ppm, residual chlorine content and after cooling, the discharge water should contain ≥ 0.5ppm residual chlorine content). Monitoring and verification procedures were developed for each CCP and corrective actions and record keeping systems have been established for the CCPs.

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LIST OF ABBREVIATIONS

ACP	African, Caribbean and Pacific Group of States
AGOA	African Growth and Opportunity Act
BOPP	Benso Oil Palm Limited
BRC	British Retail Consortium
CAC	Codex Alimentarius Commission
CBE	Cocoa Butter Equivalents
CBS	Cocoa Butter Substitutes
CCP	Critical Control Point
CFR	Code of Federal Regulations
CPO	Crude Palm Oil
EFK	Electric Fly Killer
EPAs	Economic Partnerships Agreements
EU	European Union
FAO	Food and Agriculture Organization
FDA	Food and Drugs Authority
FFB	Fresh Fruit Bunch
Fo	Process Value
FRI	Food Research Institute
FSMA	Food Safety Modernization Act
FSSC	Food Safety Systems Certification
GFSI	Global Food Safety Initiative
GHP	Good Hygiene Practice

GMO	Genetically Modified Organisms
GMP	Good Manufacturing Practice
GOPDC	Ghana Oil Palm Development Company
GSA	Ghana Standards Authority
HA	Hazard Analysis
HACCP	Hazard Analysis and Critical Control Point
HARPC	Hazard Analysis and Risk-based Preventive Controls
IFS	International Featured Standards
ILSI	International Life Sciences Institute
ISO	International Organization for Standardization
MOFA	Ministry of Food and Agriculture
MOTI	Ministry of Trade and Industry
MSDS	Material Safety Data Sheet
MSMEs	Micro, Small and Medium Sized Enterprises
NACMCF	National Advisory Committee on Microbiological Criteria for Foods
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NORPALM	Norwegian Oil Palm Ghana Limited
oPRP	Operational Prerequisite Programs
PKO	Palm Kernel Oil
PPM	Parts Per Million
PRPs	Prerequisite Programmes
RBD	Refined, Bleached and Deodorized
RDPO	Red Dura Palm Oil
SMEs	Small and Medium-Sized Enterprises
SQF	Safe Quality Food
TOPP	Twifo Oil Palm Plantation Limited
TOR	Terms of Reference
USDA	US Department of Agriculture
USFDA	United States Food and Drugs Authority

UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization

CHAPTER ONE

1.0. INTRODUCTION

Food can be defined as any substance consumed to provide nutritional support for the body. (Springer, 2002). As stated by Frazier and Westhoff (1994) humans need nutrients to stimulate growth, produce energy and maintain life. Access to adequate wholesome and safe food is a basic requirement for the health of mankind and now globalization or migration has become one of the drivers of making food convenient so that people everywhere can eat what they want.

Today, food ingredients and processed foods usually come from different nations, thousands of miles from farms and factories into retail markets all over the world. Food safety risks or hazards at one end of the food supply chain can therefore affect peoples on the other side of the globe (Fukuda, 2015). For instance, Africans in diaspora and African-Americans in the US still want to eat indigenous African dishes like palm soup popularly called “abenkwan” in Ghana and “banga” in Nigeria. Food processing can help to ensure a safe, diverse, abundant, and accessible food supply to meet global demands (Poti *et al*., 2015). Food safety assurance in today’s global village presents a difficult task and burden for governments, corporate institutions (food companies and regulatory agencies) and consumers alike (Fukuda, 2015). Food processing is defined as any procedure that alters food from its natural state, such as freezing, drying, milling, canning, mixing, or adding salt, sugar, fat, or additives. Thus, the US government’s definition of “processed food”—any food other than a raw agricultural commodity—includes a diverse array of foods ranging from frozen vegetables, dried fruit, and canned beans to whole-wheat bread, breakfast cereals, prepared meals, candy, and soda

(Poti *et al*, 2015). However, consumers everywhere are increasingly becoming food safety conscious and since they don't have the capacity to determine safe food, governments have the responsibility to ensure food safety so as to protect the health of consumers. For example, Regulation (EC) 2002, No. 178/2002 require that, food must not be placed on the market if it is not safe (Bratt, 2010). Food is deemed to be 'not safe' if it is considered to be:

- injurious to health; or
- unfit for human consumption.
- In deciding whether or not food is 'not safe', it is necessary to consider:
- the usual conditions of use of the food by the consumer and at each stage of production,
  • processing and distribution; and
- the information provided to the consumer, including information on the label or other information generally available to the consumer concerning the avoidance of specific adverse health effects from a particular food or group of foods.

In determining whether a food is 'injurious to health', the Legislation goes on to say that it is necessary to consider:

- not only the likelihood immediate and/or short-term and/or long-term effects of that food on the
- health of the consumer eating it, but also on subsequent generations;
- the likelihood cumulative toxicological effects; and
- the particular health sensitivities of a specific group of consumers where the food is intended for that group of consumers. Also, owners of food businesses must ensure that foods satisfy the requirements of food law which are relevant to their activities and must verify that such requirements are met (Bratt, 2010). The food business owners must also have strong permanent procedures which are HACCP based. This

applies to food business operators carrying out any stage of production, processing and distribution of food after primary production and associated operations.

In view of this regulatory requirements pertaining in the EU most companies in the developing world that are export oriented cannot trade with the EU or North America without implementing HACCP which is the internationally recognized system of ensuring food safety (Scott and Stephenson, 2006). Food safety is the concept that food will not cause harm to the consumer when it is prepared and/or consumed according to its intended use (Mead *et. al.*, 1999). Food safety is related to the occurrence of food **safety hazards** (might result in sickness or death) and does not include other human health aspects related to, e.g., malnutrition (ISO 22000). HACCP systems are designed to prevent and control food safety hazards associated with food from farm to fork (Stevenson, 1990).

The HACCP concept deals with all classes of potential food safety hazards – biological, chemical and physical, whether they are naturally occurring in the food, contributed by the environment or generated by an error in manufacturing or handling (Scott and Stephenson, 2006). While most consumers are scared by chemical hazards and physical hazards are most easily identified by consumers, microbiological hazards are the most serious from a public health perspective. In view of this, HACCP systems address all three types of hazards, a majority of the emphasis is placed on microbiological issues. For example, a piece of metal (physical hazard) in a food product may result in a chipped tooth for one consumer, but contamination of a batch of milk with *Salmonella* may affect hundreds or even thousands of consumers (Scott and Stephenson, 2006). The Pillsbury Company, the US Army Natick Laboratories and the National Aeronautics and Space Administration (NASA), developed the HACCP system in response to the food safety requirements imposed by NASA for "space

foods" produced for manned space flights beginning in 1959 (Scott and Stephenson, 2006). HACCP has been associated with the canned food industry since 1970's. FDA promulgated the low-acid and acidified canned food regulations, Title 21, Code of Federal Regulations Part 113 (originally 21 CFR 128b), "Thermally processed Low-acid Foods Packaged in Hermetically Sealed Containers," and 21 CFR 114, "Acidified Foods," respectively. While these regulations did not mention HACCP, their approach to controlling *Clostridium botulinum* certainly appears to be based upon HACCP concepts (Bratt, 2010).

Canning is a scientifically tested means of providing food which is stable at ambient temperatures, has long shelf life and in consequence is suitable for world-wide distribution (Bratt, 2010). This method of preserving foods in cans was developed 200 years ago when a Frenchman, Nicolas Appert, won a competition initiated by another great character in French history, Napoleon Bonaparte (Heinz and Hautzinger, 2007).

The main objective of canning is to achieve commercial sterility. Commercial sterility of food means the condition achieved by the application of heat which renders such food free of viable forms of microorganisms having public health significance, as well as any microorganisms of nonhealth significance capable of reproducing in the food under normal nonrefrigerated conditions of storage and distribution (Berry and Pflug, 2003).

1.1. Problem Statement

Ghana is abundantly rich in agricultural resources and has the competitive advantage required to develop a thriving commercial food processing sector for inclusive economic growth. With a very strong export potential in agricultural products, the country also has excellent climate,

rich soil, good port facilities, continuous improvement in infrastructure base and strategic location near profitable global markets such as the EU (UNIDO-MOTI, 2009).

The EU market therefore offers attractive opportunity for Ghanaian exporters to export fresh and processed food products so as to rake in foreign exchange for the country to balance its trade deficit through the EPAs signed between the EU and ACP countries and lately, AGOA, signed between Ghana and the US government. Nevertheless, the growing concerns of food safety among consumers in the EU have led to tough legislative market requirements which pose serious threat to market access and growth to Ghanaian food exporters. The EU Food Law: Regulation (EC) 2002, No. 178/2002 which made traceability mandatory effective January 1, 2006 as part of the general food law makes it obligatory for producers and exporters to be able to identify and document information on products 'one step forward and one step back' in the food chain. Also, with the coming into force of the US Food Safety Modernization Act (FSMA), 2015 which is the most sweeping reform of food safety laws in more than 70 years. Its main aim is to ensure that the U.S. food supply is safe by shifting the focus from responding to food contamination and scares to preventing it from entering the US market This means all food suppliers/manufacturers must comply with the relevant portions of the Act especially, *sections on Preventive Controls for human food and Foreign Supplier Verification Programs for food businesses.* A key element of the Act is that all low-acid canned food processors and exporters including Ghanaian food companies exporting to the US must implement HACCP. That means they must comply with the low-acid and acidified canned food regulations, Title 21, Code of Federal Regulations Part 113 (originally 21 CFR 128b), "Thermally processed Low-acid Foods Packaged in Hermetically Sealed Containers," and 21 CFR 114, "Acidified Foods," respectively (Campden BRI, 2009). This development requires appropriate response from Ghanaian producers and exporters, baring this they lose

their market share in the EU and North American markets. HACCP therefore is a basic requirement to enter the international market, especially the EU and North American markets (Nyumuah, 2016).

Canned palm cream concentrate export is now a viable business in Ghana contributing to the 120 million USD raked into the economy in 2016 (GEPA report, 2016). Its consumption locally is now common among the student, middle and upper class and expatriate population in Ghana. Currently, most Ghanaian MSMEs canning palm cream have no HACCP system and therefore do not meet the requirements of the USFDA and EU in order to access these markets. There is therefore the need to help these MSMEs to implement a HACCP system so that they can remain in business, produce safe food for our consumption, provide decent jobs to the people and ultimately rake in more foreign exchange to reduce our budget deficit through export trade. This is the reason for this research study.

1.2. Need for the Study

Canned Palm cream concentrate is made from the sauce squeezed from palm fruit (*Elaeis guineensis*) which is popularly used for soup in West Africa. In Ghana it is called "abenkwan" and in Nigeria it is called "banga". Traditionally, most Ghanaian families prepare food at home using raw foodstuff and ingredients. However, in the last ten years, processed or convenient packaged foods are becoming part of the diet due to increasing disposable incomes, more carrier women, urbanization and increasing diaspora population who still prefer to eat their local foods to the exotic foods in their host countries. This development has provided an opportunity for a lot of entrepreneurs in the micro, small and medium sized enterprises (MSMEs) who are processing convenient local foods such as "kokonte" and "fufu" powder,

"banku" mix, canned snails, canned palm cream concentrate and canned garden eggs both for export and domestic markets. These processed local foods that are exported normally goes to the African, Caribbean and Pacific niche markets in Europe and North America and is a huge source of foreign exchange earnings for developing countries like Ghana. Due to the increasing awareness of food safety among the Ghanaian middle class and the ever-changing food safety legislation globally there is the need to help these MSMEs implement HACCP system in order to produce safe food. For instance, with the coming into force of the US FSMA in 2011 all companies that want to export canned foods to the US are required to implement HACCP and file their thermal processes with the USFDA (AFI Annual Report, 2017).

1.3. Main Objective of the Study

To develop a generic HACCP system for the canned palm cream concentrate industry in Ghana.

1.4. Specific Objective of the Study

The specific objective of this study is to design a HACCP system as a food safety management tool for the canned palm cream concentrate industry in Ghana using Praise Export Services Limited as a model.

1.5. Significance of the Study

The importance of implementing HACCP as a food safety management tool cannot be overemphasized. The potential benefits to a food business from using HACCP include; compliance with legal requirements, facilitation of international trade and using HACCP to

support a defence of 'Due Diligence' for UK food safety legislation. HACCP also serves as an inexpensive control of foodborne hazards and prepare food businesses from a solely retrospective end product testing approach towards a preventative Quality Assurance approach (Campden BRI, 2009).

Most indigenous food businesses in Ghana see HACCP implementation as a difficult task but this study seeks to demystify that impression. Hence when this research study is completed, canned palm cream concentrate MSMEs in Ghana will have a readily available generic HACCP plan as a baseline data to review and incorporate into their operations to assure the safety of their products and gain access to the global market thereby providing descent jobs and raking in foreign exchange for the Government of Ghana.

1.6. Limitation of the Study

The limitation of this research includes the inability to monitor the implementation of the HACCP system for a period due to time constraints and also the lack of appropriate equipment to determine the Fo value of the thermal process as a way of validating the thermal process.

1.7. Research methodology

The study began by the researcher helping the senior management of the company to select workers with the requisite background and experience to form the HACCP team. The researcher then took a walkthrough of the canning facility and review the existing procedures and documents to identify the processing steps in palm cream concentrate canning. This helped the researcher to develop a detailed process flow diagram for the company. Details of methodology is provided in chapter three of this study.

1.8. Organization of Study

The study is organized in five chapters. Chapter one introduces the subject of the study stating the purpose and objectives for which it is to achieve. The second chapter is a review of literature and other related issues expounded by many scholars and hands-on practitioners on the principles of food canning, oil palm processing and HACCP as a food safety management system. Chapter three describe in detail, the approach used in the research work. Chapter four presents the results of the study.

Chapter five summarizes and concludes the study. Based on the findings some relevant and valuable recommendations are made for the formation of possible strategies that could lead to the successful implementation of HACCP in the palm cream concentrate canning industry in Ghana.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter reviews various works and studies carried out in the area of oil palm fruit processing, food canning principles and application of Hazard Analysis and Critical Control Point (HACCP) as a food safety management system in a food cannery. This is the section that shows the thoughts, hands-on experiences, suggestions and recommendations of various authors, industry and regulatory guidelines on food canning, oil palm processing and HACCP and its implementation in the food industry.

2.2. Economic Importance of Oil Palm in Ghana and West Africa

Folklore and anthropological evidence show that the origin of the African palm fruit or oil palm (*Elaeis guineensis)* is West Africa (Nketiah, 2011). The palm fruit, popularly called "abe" in Ghana are small, ovoid-oblong fruits that grow in clusters of several hundred, close to the trunk on short heavy stalks. Women in Ghana often refer to two forms of palm fruit (abe); the indigenous palm fruit called "abe paa" (translated: good or proper palm fruit) and the hybrid called "agric abe" (translated: the agricultural abe) (Nketiah, 2011).

The oil palm is one of the most significant cash crops in the Ghana next to cocoa (Sarpong, 2015). The oil palm is an essential oilseed and produces many products both for domestic consumption and as inputs for the industrial sector. The palm oil industry in Ghana is divided into two different markets: home consumption as palm nut soup, palm wine and industrial use in domestic manufacturing as palm oil (Sarpong, 2015). The industry provides income for many rural people who work in large and small-scale mills, especially women engaged in small scale palm oil processing. The main product of oil palm is the palm fruit, which is boiled, pounded and strained to obtain palm cream which is used to prepare palm soup in West Africa. In Ghana, it is called "abenkwan" and in Nigeria "banga". Also, the oil palm fruit is converted into commercial products such as palm oil, palm kernel oil and palm kernel cake (Sarpong, 2015).

Figure 1: Oil Palm Fruit ("abe")

Source: GNA, 2016.

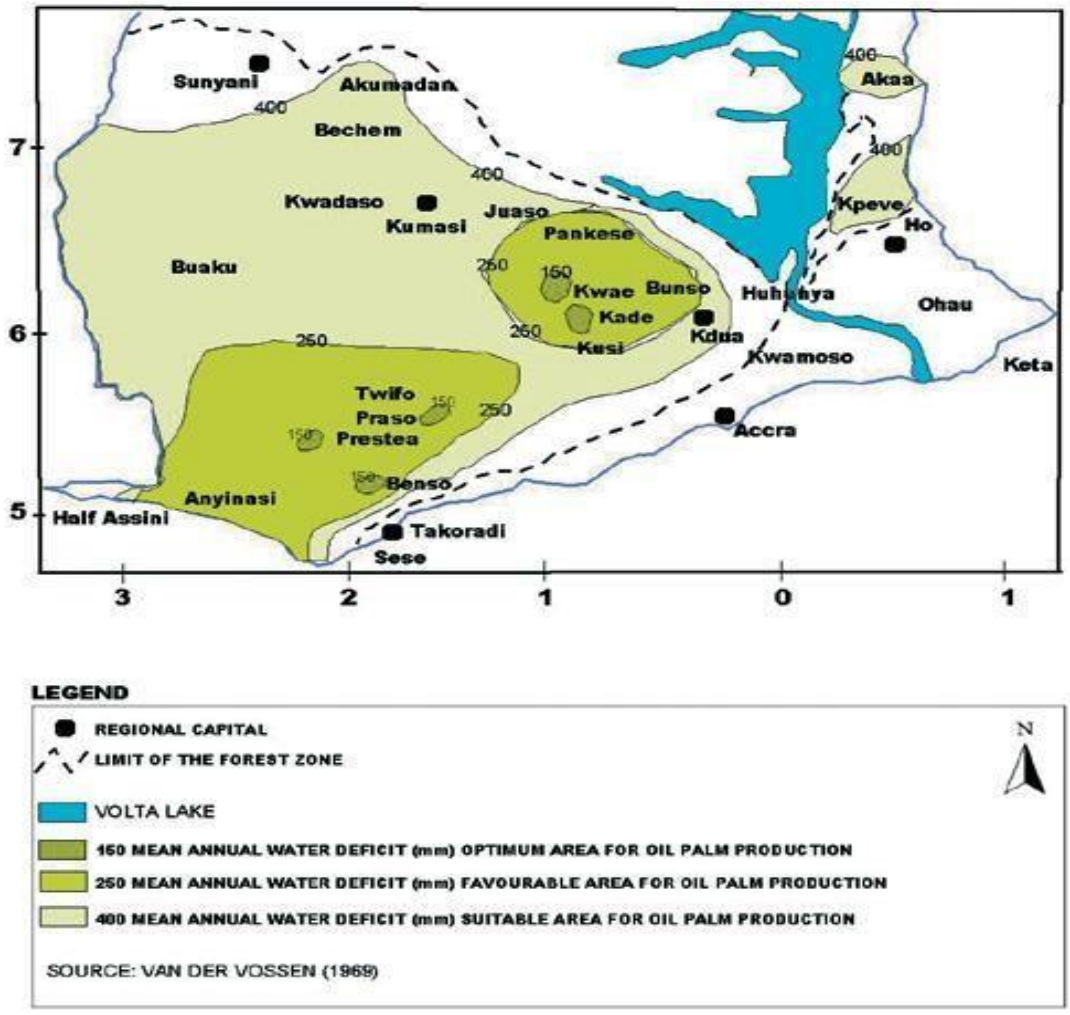
2.2.1. Types of Oil Palm Cultivated in Ghana and Dominant Growing Regions

Two main types of oil palm are cultivated in Ghana: *Dura* and *Tenera*. Most farmers in Ghana cultivate the *Dura* (Sarpong, 2015). This is because the high level of unsaturation in the *Dura* makes it nutritionally preferable to the *Tenera*. Hence, oil from the *Dura* is more preferred for food than *Tenera*. It is indicated that palm oil from red *Tenera* has higher palmitic acid content than red *Dura* palm oil (RDPO), while oleic acid content is higher in the red *Dura* (Sarpong,2015).

The growth regions of oil palm are the forest belt in Ghana, where the rainfall amount is greater than 1200 mm/annum and distributed in a bimodal fashion. The Central, Eastern and Western regions are the most suitable areas for oil palm cultivation in Ghana. Ghana, therefore has large oil palm plantations and processing mills located in these regions than other regions (Sarpong, 2015). Examples of large-scale plantations are Benso Oil Palm Limited (BOPP) and Norwegian Oil Palm Ghana Limited (NORPALM) in the Western Region, Twifo Oil Palm Plantation Limited (TOPP) in the Central Region, and the Ghana Oil Palm Development Company (GOPDC) at Kwae near Kade in the Eastern Region (see Figure 2).

Currently, it is estimated that Ghana has more than 150 000 ha of wild groves of (Dura) oil palm, as well as approximately 140 000 ha in private, unorganized small holdings, and some 40 000 ha in estates with smallholder and out grower schemes with the total estimated area of oil palm cultivation in the country as 330 000 ha (MoFA, 2010).

Figure 2: Map Showing Oil Palm Growth Areas in Ghana



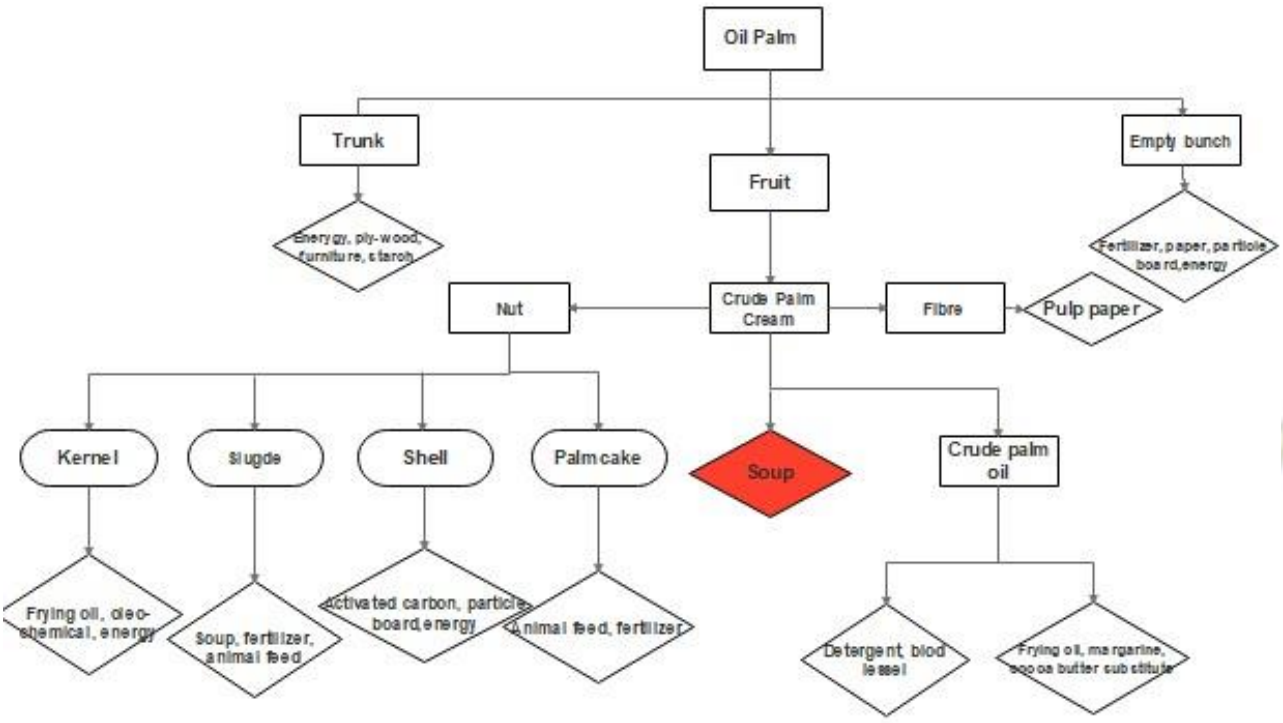
Sources: MoFA (2010).

2.2.3. The Oil Palm Product Value Chain

The value chain is divided into three segments: value addition from the trunks, the fruits and the empty fruit bunches. The fresh fruit bunch (FFB) is considered the most important element in the value chain because it yields the nuts and the crude palm oil. The crude palm oil gives palm oil, a West African popular cooking oil. Also, the sauce squeezed from the palm fruit is used for soup in West Africa at the domestic level. At the industrial level, the sauce squeezed from the palm fruit is canned as palm cream

concentrate which is a convenient sauce for use in preparing palm soup which is the focus of this research work.

Figure 3: The Oil Palm Product Value Chain



Source: MoFA (2010)

2.3 HISTORY AND ECONOMIC IMPORTANCE OF CANNING OF FOODS

Canning is a scientifically tested and traditional means of providing food which is stable at ambient temperatures, has long shelf life and therefore suitable for world-wide distribution (Bratt, 2010). This method of preserving foods in cans and jars was developed more than 200 years ago when a Frenchman, Nicolas Appert, won a competition initiated by another great warrior in French history, Napoleon Bonaparte (Heinz and Hautzinger, 2007).

Appert won his prize (12 000 francs) for demonstrating that foods which had been heated in air-tight (hermetic) metal cans, did not spoil, even when they were stored without refrigeration. Once the reliance on the refrigerated and/or frozen food chain had been broken, it was possible to open markets for shelf-stable canned products where no entrepreneur had ventured previously (Heinz and Hautzinger, 2007). For example, canned tuna is exported from countries all over the world into the consumer markets of Europe and North America (Bratt, 2010).

The canned tuna industry, needless to say, is a lever for job creation and provide the muchneeded employment, individual incomes and the means for foreign currency exchange for developing countries, Ghana not excluded (Bratt, 2010). Ghana is a leading canned tuna exporter into the EU market with figures from the Ghana Export Promotion Authority indicating that 120 million USD was realized as foreign exchange earnings from canned tuna alone in 2012. In the time since Appert's success, the technology of canning has been modified and improved, however, the principles are as true today as they were when first enunciated more than 200 years ago (Heinz and Hautzinger, 2007).

2.4. Principles of Food Canning

Unlike pasteurization of food where the survival of heat resistant microorganisms is accepted1, the aim of canning of food products is the destruction of all contaminating bacteria including their spores. Heat treatment of such products must be intensive enough to inactivate/kill the most heat resistant bacterial microorganism, which is the spores of Clostridium botulinum (Safefood 360, 2014).

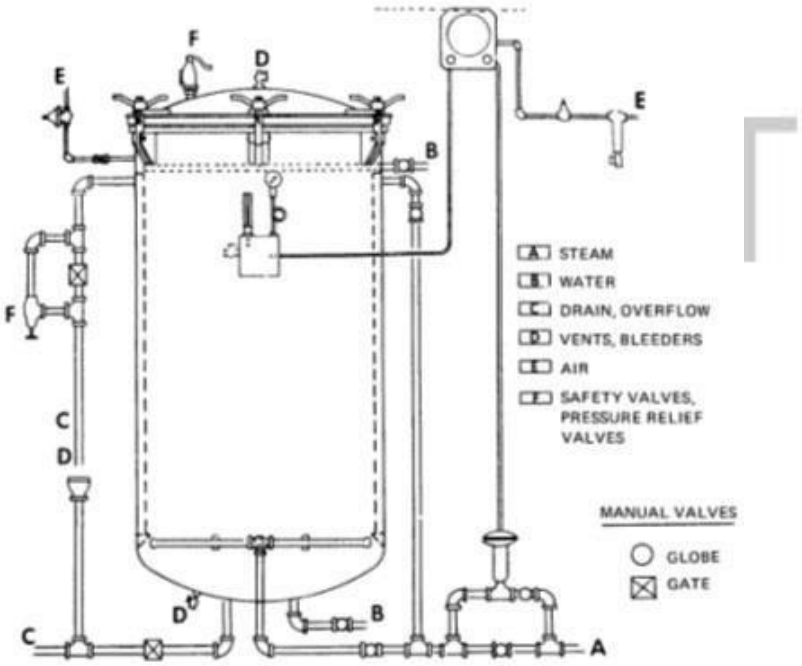
In practice, canning involves sealing food products in cans and exposing the cans to temperatures above 100°C in pressure cookers. Temperatures above 100°C, usually ranging

from 110-121°C depending on the type of product, must be reached inside the product. Products are kept for a defined period of time at temperature levels required for the entire sterilization period depending on type of product and size of container (Heinz and Hautzinger, 2007). The process for canning foods depends on the acidity of the food, which is determined by its pH. Low-acid foods have a pH more than 4.6, and high-acid foods have a pH less than 4.6. In general, vegetables and meats are low-acid foods, and fruits are high-acid foods (Boyer, Science, & Tech, 2012)

2.4.1. The Heat Sterilization Process and equipment

In order to reach temperatures above 100°C ("sterilization"), the thermal treatment has to be performed under pressure in **pressure cookers**, also called **autoclaves** or **retorts**. The retort or autoclave is the most important equipment in the canning industry (Heinz and Hautzinger, 2007). There are different types but the common one used by SMEs are the still vertical retorts which are easy to operate.

Figure 4: A Schematic diagram of a Vertical retort



Source: (Heinz and Hautzinger, 2007**)**,

In retorts (Fig. 4) high temperatures are generated by direct **steam injection**, **heating water** up to temperatures over 100°C or by **combination of steam and water heating**. The autoclave or retort must be fitted with a thermometer, pressure gauge, pressure relief valve, vent to manually release pressure, safety relief valve where steam is released when reaching a certain pressure (e.g. 2,5 bar), water supply valve and a steam supply valve. The steam supply valve is applicable when the autoclave is run with steam as the sterilization medium or when steam is used for heating up the sterilization medium water (Heinz and Hautzinger, 2007).

There are simple and small retorts that are often vertical (Fig. 4) with lids on top. Through the opened lid the products for sterilization are loaded into the retorts. The cans are normally placed in metal baskets. The baskets are placed in the autoclave, either singly or several

stapled-on top of each other. Before starting the sterilization, the lid must be firmly locked onto the body of the retort (Heinz and Hautzinger, 2007).

The retort and lid are designed to withstand pressures up to 5.0 bar. These types of retorts are suitably for smaller operations as they do not require complicated supply lines and should be available at affordable prices. In instances where steam is used instead of water as the sterilization medium, the injection of steam into a single vessel autoclave will instantly build up the autoclave temperature desired for the process (Heinz and Hautzinger, 2007).

Figure 5: Vertical retort (typically used for small-scale canning operations).

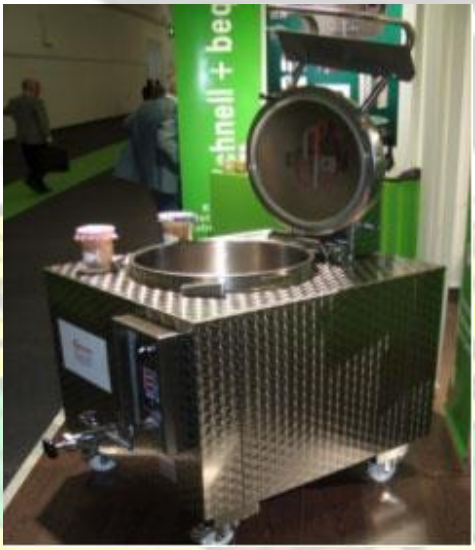
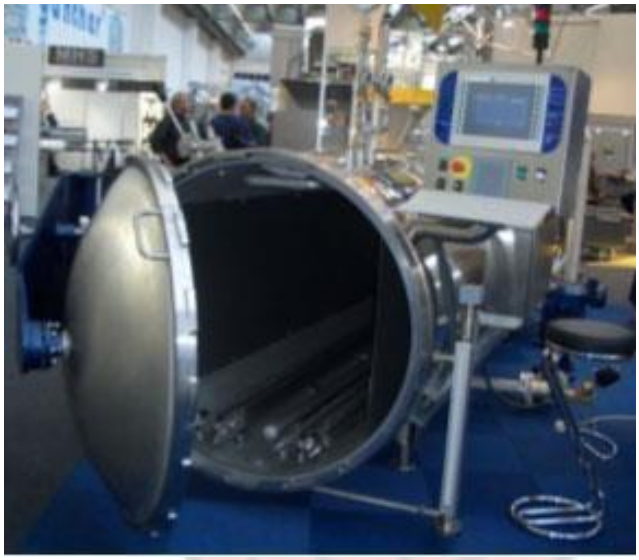


Figure 6: Large horizontal retort (autoclave) for large canning operations



During the final stage of the retorting process, products must be cooled down as quickly as possible. This operation is done in the retort by introducing cold water. The contact of cold water with steam causes the latter to condense with a rapid pressure drop in the retort. However, the overpressure built up during thermal treatment within the cans, jars or pouches remains for a certain period. During this phase, when the outside pressure is low but the pressure inside the containers is still high due to high temperatures there, the pressure difference may induce permanent deformation of the containers or cans referred to as peaking or buckling of cans ends (Heinz and Hautzinger, 2007).

2.5. HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP)

2.5.1. The HACCP Concept

HACCP stands for 'Hazard Analysis and Critical Control Point' (Bratt, 2010). Alternatives to the official meaning for HACCP have been suggested over the years but one that is quite apt,

particularly when linked to a good measure of 'common sense', is 'Hazard Analysis by Cynical Critical Pessimists' (Bratt, 2010).

It is based on a common-sense application of technical and scientific principles to the food production process from production/harvest to consumption (Scott and Stephenson, 2006). The principles of HACCP can be used for all stages of food production including farming, food preparation and handling, food manufacturing, distribution, food service, retail and consumer handling and use (Scott and Stephenson, 2006).

The fundamental concept underlying HACCP is that of prevention rather than inspection. A food producer, manufacturer, handler, distributer, retailer or consumer should have adequate information regarding the food and the associated procedures they are using, so that in the event of food safety crisis, they will be able to identify where and how a food safety problem may occur. Once the "where" and "how" are known, prevention becomes easy and clear, and finished product inspection and testing become superfluous. (Scott and Stephenson, 2006).

HACCP systems address the control of factors affecting ingredients, products and processes. The aim is to make the product safe to consume and to be able to prove it. The **where** and **how** are the **HA** (hazard analysis) part of HACCP. The proof of the control of processes and conditions is the **CCP** (critical control point) part (Scott and Stephenson, 2006).

According to Knight, (2013) HACCP does not stand for Hazard Analysis Critical Control Point as some text books have stated. It stands for Hazard Analysis **and** Critical Control Points. This is because the HACCP concept involves two important activities: performing Hazard Analysis (HA) and determining Critical Control Points (CCP), (Knight, 2013). Flowing from this basic concept, HACCP is simply a methodical and systematic application of appropriate science and technology to plan, control and document the safe production, handling and preparation of foods (Scott and Stephenson, 2006).

The HACCP concept covers all classes of potential food safety hazards – biological, chemical and physical, whether they are naturally occurring in the food, contributed by the environment or generated by an error in the manufacturing process or handling (Scott and Stephenson, 2006). While most consumers are scared by chemical hazards and physical hazards are most usually identified by consumers, microbiological hazards are the most serious from a public health perspective. That's why, though, HACCP systems address all three types of hazards, a majority of the emphasis is placed on microbiological issues. For example, a piece of metal (physical hazard) in a food product may result in a chipped tooth for one consumer, but contamination of a batch of milk with *Salmonella* may affect thousands of consumers (Scott and Stephenson, 2006).

2.5.2 Origin of HACCP

The Pillsbury Company, the US Army Natick Laboratories and the National Aeronautics and Space Administration (NASA), invented HACCP in response to the food safety standards required by NASA for "space foods" produced for manned space flights in the 1960s (Scott and Stephenson, 2006). NASA had two principal safety issues. The first was related to potential problems with food particles, crumbs and water in the space capsule under conditions of zero gravity. (They were concerned about potential problems of crumbs or water droplets interfering with electrical equipment.) The second issue was the need for absolute assurance of freedom from pathogens and biological toxins. A case of foodborne illness, e.g., staphylococcal food poisoning, in a space capsule would have been catastrophic.

The first concern, food crumbs or liquid droplets in zero gravity, was tackled by producing bite-sized foods and using specially formulated edible coatings to hold the food together. Highly specialized types of packaging were also used to reduce the exposure of foods and

liquids to the environment during storage, preparation and consumption. The most difficult one to tackle was the second concern which is microbiological safety. Sampling of end products to determine microbiological safety of every lot of space food produced became impractical, if not impossible. Dr. Howard Bauman (1990), who managed the development of HACCP at Pillsbury, gave us the full facts as follows "We quickly found that by using standard methods of quality control there was absolutely no way we could be assured that there would not be a problem. This brought into serious questions the then prevailing system of quality control in our plants. If we had to do a great deal of destructive testing to come a reasonable conclusion that the product was safe to eat, how much were we missing in the way of safety issues by principally testing only the end product and raw materials?

We concluded after extensive evaluation that the only way we could succeed would be to establish control over the entire process, the raw materials, the processing environment and the people involved (Scott and Stephenson, 2006).

To prove the impracticality of attribute sampling and the resultant destructive testing of finished product that would be important to guarantee microbiological safety, think about the following illustration. If *Salmonella* was present in a batch of product at the rate of 1out of each 1000 units of product (defect rate = 0.1%), a testing plan that analyzed 60 units from a batch would have > 94% likelihood of approving the batch and missing the *Salmonella* – contaminated product.

Notwithstanding the factual proof that this that this sampling plan would be insufficient in detecting the contaminated product, there is the practical and financial reality that no organization would have the capacity to destructively test 60 units out of every batch of products for the presence of *Salmonella*, as well as other pathogens of concern in specific products. Consequently, an alternative approach must be created with a specific aim to obtain

the level of assurance of products safety that NASA required for foods produced for the space program. This program utilized a series of non-destructive tests of hardware for the purpose of assuring that the hardware functioned properly. While repeated, non-destructive testing could be utilized on each piece of equipment, this program was not appropriate for adaptation to foods.

Eventually, the "Modes of Failure" concept created by the US Army Natick Laboratories was adjusted to the processing of foods. By gathering knowledge and experience concerning a food product/process, it was conceivable to anticipate what might go wrong (a" hazard"), how it would happen, and where it would happen in the process. Based on this type of analysis of the hazards associated with a specific product and process, it was conceivable to choose points at which measurements and/or observations could be made that would reveals whether or not the process was being controlled. If the process was out of control, there was an increased probability that a food safety problem would occur. These points in the process were then, and are today called Critical Control Points (CCPs). Consequently, HACCP was developed to target proper design of all of the factors associated with ingredients, processes and products in order to prevent hazards from occurring, and thereby ensure the safety of the products" (Scott and Stephenson, 2006).

2.5.3 Tracing the use of HACCP and evolving Legislation from Inception to date

Pillsbury Company presented HACCP at the first American National Conference for Food Protection in 1971; ever since the concept has been evolving in the food industry (Campden BRI, 2009). The US Food and Drug Administration (FDA) incorporated HACCP into its Low Acid Canned Foods Regulations (1973) and has applied HACCP to its fish and seafood production processes (Campden BRI, 2009). According Pillsbury (1973), training of

inspectors in elements of HACCP by the US FDA began in 1973 and they instituted special HACCP inspections of food plants. Numerous conferences and sessions on HACCP, including a symposium at the 1974 Annual Meeting of the Institute of Food Technologists were held (Scott and Stephenson, 2006).

In the 1970's, FDA enacted the low-acid and acidified canned food regulations, Title 21, Code of Federal Regulations Part 113 (originally 21 CFR 128b), "Thermally processed Low-acid Foods Packaged in Hermetically Sealed Containers," and, "Acidified Foods," (21 CFR 114) respectively. Though, these regulations did not mention HACCP, their approach to controlling *Clostridium botulinum* appears to be based on HACCP principles.

According to Scott and Stephenson (2006) the enthusiasm and interest in HACCP began to wane after the initial flurry of activities. This is based on the fact that while the description of the HACCP concept was generally short, designing and implementing a HACCP system is a daunting task. It requires considerable time and expertise to design a HACCP system. Thus, except for use by a few large food industries and the mandatory use of HACCP principles for FDA-controlled thermally processed low-acid and acidified foods, HACCP was not generally used in the food industry (Scott and Stephenson, 2006). However, enthusiasm for HACCP was revived in 1985 when a Subcommittee of the Food Protection Committee of the National Academy of Sciences (NAS) issued a report on microbiological criteria. This report (NAS, 1985) was the result of a research commissioned by some government agencies with obligations for food safety in the US (Scott and Stephenson, 2006). While the objectives of the study were principally about setting up microbiological standards for foods, the report included a particularly strong endorsement of HACCP (Scott and Stephenson, 2006). Based upon recommendation in the 1985 NAS report, a committee, consisting primarily of food microbiologists, was appointed to serve as an expert scientific advisory panel to the secretaries

of Agriculture, Commerce, Defense, Health and Human Services (Scott and Stephenson, 2006).

This committee held its first meeting in 1988, and was named the National Advisory Committee on Microbiological Criteria for Foods (NACMCF). In the same year 1988, the US Department of Agriculture (USDA) mandated or applied HACCP to meat and poultry production. Part of the mission of the NACMCF is to champion the use of the HACCP concept to food safety and on the heels of that the World Health Organization (WHO, 1995, 1996, 1997) and International Commission on Microbiological Specifications for Foods (1988) also promoted the use of HACCP on a global scale (Bratt, 2010) as has the British government based on recommendations made in the Richmond Report (1990, 1991)9 and the Pennington Report (1997) (Campden BRI, 2009). Based upon additional information and experience in applying HACCP principles in the US, the NACMCF adopted two revisions of its HACCP document (NACMCF, 1992 and 1997). Under the UK Food Safety Act (1990), an implementation HACCP by a food company may be used to demonstrate 'Due Diligence'. The Food Hygiene Committee of Codex has documented a standardized point of view to HACCP application for all its member nations. This document adopts the Codex "HACCP System and Guidelines for its Application" 1993 and its revisions (1997 and 2003). Codex standards, guidelines and recommendations now serve as the minimum requirement for consumer protection under the Agreement on Sanitary and Phytosanitary Measures (1994), agreed at the Uruguay round of GATT negotiations. According to Campden BRI (2009), within the European Union, systems based on HACCP have been incorporated into the EC food hygiene regulations and also feed legislation (DG SANCO, 2005; EU, 2004a, 2004b, 2005). In 2002 the US regulations made it mandatory for juice processing and packaging plants to use HACCP system and voluntary HACCP for Grade A fluid milk. It is significant

to note that the US FSMA which was signed in 2011 is HACCP based. In 2004, Europe adopted several new regulations which was made compulsory that all food manufacturing companies must establish HACCP based procedures effective January 1, 2006. Government agencies across the world then follows the examples of the US and EU with Canada, Japan and Australia, adopting HACCP systems (Bernard and Scott, 2006). Significant among them was Ghana incorporated HACCP into its Fisheries Products Legislation, 2006 and made it mandatory for all fish processors to implement a HACCP system. Also, HACCP Canada was adopted in 2008 for the hospitality industry and HACCP America in 2010 for all retail settings worldwide. HACCP is now being accepted globally as the best approach for managing and assuring food safety. The Global Food Safety Initiative (GFSI) whose aim is to harmonize food safety standards has incorporated HACCP into its approved schemes (Campden BRI, 2009). These approved schemes include British Retail Consortium (BRC), International Featured Standards (IFS), Food Safety Systems Certification (FSSC) 22000 and Safe Quality Food (SQF). Needless, to say HACCP is the main body or content for ISO 22000 standard.

2.5.4. Benefits of HACCP

There are many potential benefits to a food business from using HACCP (Campden BRI, 2009). These benefits include:

- HACCP complies with legal requirements
- HACCP facilitates international trade
- Implementation of HACCP is useful in supporting a defense of 'Due Diligence' for UK food safety legislation
- International authorities such as the Joint FAO/WHO Codex Alimentarius Commission promote HACCP as the system of choice for ensuring food safety

- HACCP is complimentary to other Business/Quality Management Systems
- The use of proactive or preventative approaches such as HACCP instead of reactive ones leads to reduced product losses
- When supported by generic food hygiene control measures (prerequisite programmes), the use of HACCP focuses technical resources into critical parts of the process
- A correctly applied HACCP study should identify all currently conceivable hazards, including those which can realistically be predicted to occur
- HACCP is the most cost-effective method of preventing foodborne hazards globally
- Use of HACCP will move a company from a solely retrospective end product testing approach towards a preventative Quality Assurance approach
- HACCP is a systematic approach that can cover all aspects of food production from raw materials, growth, harvesting and purchase to final product use to assure safe food.

2.5.5. HACCP and Product Quality

The HACCP technique was developed initially to deal with microbiological hazards that affect product safety and also those leading to microbial spoilage (Campden BRI, 2009). Internationally, HACCP became accepted principally as the technique applicable to issues of product safety associated with biological, chemical or physical hazards Campden BRI, 2009). Though, of late, there has been suggestions to apply the HACCP technique to identify product quality defects (e.g. particle size, colour, taste, texture) and to come out with appropriate "preventive measures". In theory, the philosophy inherent in HACCP (i.e. identify potential hazards and implement preventive measures to avoid them occurring) is equally useful to both product safety and quality issues (including microbial spoilage). But, there is a school of

thought that maintains that HACCP should be restricted to product safety issues (Campden BRI, 2009).

It is important that the overriding significance of HACCP as a globally accepted approach of ensuring the safety of foods is not diluted by suggestions to develop CCPs for topics like product quality attributes (Campden BRI, 2009).

2.5.6. Principles of HACCP

HACCP identifies specific physical, chemical or biological hazards that adversely affects the safety of food products and specifies preventive measures for their control. HACCP consists of seven principles (cf. Codex Alimentarius Commission, 2003). These seven principles are as follows:

- Conduct a hazard analysis. Prepare a flow diagram of the steps in the process. Identify and list the hazards together with their causes/sources, conduct a hazard analysis to determine if the hazards are significant for food safety and specify the control measures (***principle 1***).
- Determine the critical control points (CCPs). A decision tree can be used (***principle 2***). - Establish critical limit(s) which must be met to ensure that each CCP is under control (***principle 3***).
- Establish a system to monitor control of CCP by scheduled testing or observations (***principle 4***).
- Establish the corrective action to be taken when monitoring indicated that a particular CCP is not under control or is moving out of control (***principle 5)***.
- Establish procedures for verification to confirm that the HACCP system is working effectively; this should also include validation and review activities (***principle 6***).

- Establish documentation concerning all procedures and records appropriate to these principles and their application (***principle 7***).

2.5.7. Prerequisite programmes

In a food manufacturing enterprise, there will be many hazards or sources of contamination that may occur at many steps of the process and are not specific to a particular process step, e.g. environmental conditions that ensure product is produced under safe and sanitary conditions. They are called prerequisite programmes (Campden BRI, 2009).

The term PRPs which stands for "prerequisite programmes" provide the basic environmental and operating conditions that are necessary for the production of safe and wholesome foods. A loss of control could result in a low risk food safety problem, an economic issue or a quality defect. Codex identifies six categories of prerequisite programmes with each program divided into elements and sub-elements but for the purpose of this study the pre-requisite programmes defined in the Campden BRI Guideline No. 42 which in practice are widely used in the food industry (Campden BRI, 2009) will be applied. These PRPs come under three main areas referred to as the "3Ps": **plant** (premises), **personnel** and **products** (raw materials) (Campden BRI, 2009).

Examples include:

Plant/Premises

- All buildings must be designed, located, built and maintained following the principles of good hygienic practice

  Plant or factory layouts must ensure that there are appropriate flows for personnel, product/raw materials and waste

- Equipment should be designed, constructed and installed following the principles of good hygienic practice.
- Preventive maintenance and calibration schedules should be in place
- Documented procedures and schedules for cleaning equipment and premises, including external areas, should be established.
- An integrated pest management programme should be implemented
- There should be effective control for chemicals (e.g. cleaning, solvents, inks and lubricants)
- Suitable services (e.g. water, steam, ice and air) should be provided and maintained at an adequate quality.
- Suitable lighting and ventilation should be provided
- Glass and hard brittle plastic and other foreign bodies should be effectively controlled
- Internal audit programmes, including housekeeping and inspections against glass and hard brittle plastic registers should be established
- Where necessary there should be temperature-controlled storage/dispatch and production areas
- Effective waste management control procedures must be implemented.

Personnel

- Documented systems for personal hygiene and appropriate personal hygiene practices such as wearing of personal protective equipment and rules for jewelry, eating, smoking and hand washing applicable to both staff and visitors to the premises must be implemented
- Proper procedures must be implemented for medical screening of food handlers, visitors and contractors, including sickness reporting.

- Cuts and wounds should be protected by appropriate waterproof plasters/coverings
- There should be procedures to ensure the effective laundering of protective clothing
- Where relevant there should be specific procedures for the wearing of gloves
- Documented procedures and protocols should be implemented for personnel training
- Suitable and adequate hygiene facilities should be provided (e.g. toilets, locker rooms, changing areas and hand washing).

Product/raw materials

- Effective procedures for supplier approval and control should be implemented
- Agreed specifications for raw materials, including packaging must be implemented
- Storage and delivery of raw materials and finished products should be done under clean conditions
- Materials and products should be recorded in a system that provides traceability and allows rapid and accurate recall
- There should be procedures for the control of non-conforming products (e.g. quarantine, rework and disposal)
- There should be specifications for finished products
- There should be clear product information and customer/consumer instructions provided as appropriate
- There should be a procedure for dealing with customer/consumer complaints
- Raw materials and finished products should be transported under controlled temperature conditions, where appropriate.

The prerequisite programmes provides a solid foundation on which the HACCP system can be based and therefore are usually expected to be implemented before the HACCP plan is installed. If the prerequisite programmes are not in place and maintained, food safety

management will not be effective and may cause the HACCP system to fail (Campden BRI, 2009).

Strong and workable PRPs allow the HACCP system to be focused on important product and process food safety hazards that require specific control to assure consumer safety. By "screening-out" the general hazards, only few numbers of CCPs are identified which can be properly handled (Campden BRI, 2009).

2.5.8 Setting up and Conducting a HACCP study for canned foods

This HACCP study is based on the approach prepared by CAC (2009) and outlined by workers in this field (ILSI Europe, 1998, 2004; Mayes and Mortimore, 2001; Mortimore and Wallace, 1998; NACMCF, 1997). Specific details about canning, HACCP and fish processing/canning can be found in Horner (1992), Bratt (1995), USFDA (2001), Ababouch (2002) and Seafood Products Association (2008).

HACCP system should be underpinned by adherence to general principles of food hygiene, appropriate industry codes of practice and appropriate food safety legislation. Also, prerequisite programmes discussed earlier are required to be implemented before applying the principles of HACCP (Campden BRI, 2009).

The company must select the HACCP approach most applicable to their operation; they may decide to look at all products or process lines on an individual basis (linear approach) or they may combine similar products or processes into modules (modular approach). In some instances, pre-developed HACCP plans may be appropriate (generic approach) (Campden BRI, 2009).

Generic – company, sector or national generic HACCP plans may also be available to guide companies through the application of the HACCP principles. These can be very useful for, in particular, small and medium sized enterprises (SMEs)/or less developed food operations; however, the information must be fully checked for applicability to the actual operation as it is very unlikely that two operations will be identical in all aspects. In the majority of cases they need to be modified by the user, but they do provide a very good starting point (Campden BRI, 2009).

When conducting a HACCP study, there is a need to apply seven preparatory stages before applying the seven principles (Campden BRI, 2009). It should be noted that Codex Alimentarius has five preparatory stages before applying the seven principles, resulting in twelve stages to their 'Logic sequence' (Campden BRI, 2009).

2.5.9. The 14 stages in setting up and conducting a HACCP study

1 – Get senior management commitment

2 – Agree on the scope or terms of reference of the study

3 – Choose the team

4 – Describe the product and process

5 – Identify intended use of the product

6 – Draw a process flow diagram

7 – Confirm or verify the flow diagram

8 – List the potential hazards you can think of or guess that they are associated with each process step, do a hazard analysis and determine the control measure of the identified hazards

9 – Determine your CCPs

10 - Establish critical limits for each control measure at each CCP determined

11 – Have a monitoring system for each CCP

12 – Have a corrective action plan for each CCP

13 – Establish verification procedures to confirm that the HACCP system is working effectively. Verification procedures involve performing validation, verification and review activities

14 – Have documentation and record keeping procedures in place

Management commitment (*Preparatory Stage 1*)

In order to carry out an HACCP study senior management will have to appoint the HACCP team

leader and ensure the availability of the necessary team members for a number of study periods. Before any HACCP study begins, the team leader/chairperson must ensure that senior management of the company is committed to providing the necessary resource for the study to be completed and implemented, together with the resource to review and update the study. Without such commitment there is no point in beginning a study. To help provide evidence of management commitment, some food operations have a Food Safety Policy or include a statement on HACCP within their Quality Policy. Such policies should clearly define the food safety objectives and should be regularly checked and reviewed. Many food operations have also included an introductory statement from senior management in the HACCP plan for the same reason. Senior management must ensure that the responsibilities for key personnel have been defined; this would include those responsible for food safety and

HACCP; this includes ensuring clear communication and reporting channels are in place. Ongoing management commitment is also needed to ensure regular reviews of their quality and production systems that are carried out; this will include the HACCP system.

Scope/terms of reference of the study (*Preparatory Stage 2*)

Terms of reference (TOR) or scope of the study should be clearly agreed on early to help the HACCP team focus on the key issues. This will include:

- Determining the approach to be followed;
- Defining the product/process;
- Stating the start and end points of the study; and
- Defining the hazards to be considered.

The hazards to be considered should be clearly stated here (i.e. biological, chemical or physical hazards – or any combination of these). It is also important that the objective of the study is defined (i.e. whether product safety only or microbiological quality aspects such as spoilage are to be considered. It is recommended that the hazards are precisely defined, e.g. specific pathogenic organisms (such as *C. botulinum, C. perfringes and S. aureus*) or specific physical hazards such as pieces of metal, glass and hard plastic. The TOR must also clearly state whether product is to be judged safe at the point of dispatch, or at the point of consumption by the user. The start point of the study should be clearly defined (to include all raw materials and ingredients), as should the end point. If the completed HACCP study is supported by, and interrelates with, other documents, e.g. PRPs or those that form part of a Business Management System, this should be stated in the TOR to help to clarify the relationship. Sources of information that were used during the development of the HACCP plan should also

be listed. This list may include legislation, codes of practice, guideline documents, relevant scientific literature and sources of HACCP guidance.

Choose the HACCP team (*Preparatory Stage 3*)

HACCP studies require the collection, collation and evaluation of technical data hence it must be done by a team with diverse backgrounds and experiences (Bratt, 2010). The use of such teams is known to improve greatly the quality of data considered and therefore the quality of decisions reached.

In most operations, the team should be able to draw on the following skills:

- A production specialist: this person is the product expert and will be able to contribute in details what actually occurs on the manufacturing line throughout all shift patterns.
- A quality assurance/hazard specialist: this person is the expert on hazards who understands the microbiological and/or chemical hazards and associated risks for each product category.
- A plant expert: this is someone who has a working knowledge of the hygienic design and engineering operation/performance of the process equipment under study.
- Others: Other relevant specialists may be co-opted onto the team as necessary, e.g. buyers, operators, packaging and distribution experts, and a hygiene specialist.
- Team Leader: A person knowledgeable in the HACCP technique and/or the process should be nominated as team leader and must be tasked with the duty of managing the HACCP study. In most companies, this is a quality assurance or control manager,

however, appointing the production specialist as the team leader can help to promote ownership provided such a person is the most experience individual with HACCP training.

Secretary: An individual to take notes at HACCP team meetings and write the HACCP plan. In most organizations, this is the deputy to the team leader (often within the technical/quality department) with good HACCP knowledge. The team must ensure that the HACCP plan is easy to read and understand by all employees and relevant stakeholders such as customers.

Team members should have adequate practical knowledge of the process, product and the likely hazards to be able to contribute to the discussion of what actually happens on the production line, particularly if this is not revealed by the flow diagram. It is advisable that the team should not be made up of just managers. The team should be small, typically four to seven persons, although additional personnel may attend specific meetings as required (as non-core team members). In a small company, these skills may have to be represented by one person in this case, it is advisable that external support or information is sought carefully to ensure an effective HACCP study.

Describe the product (*Preparatory Stage 4*)

A complete description of the final product under study, or semi-finished product if only part of the process is being looked at, should be done. It is essential for a successful hazard identification and analysis that the HACCP team should:

- 'Know' their product and 'What makes it safe?'
- Understand the factors that could affect product safety.

The product should be defined in terms of the key parameters which influence the safety of the product. Key parameters would include:

- Composition (e.g. recipe, raw materials/ingredients and their origin);
- Chemical and physical nature/properties (e.g. aW, pH, acidity, salt%, emulsion, solids/liquid ratio);
- Processing (e.g. has product been heated and to what extent cooking, pasteurization, sterilization) and/or other preservation methods (e.g. brining, smoking, freezing) – what are the times and temperatures involved?
- Packaging system/materials (e.g. metal containers, aseptic packaging, glass bottles, vacuum)
- Storage and distribution conditions (e.g. product to be kept ambient, chilled or frozen, transport of canned goods in containers);
- Standard shelf life under defined conditions (e.g. stated 'use by' date or 'best before' date); and
- Instructions for product use (e.g. storage, handling and cooking instructions). There is a need to consider the potential for abuse/misuse of the product, e.g. during storage and transport.

Identify intended use (*Preparatory Stage 5*)

The intentional or known use of the product by customers or consumers and their target groups should be defined to include any special considerations; for example, is the product designed for babies, young children or the elderly, and is the product ready-to-eat? Other vulnerable or sensitive groups could include consumers who are allergic to specific food ingredients, immune-suppressed or compromised and/or pregnant. The HACCP team needs to:

- Understand their consumers and how they might use/abuse the product (e.g. freezing of chilled or ambient products); and
- Determine if the product is focused on a vulnerable group.

This stage is useful to help the HACCP team identify other hazards that may become significant for vulnerable consumers. In practice, this stage is often combined with Stage 4.

Draw a flow diagram (*Preparatory Stage 6*)

Before starting a hazard analysis, it is important to carefully examine the product/process (as defined in the TOR) and design a process flow chart around which the study can be based.

The HACCP team should:

- Know their process;
- Ensure that the flow diagram covers all relevant steps of the process;
- Gather information to help identify where hazards could occur; and
- Update the flow diagram as changes to the process occur.

The style of the process flow chart is a matter of choice; however, it must be noted that best practices demands that all process steps are numbered and use arrows to show transfer from one process step to the next. Some organizations have found it beneficial to use rectangular boxes to clearly identify the process steps, or a range of different shaped boxes to denote different types of activity (e.g. raw material receipt, storage and mixing or preparation activities). Every step in the process (including process delays, recycle/rework loops and waste outputs) must be clearly outlined in the correct sequence from the selection of raw materials through to processing, distribution, retail or customer handling. The flow diagram should illustrate the introduction of utilities (e.g. steam and gas) and other materials that come into contact with the product (e.g. water and packaging materials). The HACCP team should also

gather sufficient supporting technical data for the study to proceed. Examples of the supporting data may include, but are not necessarily limited to:

- Floor plans of production and ancillary areas, and layouts of equipment and services (e.g. water, steam, air, vacuum and gas supplies);
- Time/temperature history of all raw materials, semi-finished products and finished products, including potential for delay;
- Equipment design features (including the presence of voids);
- Personnel routes;
- Routes of potential cross-contamination, including raw material movement and storage;
- Routes for removal of waste/by-product materials; and
- Segregation of high-/low-risk areas and clean/dirty areas.

Some food operations find it useful after having determined the CCPs at Stage 9, to return to Stage 6 and highlight the CCPs on the process flow chart (Campden BRI, 2009).

Verification of process flow chart on site (*Preparatory Stage 7*)

As the flow diagram depicts the process steps that will need to be examined during Principle 1, the HACCP team should make sure that it is correct and that each process step is the exact representation of the actual manufacturing process.

- The flow diagram must be confirmed as correct.
- The confirmed flow diagram should be signed off and dated.
- The accuracy of the flow diagram must be maintained.

As the process changes, the flow diagram must be updated to reflect these changes. This will be an important element of the 'Review' activities (see Stage 13). The confirmed flow diagram and any amended versions should be signed off; all changes must be recorded.

***Principle 1*: List all potential hazards associated with each process step, conduct a hazard analysis) and consider any measures to control the identified hazards (*Stage 8*)**

By practical examination of the process, step-by-step, and applying the process flow chart as a guide, the HACCP team should be able to:

- Make a list of all hazards at each process step;
- Analyze the hazards to determine the causes which are significant for food safety;
- Maintain records of the hazard analysis; and
- Ensure effective control measures are identified/implemented.

List the potential hazards

The HACCP team should include all the hazards which may be present in the raw materials, which may be introduced during the process (e.g. contamination from the equipment, environment or personnel) and which could increase or survive at a process step (Bratt, 2010). The HACCP team needs to make good use of the supporting technical data that have been previously gathered. For example, the team must consider the manner in which the manufacturing process is controlled and what could realistically happen that may not be covered by the process flow chart (e.g. process delays and temporary storage). Additionally, the nature of the food (e.g. intrinsic factors such as pH, Aw and temperature) must be taken into consideration to ensure that the causes of potential hazards are clearly understood. Taking the above into consideration, the HACCP team should develop its list of all conceivable hazards using structured idea generating sessions (e.g. 'brainstorming' or 'mind mapping').

Conducting the Hazard Analysis

The HACCP team should next conduct a hazard analysis to determine which of the listed hazards are of such a nature that their prevention, elimination or reduction to acceptable levels is essential to the production of safe food. This can be divided into two activities:

- Clear and accurate description of the hazard including source or causes; and
- Assessment of the level of significance of the hazard with regard to food safety.

To define the hazard accurately, many HACCP teams have found it useful to use set descriptors, for example:

- Presence of the hazard (typically used when the hazard is already present in a raw material from the supplier);
- Contamination by the hazard (used when the hazard is introduced during the process);
- Growth of the hazard (typically used for microorganisms when they are able to increase their numbers); and
- Survival of the hazard (again typically used when microorganisms are not killed, inactivated or destroyed by a process step that was designed to do this).

To complete this hazard description, the source or causes of the hazard will need to be clearly defined; this is essential in order to help the HACCP team determine appropriate control measures. The significance of any hazard to the food safety of the finished product will need to be assessed (at this stage no attempt should be made to identify the CCPs). The decision process must consider the risk associated with any hazard identified in practice. Such considerations will always include a combination of the following:

- The likelihood of the hazard occurring and its consequent effects, e.g. previous company/industry experience or complaints and epidemiological data;
- The severity of the hazard, e.g. life-threatening/mild, chronic/acute;

- Numbers potentially exposed to the hazard, e.g. lot size and distribution;
- Vulnerability of those exposed, e.g. young/elderly, pregnant and allergic response;
- Survival or multiplication of microorganisms of concern;
- Production or persistence in foods of toxins, chemicals or physical agents;
- Severity of hazard.

Table 1: Example of a scoring system approach to assess the significance of hazards (in this example, any hazard with a total score of three or more is deemed to be significant).

Hazard	Severity (S)a	Likelihood (L)b	Significance (S × L)
Presence of glass fragments in glass jars from supplier	2	2	4
Introduction of wood splinters from damaged pallets into empty metal cans during storage	1	2	2
Introduction of pathogens due to postprocess contamination of wet jars and cans.	2	3	6

1: minor injury to consumer; 2: consumer in hospital/serious short-term injury; 3: death of consumer/long-term illness leading to death.

B Likelihood of hazard.

1: possibly could occur (unlikely to occur but might); 2: probably could occur (likely to occur at some time but no history of it occurring); 3: definitely will occur (at some time it is going to happen or has occurred in the past).

- Sources or causes of the hazard or conditions leading to the above; and
- Contamination of raw materials, intermediate product and final product.

Tools have been designed to assist HACCP teams carry out this part of hazard analysis; these include ‘scoring systems’, ‘quadrant graphs’ and ‘logic tables’ (Campden BRI, 2009). An

example of the scoring system, one of the more popular methods used by food operations, is shown in Table 1. It must be remembered that the successful use of tools for hazard analysis, such as those noted above, depends on the experience and judgement of the HACCP team.

The aim of such tools are to make the hazard analysis stage more formal, organized and logical, as well as providing documentary evidence that this vital stage has been performed. Though, these tools may appear to be quantitative in nature, they are in fact qualitative because they still depend on the professional judgement of the team (Campden BRI, 2009).

Maintain records of the hazard analysis

The team must ensure that records of their decision-making process are maintained; this will enable them to show why a certain hazard was deemed to be significant. Even where a tool has not been used, records of the decisions made by the team should be maintained; it is important to include why hazards were discounted as not being significant. Examination of the records of hazard analysis should form an important part of any HACCP-based audit.

As a result of the increased emphasis given to the use of risk assessment (CAC, 1999; ILSI Europe, 2007), data will become increasingly available from Microbiological Risk Assessments (Brown and Stringer, 2002; Campden BRI, 2007). These data may be useful in hazard analysis and in the validation of HACCP plans, in particular of critical limits. Until reliable data of this sort become available, HACCP team judgements will remain qualitative techniques as described above.

Identify appropriate control measures

The next action for the HACCP team is to decide what control measures can be used to control each hazard.

Table 2: Categorization of control measures.

Control measure	Description
Prerequisite programmes (PRPs)	Activities associated with the process, which manage the basic environment and operating conditions of the facilities and process operation, i.e. hazards that are 'generic' (not specific to a particular process step). The consequence of a momentary failure could result in a low-risk food safety problem or quality defect. Alternatively referred to as Good Manufacturing Practice (GMP), Good Hygiene Practice (GHP) etc.
Operational PRPs	Activities that are associated with a typical specific process step and which manage specific significant hazards identified during hazard analysis, but not otherwise managed by critical control points. Regular checking of the effectiveness of operational PRP will be required. A loss of control would result in a low-risk food safety issue but timely correction of the problem must be taken. There must also be an evaluation of the impact of this loss of control on food safety.
Control measures applied at CCPs	Actions associated with the product at a particular process step, and are specifically applied to prevent or eliminate a significant hazard or reduce the hazard to an acceptable level. Continuous or 'realtime' monitoring of the effectiveness of the control will be required. Loss of control is likely to result in a high-risk food safety issue and will need immediate corrective action.

Control measures are those actions and/or activities that are required to prevent, eliminate or reduce the occurrence of hazards to acceptable levels (see Stage 13: Validation). Unfortunately, many teams confuse control with monitoring; monitoring is performed to check that the control measure is working effectively (Campden BRI, 2009).

***Principle 2*: Determine CCPs (*Stage 9*)**

CCPs are those process steps where it is significant to prevent or eliminate food safety hazards or reduce them to acceptable levels (Campden BRI, 2009). Using professional knowledge,

judgement and experience, measured with a good dose of common sense, the HACCP team should:

- Determine the CCPs;
- Consider the role of PRPs;
- Use a decision tree as tool if helpful; and
- Record the justification for all CCPs.

The correct determination of CCPs is vital to ensure that there is effective management of food safety; this is obtained through focusing the resources (e.g. monitoring and verification activities) at the CCPs. When considering where the CCPs are in a process, the HACCP team must avoid the trap 'we test for it therefore it must be a CCP' or the more serious reverse situation 'we do not test for it therefore it is not a CCP'.

The identification of a CCP in a HACCP study needs a logical approach, hence the use of a decision tree is recommended (Bratt, 2010). The Codex decision tree is widely used (CAC, 2009); however, a number of decision trees have been developed, primarily with the aim of making the sequence of questions more user friendly.

Records of the use of the decision tree and a copy of the actual tree used should be maintained; these will be important evidence to show during audits. In addition to identifying CCPs, food operations working to the requirements of ISO 22000 will need to determine if hazards will be controlled by standard PRPs or operational prerequisites.

Following a careful review of hazards and effectiveness of PRPs, some canneries have focused their CCPs on those specifically managing microbiological food-poisoning hazards (i.e. can seaming, sterilization and water cooling/can drying). This is clearly shown in the 2008 Salmon Control Plan, a voluntary cooperative agreement between the Packers and the Seafood Products Association (2008); agreed that there are three CCPs as declared below:

- Can seaming;
- Thermal Processing; and
- Water cooling of cans in the retort.

***Principle 3*: Establish critical limits for each CCP (*Stage 8*)**

After determining all the CCPs for the product/process under study, the team should then go ahead to:

- Determine the critical limits for the control measure(s) at each CCP;
- Ensure that they are measurable or observable in 'real time';
- Ensure that the critical limit is for the control and not the hazard;
- Where relevant, state any action limits, target values and tolerances; and
- Ensure that there is documented evidence that the critical limits have been validated.

The critical limit (or 'bottom line' for safety) is the value which separates a safe product from a Details of how the critical limit was determined should be recorded; this should include sources of information or the actual data used. The stated critical limits will need to be validated to provide evidence that they are appropriate to control the specific hazard. A common mistake made by HACCP teams is to try and set the critical limit on the hazard and not the control measure (e.g. no broken glass in the product or numbers of food-poisoning bacteria/g). It is usually impossible to monitor such 'limits' or measure them in real time. It can also be appropriate to set operational limits for PRPs, in particular for the operational prerequisites.

***Principle 4*: Establish a monitoring system for each CCP (*Stage 11*)**

Selecting the correct monitoring system is an essential part of any HACCP study. The monitoring system describes the methods by which the company is able to confirm that all

CCPs are operating within the defined critical limit (i.e. that they are 'in control') and it also produces an accurate record of performance for future use in verification. The monitoring system must be able to detect loss of control at the CCP. Ideally the monitoring method should be rapid enough to provide information in time for corrective action to be taken to enable control of the CCP to be regained. Monitoring systems may be either online, e.g. time and temperature measurements, or offline, e.g. measurement of salt, pH, Aw, total solids, and can seam dimensions.

Microbiological testing methods are seldom suitable for monitoring CCPs, because of the time delays involved and the additional difficulty of having to interpret the results in the light of the known (or unknown) distribution of the organisms in the product. In some circumstances, rapid microbiological testing methods may be suitable for monitoring purposes, although the majority of microbiological testing activities have a vital role to play in verification.

Monitoring systems may be continuous (e.g. recording continuous process temperatures on a thermograph for a retort) or discontinuous (e.g. visual can seam inspection every 30 minutes or fish sample collection and analysis). Continuous systems provide a dynamic picture of performance, whilst with discontinuous systems, it must be ensured that the discrete sample monitored is representative of the bulk product.

Ideally, an online continuous monitoring system should be chosen that responds dynamically to situations where the specified tolerance has been exceeded. In reality, the choice of monitoring systems available for a particular CCP may often be quite limited.

The HACCP team should ensure that the monitoring system includes the following:

- The responsibility for monitoring must be clearly stated – WHO is to act?
- WHAT are they to measure and HOW are they to act?

- All personnel performing monitoring must be trained and competent.
- WHEN are they to act? The frequency of monitoring must be stated and be appropriate.
- Clear work instructions or procedures may be required.
- Accurate records of the results of monitoring must be maintained.
- Monitoring records need to be reviewed.

All records and documents associated with monitoring CCPs should be signed by the person doing the monitoring and by a responsible designated person who reviews the stated results. All monitoring records must be accurate and include the date, time and the actual result of the monitoring activity carried out. Computer records, as well as paper records, may be used for monitoring (Bratt, 2010).

***Principle 5*: Having a corrective action plan in place (*Stage 12*)**

The HACCP team should specify the actions to be taken when first of all, the results of monitoring at a CCP show that there has been a failure to meet the critical limit (deviation) or secondly, when there is a trend towards loss of control. In the second instance, action may be taken to bring the process back into control before a deviation occurs. All corrective actions should be realistic and doable:

- Consider immediate actions to regain (maintain) control – 'the now' or 'present' actions;
- State what is to happen to product produced since the last good check – 'past' product actions;
- Investigate the cause of the deviation and take preventative action – 'future' actions;
- Assign clear responsibilities for these actions, personnel must be trained and competent;

- The relevant personnel should have the authority to take the stated corrective actions; and
- All corrective actions must be recorded.

Present: Prompt actions are required to regain control (e.g. stopping a process, diverting to a holding stage and increasing a process temperature). Past: An action must be taken about the product that has been produced during the time period that the CCP was 'out of control' (i.e. since the last good check). Suspect product should be identified (an effective traceability system will be required) and would normally be put on hold following company quarantine procedures. Authorized personnel must decide what happens to this product. Typically, there are only two options:

- If possible, product could be reworked to make it safe; and
- If rework is not possible then the product must be destroyed.

Future: The cause of the deviation should be investigated and appropriate and timely remedial action taken. It is important to prevent the same issue occurring in the future. The company should confirm that appropriate remedial actions have been taken and have been effective. These remedial actions are additional to those needed to regain immediate control. Both corrective actions and destruction/rework actions should be documented, and accurate records maintained. These records are important as they provide evidence that potentially unsafe food did not reach the consumer. Remedial actions for PRPs: PRPs have to be checked to ensure that they are working effectively.

If they are found to be ineffective, remedial action has to be taken. This is similar to the way that monitoring and corrective actions are taken for CCPs. Consideration should therefore be given to the remedial action necessary should checking of the PRPs indicate a loss of control (i.e. whether the PRP is being implemented effectively).

***Principle 6*: Verification (*Stage 13*)**

This stage comprises three distinct activities:

- Validation
- Verification
- Review

Validation

The principal goal of validation is to ensure that the hazard identified in the study is complete and correct, and that the selected control for the hazard is suitable, i.e. a hazard can be effectively managed if the stated measure is followed. The food operation must have evidence that the HACCP plan is scientifically/technically correct (valid). The validation should cover the overall HACCP plan and the specific CCPs, together with operational prerequisites and prerequisites, where it is relevant (CAC, 2008; ILSI Europe, 1999). It is the responsibility of the food business operators to validate their HACCP plans. A team may be required to perform the validation; this may consist of the HACCP study team plus additional internal or external specialists. It is useful to include personnel who were not directly involved in developing the HACCP plan; they will bring a 'fresh pair of eyes' and be better able to challenge the identified hazards and the stated measures to control these hazards (i.e. take on the role of 'devil's advocate' and challenge decisions made).

Testing may be performed at the controls to check their efficacy, both prior to implementation and periodically thereafter. Examples of validation activities in food canneries would include:

- Thermal evaluation trials;
- Temperature distribution trials;

- Challenge testing;
- Mathematical modelling; and
- Document review of the HACCP plan (i.e. desk-top activity).

Validation should include the formal sign-off of the HACCP plan by the person ultimately responsible for product safety management at the food operation. Where the validation shows the HACCP, plan is not capable of producing safe food, the plan must be amended and revalidated where necessary. Some validation will take place after implementation, for example as a result of review and maintenance activities of the HACCP plan (e.g. when a new significant hazard is identified, control measures are modified, or a new critical limit is set). Records of the validation activities must be maintained. They will form an important element of the evidence that will be subject to scrutiny during third party audits including official visits by public health personnel.

Verification

The HACCP team should put into place procedures that can be used to demonstrate compliance with the validated HACCP plan and to determine its effectiveness once in use. There are two main aspects of verification: firstly, demonstrating conformance (i.e. personnel are following the stated procedures/work instructions and that the HACCP plan has been correctly implemented), and secondly, gathering information that the HACCP system and prerequisites are effective in practice (i.e. safety requirements are being met). Verification needs to be an ongoing activity. Verification should examine the entire HACCP system including all CCPs and relevant records, and PRPs where appropriate. The HACCP team should specify the methods and frequency of verification activities in the HACCP plan. Examples of key verification activities include:

- First-party audits of CCPs and relevant PRPs (based on the actual practices at the CCPs and records of monitoring and corrective actions);
- External auditing programmes (supplier audits);
- Finished product and interim product testing (e.g. microbiological and chemical examinations of product samples);
- Outcomes or results of second-party and third-party audits;
- Analysis and trending of customer complaints;
- Sampling and testing of product already in the market place to look for unexpected safety problems (i.e. product buy-back);
- A review of deviations, corrective actions and resulting product disposal/rework; and
- Trending of monitoring results.

Records of verification activities must be maintained to provide evidence that the HACCP plan has been correctly implemented and that the controls are working effectively in practice.

Review

The HACCP team should perform a formal planned review of the entire HACCP system. The frequency of the review should be based on a number of factors, typically these will include the nature of the product, its intended use and the product sector involved (especially where rapid changes can occur). Typically, this formal review should be performed at least annually. These reviews should be performed by the HACCP team prior to the implementation of any changes that may affect product safety. The changes may be internally generated or may be due to some external factors. Examples of typical internal factors (not an exhaustive list):

- Change in raw material/ingredient/product formulation/packaging;

- Change in processing system (e.g. changes in method of preservation – such as addition of preservatives, water activity changes, going from a sterilization to a pasteurization activity);
- Changes in layout and environment of the factory;
- Modification to process equipment (e.g. new equipment, modification of existing equipment);
- Changes in cleaning and disinfection programme (i.e. a change to any supporting PRP);
- Failures in the system, e.g. corrective actions or the need for product recall/withdrawal;
- Changes in staff levels and/or responsibilities; and
- Receipt of information from the market place indicating a health risk associated with the product.

Examples of typical external factors (not an exhaustive list):

- Emergence of food-borne pathogens with public health significance;
- Changes in legislation, COPs, standards;
- New scientific/technical knowledge (e.g. new information on hazards and control measures);
- Unexpected use of product by the consumer; and
- Environmental changes/issues (i.e. local changes external to the food operation; climate changes).

It is recommended that the HACCP team detail the factors relevant to their operation in the HACCP plan. Data arising from HACCP reviews must be documented and form part of the HACCP recordkeeping system. It is essential that the records of review are accurate because

they provide the evidence that the HACCP plan is up-to-date. Any changes arising from an HACCP review must be fully incorporated into the HACCP plan and may need to be validated. This is because such changes may result in modification of CCP control measures and/or critical limits.

A system of management for the maintenance of the HACCP system is required, and its proper operation is essential.

***Principle 7*: Establish documentation and record keeping (*Stage 14*)**

Efficient and accurate record keeping is essential to the successful application of HACCP by a food operation. Documentation of HACCP procedures at all process steps should be assembled and included in a manual and/or integrated into a controlled Business Management System.

- The food operation must decide on the level and format of all documentation.
- An HACCP plan must be developed and maintained.
- Supporting documentation should also be in place and maintained.
- Records must be accurate and easily retrievable.
- Records must be retained for an appropriate period of time.

Examples of HACCP system documentation includes:

- The HACCP plan;
- List of hazards and details of the hazard analysis; and
- Supporting information:
- Standard operating procedures (SOPs/SSOPs), and
- Records, e.g. from monitoring and corrective action activities.

HACCP IMPLEMENTATION

Implementation is the process of making the HACCP plan 'live' within the food operation. Prior to implementation, it is necessary that the conclusions reached in the HACCP plan are validated, i.e. are the specified control measures capable of eliminating or controlling the identified hazards to an acceptable level? (Campden BRI, 2009).

The implementation process will need very careful planning, and some food operations have found it useful to appoint an implementation manager for this stage of HACCP. Some of the issues to consider for the effective implementation of an HACCP plan include:

- Clearly defined pathways and responsibilities for communication to keep all staff informed;
- Involvement of operational personnel in the development of procedures and records;
- Training: Ensuring the right type and level of training is given relevant to role;
- HACCP visibility within the production environment; and
- Verification of effective implementation as soon as the HACCP system is operating.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1. Introduction

This section discusses the research design, methodology and approach in developing a HACCP plan for 'canned palm cream concentrate' at Praise Export Services Limited (an

indigenous Ghanaian small and medium-sized enterprise). It includes the description of the company that was selected, prerequisite programmes in the factory prior to the design and implementation of the HACCP system.

3.2. Subject Selection and Description

Praise Export Services Limited is a wholly-owned Ghanaian SME engaged in food processing. It was incorporated in October 1994 as a private Limited Liability company. The company is a leading manufacturer and exporter of indigenous Ghanaian processed foods such as "Banku" mix, "Hausa Koko", "Tom Brown", "Kokoknte", Canned palm cream concentrate and Garden eggs to the African niche markets in the United Kingdom, US, Canada, Netherlands, Australia, Germany and Norway. In view of the changing food safety legislations in Europe and North America there is demand from both customers and regulatory agencies for all food imports to meet basic food safety standards. For example, the Food Safety Modernization Act, 2011 of the US, all food products exported to the US must be registered with the US FDA. All companies exporting food products into the US market are required to implement HARPC (Hazard Analysis and Risk-based Preventive Controls) within 3 years of coming into force of the FSMA (2011) in 2015 whilst companies producing low-acid canned foods including canned palm cream concentrate are also required to implement HACCP.

Praise Export Services Limited is the leading producer of canned palm cream concentrate in Ghana that receives technical support from Partners in Food Solutions, a US based non-profit organization.

The company presently has staff strength of one hundred and three (103), operating from its factory at Pokuase and exports about 50, 000 MT of canned palm cream concentrate to both the US and EU markets. There is therefore the need to develop a HACCP system for them to

implement so as to meet regulatory and export market requirements and also protect the jobs of its employees. Needless to say, that Praise Export Services Limited rakes in foreign exchange into the country which helps the government to balance its budget deficit through its exports. This research is hopeful that the development of generic HACCP system for Praise Export Services Limited can be replicated in other related enterprises to make them meet international market requirements.

3.3. Conducting and implementing the HACCP study

All the fourteen (14) stages including the seven (7) preparatory steps and the seven (7) principles of HACCP as recommended by Campden BRI (2009) were applied. Since none of the five major canned palm cream concentrate SMEs have implemented HACCP before, the researcher learned from experiences of the Ghanaian canned tuna industry which has implemented HACCP system since 2006 to come out with a generic HACCP plan for the canned palm cream concentrate industry using Praise Export Services Limited as a model.

Stage 1: Obtaining Management Commitment

The first step employed was to obtain senior management commitment especially the founder and Chief Executive Officer by asking them to appoint a HACCP team leader and subsequently issue each team member that will be selected by the team leader an appointment letter stating that they are required to give equal attention to HACCP activities like their normal responsibilities. Management was also assisted to develop the food safety and

management commitment policy statements. It was also agreed with management that the HACCP team as a minimum shall meet once in a quarter and that senior management shall also attend management review meetings to discuss issues bordering on food safety once a year.

Stage 2: Agreeing on the scope or terms of reference

The terms of reference were determined as follows:

1. Hazard types to be considered in the study
2. Process and product description
3. Where will the HACCP plan start from and where will it end
4. Which legislations in Ghana and country of final product destination are to be complied with regarding canned foods and HACCP
5. Which PRPs applicable to the industry are to be considered for implementation.

Stage 3: Selecting the HACCP team

The third step taken was to select the team members with recommendation from the HACCP team leader and approval from senior management who issued them with appointment letters.

The HACCP team was made up of 8 members:

1. The Quality Assurance Manager
2. The Head of Canning department
3. The HR Manager
4. The Compliance and Training Manager
5. The Operations Manager
6. Maintenance Technician

7. QA Inspector
8. Wet and Dry Products Team leader

After the selection, all the team members were given training on HACCP including PRPs and basic food microbiology by Partners in Food Solutions and certificates were issued to each participant.

Stage 4: Describing the product

The fourth step involved a comprehensive description of the final product, canned palm cream concentrate. In describing the final product, the product description form in table was used:

Table 3: Product Description Form Product

Please answer the following questions in describing the product
Description
1. Name of product?
2. Product Composition?
3. Nature of the product?
4. How the product is to be used?
5. Type of packaging and labeling?
6. Storage, transport and distribution condition?
7. Shelf-life of product?

Source: Motarjemi, (2013)

Stage 5: The intended use of the product

The fifth step was to provide information on the intended use of the canned palm cream concentrate. In furnishing the intended use of canned palm cream concentrate, the questionnaire in table 3 was used by the HACCP team;

Table 4: Intended use of Product Form

Please answer the following questions in developing product
1. What is the intended use of our product?
2. Who are the target consumers?
3. What preparation guidelines are required by the end user?
4. What is the potential for mishandling?

Source: Motarjemi, (2013)

3.3.1. Construction of Process Flow Diagram

The flow chart was constructed by the HACCP team. It covered all process steps in the operation from raw material reception to dispatch to customer. The flow diagram showed all interactions along the process in a linear order with CCPs, oPRPs and critical limits included in the steps where appropriate.

Stage 6: On-site confirmation of flow diagram

The HACCP team then took a walk through the process steps to verify the actual processing operation against the drafted flow chart during all stages and hours of production and made the necessary corrections where needed. The confirmed flow diagram and any amended versions were signed off and all changes recorded. The confirmed flow diagram is the visual schematic sketch of how the final product is attained as indicated in Fig. 8.

Stage 8: Conduct a Hazard Analysis (Principle 1)

The HACCP team listed all likely occurring hazards associated with each step or reasonably expected to occur at each step right from oil palm farms, storage, transport, receiving, processing to the point of dispatch to the customer. In doing so, much emphasis was laid on physical, biological and chemical hazards.

In order to achieve an efficient hazard analysis, the following were considered:

- All incoming materials; ingredients, primary packaging and secondary packaging items were reviewed to ascertain how they influence the process.
- Each step in the process flow diagram was looked at for existence or possible ingress of food safety hazards─ Microbiological, Chemical and Physical Hazards.

For food safety hazard identification, the following steps were taken:

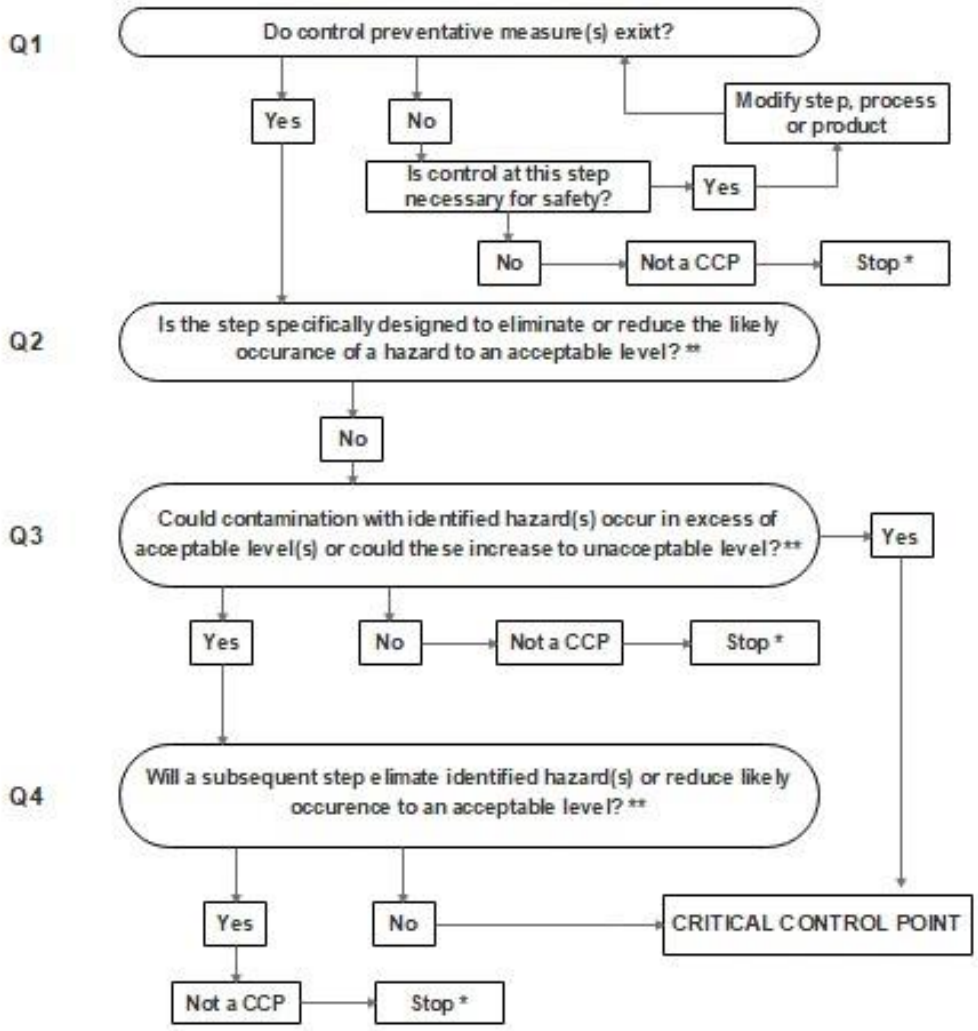
Observing manufacturing operations on the ground: each batch of production was observed from point of receipt of oil palm fruits to the point of dispatch to the market. The likely occurrence of the identified hazards and severity of their adverse health effect were evaluated using a quantitative scoring system approach adopted by Campden BRI (2009). Also, the

conditions leading to the introduction of the hazards were addressed and as a final step, a control measure was employed to eliminate or reduce its incidence.

Stage 9: Identifying the Critical Control Points (Principle 2)

The HACCP team identify points in the process steps where hazards could be avoided, eliminated or reduced to an acceptable level. The team applied the Codex decision tree as in Fig. 6 based on a modified version of the Codex decision tree approach in identifying the CCPs.

Figure 1: Codex CCP Decision Tree



Source: (CAC RCP, 2003)

Stage 10: Establish Critical Limits for each CCP (Principle 3)

After determining the CCPs for the product/process based on the process flow diagram, the team proceeded to determine the critical limits for each CCP.

Stage 11: Establishment of Monitoring Procedure for Each CCP (Principle 4)

Monitoring procedures were written to assess, measure and to determine whether a CCP was under control to provide an accurate record for future use and verification (Table 5). The monitoring served the function of warning if trends are deviating from required results to provoke correction to bring the critical control point under control. Trained line QA Inspectors were detailed to periodically take records to influence online adjustment.

Table 5: Critical Limit Monitoring Form

CCP	Critical Limit	Monitoring Procedure What/How/When/Who	Corrective Action
Date:			Approved by:

Stage 12: Establishment of Corrective Actions (Principle 5)

Corrective Action is the action taken when a deviation occurs or a product fails to meet the requirements. The HACCP documented a procedure or plan to address potential deviations from established critical limits when they occur in advance. In considering the corrective action for CCPs the 4 steps below were considered:

1. Determining the disposition of non-conforming products (NCP)
2. Correcting the cause of the NCP to avert a reoccurrence
3. Demonstrating that the CCP is once again under control. Thus, results from employed corrective action confirm that product is within the critical limit.
4. Maintaining the records of the corrective action as evidence of an activity taking place.

Stage 13: Establishment of Verification Procedure (Principle 6)

The HACCP team designed verification procedures. The verification was to confirm if the HACCP system is working correctly by using audit method, sampling methods and laboratory test. The following records and documents designed by the HACCP team in the implementation process were reviewed periodically:

1. HACCP plan and its records
2. Deviations and product depositions
3. Confirmation that CCPs are kept under control

Stage 14: Establishment of Documentation and Record Keeping (Principle 7)

Efficient and accurate record keeping is essential to the application of a HACCP system. All the HACCP procedures and records designed were documented and maintained by the HACCP team to serve as guiding materials to verify whether the HACCP controls are in place. The following documents and records were established during the HACCP implementation process:

1. Prerequisite programs (PRPs)
2. Product Description and Intended use
3. List of incoming ingredients
4. Process flow diagram
5. Hazard Analysis Worksheet
6. CCP Determination Worksheet Using Codex Decision Tree
7. HACCP plan

CHAPTER FOUR

4.0 PRESENTATION OF RESULTS

4.1. Management Commitment

The following two management commitment programmes were developed, implemented and communicated to all staff and other stakeholders of the company. These policy documents are evidence or indication of senior management commitment to the implementation of the HACCP system in the company. The two signed policy documents are the Company management commitment policy and the food safety and quality policy. These are shown in APPENDIX 1 and 2 respectively.

4.2. Scope or Terms of Reference of The HACCP Study

4.2.1 HACCP Terms of Reference

The HACCP team agreed on the following scope of term of reference for the study:

- This HACCP document covers Hazard Analysis Critical Control Points for **canned palm cream concentrate**
- The HACCP plan covers physical, **biological and chemical** hazards including allergens.
- It also covers all steps and processes involved in our production chain from **raw material reception** to product dispatch and do not include distribution, retail and consumer handling at the receiving end.

4.2.2 Legislation governing the HACCP study

This HACCP study is based upon the principles and guidelines contained in:

- Codex Alimentarius Commission 1993
- National Advisory Committee on Microbiological Criteria for Foods (NACMCF 1992)
- Guidelines for the Safe Production of Heat Preserved Foods, UK Department of Health, 1994.
- 21 CFR 113 – Thermally Processed Low-Acid Foods Packaged in Hermetically Sealed Containers, US Food and Drugs Agency.
- EC Regulation 852/2004 on the hygiene of foodstuffs
- 2001/13/EC Labeling Directive.
- Directive 2003/89/EC amending Directive 2001/13/EC amending Directive 2000/13/EC as regards indication of the ingredients present in foodstuffs.
- Directive 2005/26/EC establishing a list of food ingredients or substances provisionally excluded from annex III a of Directive 2000/13/EC.
- EU 2073/2005 the criteria for microbiological testing.
- EU 1829/2003, 1830/2003 GMO control.

The company is also concerned that products manufactured should give rise to no microbiologically generated risks to the consumer. The two relevant areas of microbiological concern in the manufacture of canned products are recognized as follows:

Botulism: Canned foods are heat processed to a condition of commercial sterility. Under such condition the food is rendered free of viable microorganisms, including those of known public health significance, capable of growing in the food at the temperatures at which the food is likely to be held during distribution and storage. In practical terms it is necessary to ensure the destruction of the spore of the most heat resistant pathogen, *Clostridium botulinum*. This organism during metabolism produces a neurotoxin which if ingested may cause severe

paralysis or death. The measure of sterilization of low acid foods (pH>4.5) is provided by a parameter of microbial destruction known as the Fo number. By common agreement it is recognized that in order to reliably destroy the spores of *Clostridium botulinum* the Fo value provided by the sterilizing process should be ≥ 3. All sterilizing processes scheduled at the company will provide Fo ≥ 6.

Post-Process Infection: Cans are closed with a mechanical double seam. If the seam is poorly formed or if the can is subject to improper handling immediately after sterilization it may be susceptible to microbial leaker infection. The infecting organism, depending on type, may simply cause non-toxic spoilage or may be capable of causing food poisoning or even death. The company employs proper procedures, and suitably trained staff to ensure that seams are formed correctly and subsequent procedures to minimize any risk of post process infection. The cooling water in contact with the cans is treated to contain free residual chlorine at the end of the cooling process and the level of chlorine is monitored for each retort batch. After cooling, cans are held in a clean restricted area until cool and dry, before progressing to the labeling and casing area. Seals of powdered products are equally monitored for effective seals against post process contamination or infections.

4.2.3. Prerequisite Programmes

Pre-requisite programmes are those generic, non-products specific, measures that provide a suitable manufacturing environment for the production of safe products. The company has documented and implemented the following prerequisite programmes and monitoring is an ongoing activity in the company:

✦ Cleaning and sanitation ✦ Pest control program ✦ Preventive Maintenance of machinery ✦ Maintenance of factory structures ✦ Personnel hygiene regulations ✦ Water quality monitoring ✦ Calibration and equipment testing ✦ Material Identification and Product traceability ✦ Product Withdrawal and Recall procedure ✦ Protective clothing ✦ Approved Suppliers ✦ Glass and hard plastic control ✦ Transportation system ✦ Complaints management procedure ✦ Storage of chemicals

✦ Personnel Medical Screening

✦ Training of personnel.

✦ Allergen Control

The Pre-Requisite Programs above considered for the company by the HACCP team are shown with details in Table 8.

4.3. HACCP TEAM

The HACCP team was formed based on experiences and area of expertise of each staff in the food processing facility and all members were trained on the application of the principles of HACCP. Refer to APPENDIX 4, for the certificates of participation given to HACCP team members as evidence that they have been trained.

The table below gives the full composition of positions, experiences and function of the HACCP Team.

Table 6: Composition of HACCP Team

Title/Position	Qualification	Experience	Responsibility/Function
Quality Assurance Manager	(BSc. Environmental Science/Intermediate HACCP Certificate)	6 years QA in the food canning industry	(HACCP Team Leader)
Compliance/Training Manager	(PG Certificate in strategic management) Intermediate HACCP Certificate	15 years Production and Regulatory compliance in the food canning industry	(HACCP team member for Training)

Operations Manager	(BSc. Agric. Engineering) Intermediate HACCP Certificate	20 years manufacturing and engineering experience	(Chairman for HACCP approval)
HR/ LOGISTICS Manager	(B.M.S) Intermediate HACCP Certificate	20 years HR and Logistics management in the food canning industry	(HACCP team member)
Head of Canning	(MSc in Food Technology) Intermediate HACCP Certificate	25 years food canning operations	(HACCP team member)
Q.A Assistant	(SSCE) Intermediate HACCP Certificate	4 years QA inspection experience	(HACCP team member)
Wet & Dry Team Leader	(Engineering Practice Course) Intermediate HACCP Certificate	10 years food processing practitioner	(HACCP team member for Packaging)
Maintenance Technician	(SSCE) Intermediate HACCP Certificate	14 years maintenance practice in the food canning industry	(HACCP team member)

4.4 PRODUCT AND PROCESS DESCRIPTION

4.4.1. Product Description

Table 7: Product Description, Storage and Distribution

No.	**Product Name**	Canned palm cream concentrate
1.	**Source of palm fruits**	Contracted farmers at Asuom, Apegusu Farms
2.	**Treatment**	Heat Sterilized
3.	**Ingredients**	Palm Fruits and Salt
4.	**Packaging**	Hermetically seamed metal cans (400g and 800g)
5.	**Physical and Chemical properties**	Paste in appearance with no chemical preservative

6.	**Target Shelf Life under prescribed storage and usage condition**	3years
7.	**Where the product will be sold**	For retail or catering use in the international markets (Mall, super markets etc.)
8.	**Instruction for use**	After opening the can any unused contents should be placed in a covered food container, and refrigerated and used within 2 days.
9.	**Storage and Distribution condition**	Ambient storage in cool dry place Avoid rough handling and handle with care

4.4.2. Process Description

Summary of the manufacturing process flow of Palm Cream Concentrate

Canned Palm concentrate:

Reception of palm fruits is on daily basis. Salts, cans and other packaging materials are received and kept in stores.

The palm fruits are delivered in sack loads. Upon reception, the sacks are weighed and inspected for their quality. The sacks containing good quality fruits are sorted from the rotten fruits and foreign material and sent for washing.

After washing, the fruits are loaded into cooking jackets and cooked at a temperature of 100˚C. The cooked fruits are de-pulped into a paste containing cream, fiber and kernels. The paste containing cream and fiber is strained to remove the fiber to obtain cream. The fine cream collected is blended with 0.5% salt and heated to a temperature ≥ 70˚C.

Cans are washed with hot water at temperature ≥ 70 ˚C, before filling them with hot cream. The filled cans are seamed and washed with soap water to get rid of stains of cream. Prior to seaming, sample cans are seamed and each seamer head is identified and marked for seam tear down to ensure seam parameters are within specified limits to achieve hermetic seams.

Hence, the seaming stage is a CCP. The seamed cans are loaded into metal basket for retorting. The loaded basket is lifted and lowered into the vertical retort using a hoist.

Retorting is done by introduction of direct steam at Pressure = 1bar, with the drain pipe and vents fully opened. The drain pipe is closed at temperature = 100 ˚C whilst the vent is closed at temperature = 110 ˚C. the time and temperature at which the drain and vents are recorded.

The retort process starts when the temperature reaches 121 ˚C and the time is recorded. The process duration is 60 minutes, but when there is temperature deviation due to low steam pressure, the time is extended. At the end of the retort process the steam valve is closed. The drain and vent are opened. Retorting stage is also a CCP.

Cooling of retorted products is done by introducing chlorinated water with concentration of 3ppm into the retort to submerge the cans. The cooling process is the final CCP identified. The cooling water is held in the retort to allow efficient heat transfer to occur. The drain is opened to let out the waste water. The cooling process is repeated until the temperature of the canned products reaches ≤ 40 ˚C. At the end of cooling, concentration of chlorine in waste water should be ≥ 0.5ppm. After cooling, the products are packed into the incubation room

for 7 days. At the end of incubation period they are examined for bloating, leakages and dents. Such defective cans are isolated from the lots. The non- defects are kept in the finished goods warehouse and released to labelling and casing department for labelling and casing according to customer requests.

4.4.3. Intended Use of the Product

The consumer target of the Canned Palm Cream Concentrate is the general public and its intended use is for the preparation of Palm Soup.

4.5. PROCESS FLOW DIAGRAM

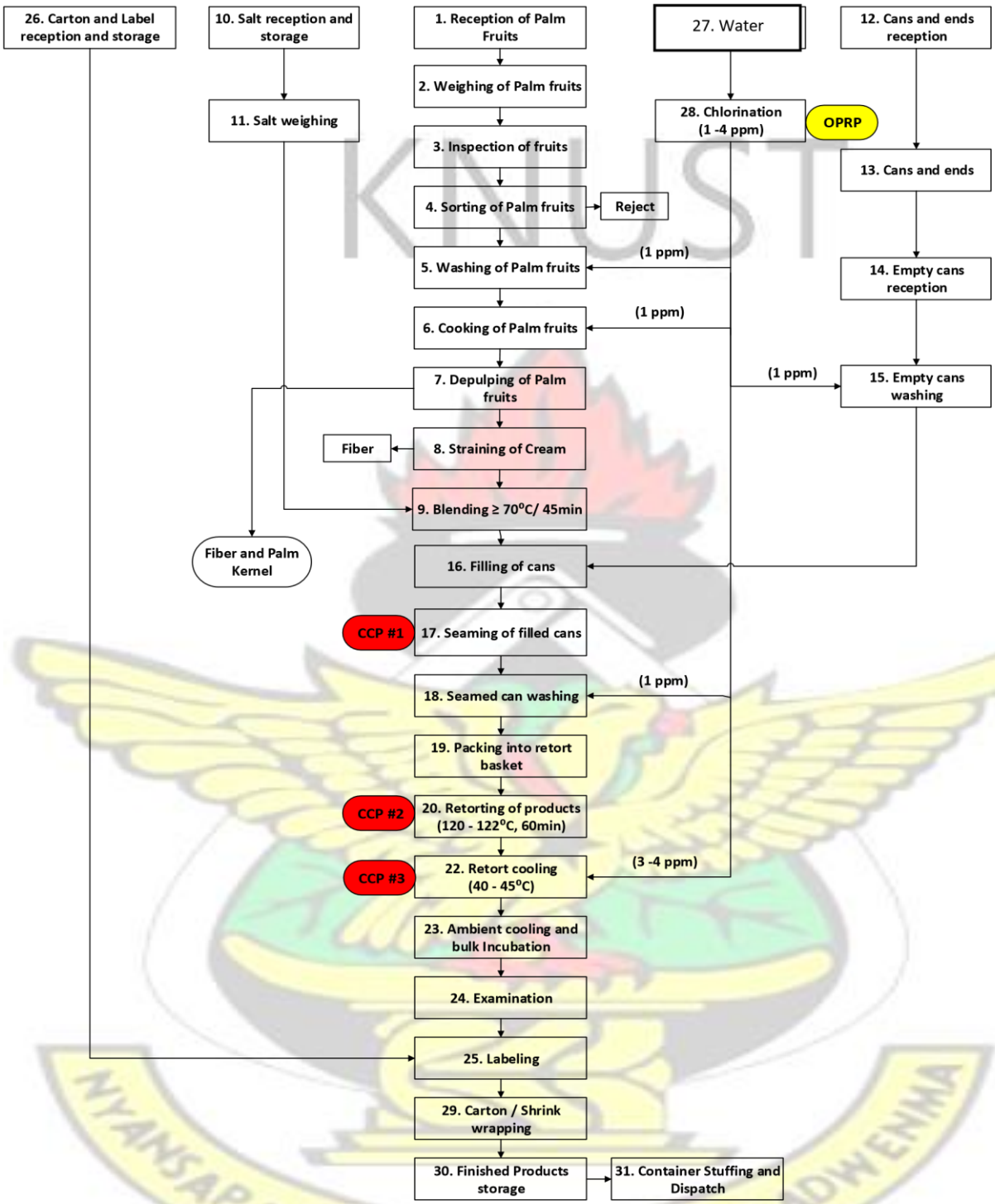


Figure 7: Process Flow Diagram for Palm Cream Concentrate

4.5.1. Confirmation of Process Flow Diagram

The above process flow diagram is the confirmed one.

Table 8a: Prerequisite Programs for Palm Cream Concentrate canning

PREREQUISITE	CONTROL MEASURE	MONITORING			CORRECTIVE ACTION
		FREQUENCY	DOCUMENT	RESPONSIBILITY	
Cleaning and Sanitation	Cleaning and Sanitation schedule	Daily	Cleaning Checklist Worksheet	Quality Assurance Inspector	Re-clean
Pest Control program	Fumigation, installation of electric fly killer (EFK) at factory entry points and rodent bait boxes against walls of factory	Quarterly fumigation plus weekly inspection of EFK and rodent bait boxes	Fumigation certificate and pest management records	Quality Assurance Supervisor	Investigate errors and review frequency of fumigation
Preventive Maintenance of machinery	Follow maintenance schedule	Daily	Maintenance records	Maintenance manager	Investigate root cause of breakdown of machinery and review maintenance schedule
Maintenance of Factory Structures	Factory condition audits or checks	Monthly	Monthly factory audit report	Maintenance manager	Immediate Repair of areas of non-compliance as indicated on the monthly factory audit report

Table

Personal Hygiene	Hygiene Policy: all employees and visitors must observe requirement for personal hygiene regarding personal protective equipment and handwashing protocol	Ongoing	Daily personal hygiene checklist	Quality Assurance Supervisor	Punitive measures for staff who do not comply with Hygiene policy.

8b: Prerequisite Programs Palm Cream Concentrate processing

PREREQUISITE	CONTROL MEASURE	MONITORING			CORRECTIVE ACTION
		FREQUENCY	DOCUMENT	RESPONSIBILITY	
Water Quality monitoring	Microbiological and physico-chemical analysis	Annually	Laboratory report	Quality Assurance Supervisor	Treat water with chlorine
Calibration and equipment Testing	Calibration of Weighing scale, Retort and seamer	Annually	Certificate of calibration traceable to GSA	Quality Assurance Manager	Remove from use and arrange for repair or replacement
Material Identification and Product Traceability	All raw materials, work in progress and finished products are batch coded to aid product withdrawal and recall when necessary	Annually	Traceability Record	Quality Assurance Supervisor	Investigate Errors and omissions

Table

Product Withdrawal and Recall procedure	Withdrawal and recall procedures should be adhered to strictly	Annually	Product withdrawal and recall procedure records	Quality Assurance Manager	Investigate errors and review procedures

8c: Prerequisite Programs for Palm Cream Concentrate Canning

PREREQUISITE	CONTROL MEASURE	MONITORING			CORRECTIVE ACTION
		FREQUENCY	DOCUMENT	RESPONSIBILITY	
Approved Suppliers	Company has procedure for approval and monitoring of supplier performance including product safety information. Purchases of raw materials and packaging are made from suppliers on the company approval list	Quarterly audit of suppliers	Questionnaire	Quality Assurance Manager	Reject or treat as a nonconforming product. Change suppliers
Glass and hard plastic control	Glass and hard plastic material procedure	Monthly	Glass and hard plastic audit records	Quality Assurance Supervisor	Investigate error and review frequency
Transportation system	All trucks used for conveying raw materials must be an enclosed one and must be in good repair	Each Batch	Incoming raw material inspection record	Quality Assurance Supervisor	Return Load
Complaints Procedure	All complaints must be reported and investigated and communicated to affected customers/consumers promptly	Each time a complaint is reported	Customer complaint log book	QA Manager	Review manufacturing procedures, retrain staff and increase monitoring

Table

Protective Clothing	Protective clothing should be clean, neat and sterile give the best protection to workers	Daily	Hygiene checks records	Quality Assurance Supervisor	Review laundry procedures. Discard inappropriate/damaged PPE's and replace

8d: Prerequisite Programs for Palm Cream Concentrate Canning

PREREQUISITE	CONTROL MEASURE	MONITORING			CORRECTIVE ACTION
		FREQUENCY	DOCUMENT	RESPONSIBILITY	
Personnel Medical Screening programmes	Medical screening for all staff prior to start of work and renewal annually	Annually	Staff Medical reports file	HR Manager and Quality Assurance Supervisor	Staff without medical screening should not be allowed to start work
Storage of Chemicals	All chemicals to be stored in a chemical room based on storage conditions on MSDS under lock and controlled by a responsible Supervisor	Daily	Chemical usage request records	Sanitation Supervisor	Review chemical usage, control and issuance procedures

Table

Training of Personnel	All employees receive training in personal hygiene and cleaning procedures before commencing work. All staffs in contact with food receives food safety training to starting work. HACCP team members receive training in principles of HACCP	Annually	Slides of Training courses and Training records Training certificates	HR Manager and Quality Assurance Supervisor	Refresher training as identified on review or change of documents
Allergen Control	Use of allergen management procedures and cleaning protocols	Daily	Allergen notices, warnings and washdown procedures	Quality Assurance Supervisor	Review of procedures and retraining of staff

4.6. Hazard Analysis and Risk Assessment Worksheet

Table 9a: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

PROCESS STEP	POTENTIAL HAZARD	HAZARD ASSESSMENT AND EVALUATION				JSUTIFICATION FOR INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	WHAT PREVENTIVE MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
		LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)				
1. RECEPTION OF OIL PALM FRUIT	**Biological:** Presence of *E. coli*, *Staphylococcus aureus* & *Fecal coliforms* in palm fruits from source and cross-contamination from hands of personnel	3	1	3	No	Not reasonably likely to occur	Best hygiene and manufacturing practices	QA Inspector	Oil Palm fruits reception and Hygiene records
	Chemical: Contamination with diesel from vehicle	1	3	3	No	Not reasonably likely to occur	Best transport maintenance practices	QA Inspector	Palm fruits reception forms
	Physical: Presence of stones, metal pieces, glass, plastic fragments, sticks and dead insects in palm fruits	3	1	3	No	Not reasonably likely to occur	Best manufacturing practices	QA Inspector	Palm fruits reception forms
2. WEIGHING OF OIL PALM FRUITS	**Biological:** Presence of E. coli *Staphylococcus aureus* & *Fecal coliforms* in palm fruits from source and cross-contamination from hands of personnel	3	1	3	No	Not reasonably likely to occur	Best hygiene practices	QA Inspector	Hygiene records
	Chemical: No known source of chemical contaminant	N/A	N/A	N/A	N/A	N/A	N/A		
	Physical: Presence of stones, metal pieces, glass, plastic fragments, sticks and dead insects in palm fruits	3	1	3	No	Not reasonably likely to occur	Best manufacturing practices	QA Inspector	Weighing records
3. INSPECTION OF OIL PALM FRUITS	**Biological:** Introduction of E. coli from hands of personnel	3	1	3	No	Not reasonably likely to occur	Best hygiene practices	QA Inspector	Oil palm fruits reception records
	Chemical: No known source of chemical contaminant	N/A	N/A	N/A	N/A				

	Physical: Presence of stones, metal pieces, glass, plastic fragments, sticks and dead insects in palm fruits	3	1	3	No	Not reasonably likely to occur	Best hygiene practices	QA Inspector	Oil palm reception records

Table 9b: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

PROCESS STEP	POTENTIAL HAZARD	HAZARD ASSESSMENT AND EVALUATION				JSUTIFICATION FOR INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	WHAT PREVENTIVE MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
		LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)				
4. SORTING OF OIL PALM FRUITS	**Biological:** Introduction of *E. coli and Salmonella sp*. from hands of personnel	3	1	3	No	Unhygienic personnel practices could lead to cross contamination	Good manufacturing practices and best personnel hygiene practices	QA Inspector	Sorting records
	Chemical: No known source of chemical contaminant	N/A	N/A	N/A	N/A	N/A	N/A		
	Physical: Presence of stones, metal pieces, glass, plastic fragments, sticks and dead insects in palm fruits	3	1	3	No	Not reasonably likely to occur	Good manufacturing practices	QA Inspector	Sorting records
5. WASHING OF OIL PALM FRUITS	**Biological:** Introduction and cross-contamination of *E. coli*, *Staphylococcus aureus* & *Fecal coliforms* from hands of personnel and Presence of *Fecal coliforms* in water	2	2	4	No	Unhygienic personnel practices could lead to cross contamination but unlikely to occur	Good manufacturing practices and best personnel hygiene practices	QA Inspector	Washing inspection records
	Chemical: Excess chlorine in washing water	1	3	3	No	Not reasonably likely to occur	Residual chlorine checks	QA Inspector	Chlorination report
	Physical: Presence of stones, metal pieces, glass, plastic fragments, sticks and dead insects in palm fruits	1	3	3	No	Not reasonably likely to occur	Best manufacturing practices	QA Inspector	Cleaning and sanitation records

6. COOKING OF PALM FRUITS	**Biological:** Introduction of microorganisms through water	1	3	3	No	Not reasonably likely to occur	Good manufacturing and best portable water treatment	QA Inspector	Chlorination report
	Chemical: Introduction of excess chlorine	1	3	3	No	Not reasonably likely to occur	Residual chlorine checks	QA Inspector	Chlorination report
	Physical: Introduction of metal chippings from parts of the cooking jacket/machinery	1	3	3	No	Not reasonably likely to occur	Best maintenance practices	QA Inspector	Maintenance records

Table 9c: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

PROCESS STEP	POTENTIAL HAZARD	HAZARD ASSESSMENT AND EVALUATION				JSUTIFICATION FOR INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	WHAT PREVENTIVE MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
		LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)				
7. DEPULPING OF OIL PALM FRUITS	**Biological:** Introduction of *E. coli* and *Salmonella sp.* from hands of personnel and machine	2	2	4	No	Not reasonably likely to occur	Good manufacturing practices and best personnel hygiene practices	Factory technician	Hygiene records and Maintenance records
	Chemical: Introduction of grease from machine parts	1	3	3	No	Not reasonably likely to occur	Use of food grade lubricants	Factory technician	MSDS data sheet
	Physical: Introduction of machine parts into the products	1	3	3	No	Not reasonably likely to occur	Best maintenance practices	Factory technician	Maintenance records
8. STRAINING OF PALM CREAM	**Biological:** Introduction of *fecal coliforms* from personnel and straining machine	2	1	2	No	Unhygienic personnel practices and machines could lead to cross contamination but unlikely to occur	Good manufacturing practices and best personnel hygiene practices	Factory technician	Hygiene records
	Chemical: Introduction of grease	1	3	3	No	Not reasonably likely to occur	Best maintenance Practices	Factory technician	Maintenance records
	Physical: Introduction of machine parts from the cooking jacket into the product	1	3	3	No	Not reasonably likely to occur	Best manufacturing practices	Factory technician	Maintenance records

9. BLENDING OF CREAM ≥ 70°C/45 min	**Biological:** Introduction of *Listeria monocytogenes, E. coli, Staphylococcus aureus and Salmonella sp*. from personnel and blending equipment	2	1	2	No	Not reasonably likely to occur	Best manufacturing practices	QA Inspector	Hygiene records
	Chemical: No known source of chemical contaminant	N/A	N/A	N/A	N/A	N/A	N/A		
	Physical: Introduction of metal chippings from equipment	1	3	3	No	Not reasonably likely to occur	Best manufacturing practices	QA Inspector	Hygiene records

Table 9d: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

PROCESS STEP	POTENTIAL HAZARD	HAZARD ASSESSMENT AND EVALUATION				JSUTIFICATION FOR INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	WHAT PREVENTIVE MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
		LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)				
10. CANS AND ENDS RECEPTION AND WASHING	**Biological:** Introduction of *E. coli* and *Salmonella* sp. from hands of personnel and can manufacturing process of supplier	2	1	2	No	Unhygienic personnel practices and machines could lead to cross contamination but unlikely to occur	Good manufacturing practices and best personnel hygiene practices	QA Inspector	Approved Supplier List Hygiene records
	Chemical: Contamination from lubricants	1	3	3	No	Not reasonably likely to occur	Use of food grade lubricants on process equipment. Preventive Maintenance records	QA Inspector	MSDS Data on lubricants
	Physical: Introduction of metal chippings from equipment	1	3	3	No	Not reasonably likely to occur	MSDS of lubricants used on process equipment. Preventive Maintenance records	QA Inspector	Maintenance records

11. FILLING OF CANS WITH PALM CREAM	**Biological:** Introduction of *Listeria monocytogenes, E. coli, Staphylococcus aureus and Salmonella sp*. From ladles used to fetch cream	2	1	2	No	The presence of the identified hazard could lead to food-borne diseases resulting in death but unlikely to occur	Good manufacturing practices, best cleaning practices and best personnel hygiene practices	QA Inspector	Hygiene records
	Chemical: No known source of chemical contaminant	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Physical: Introduction of metal pieces	1	2	2	No	Not reasonably likely to occur	Ensure adherence to PRP for Cleaning and Sanitizing	QA Inspector	Hygiene records

Table 9e: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

PROCESS STEP	POTENTIAL HAZARD	HAZARD ASSESSMENT AND EVALUATION				JSUTIFICATION FOR INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	WHAT PREVENTIVE MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
		LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)				
12. SEAMING OF FILLED CANS	**Biological:** Microbial infection of *C. botulinum, Staphylococcus aureus and E. coli* due to poor double seams	2	3	6	Yes	Improper seam formation can facilitate contamination with microorganisms. The presence of the identified hazard could lead to food borne disease resulting in death	Strict adherence to seam specification, Visual seam defect inspection	QA Supervisor and Seamer Mechanic	Double seam evaluation records
	Chemical: Introduction of grease into products	1	3	3	No	Not reasonably likely to occur	Use of food grade lubricants Preventive Maintenance Program	Seamer mechanic	MSDS Data Maintenance records

	Physical: Introduction of metals chippings from seamer machine	1	2	2	No	Not reasonably likely to occur	Preventive Maintenance Program	Seamer mechanic	Maintenance records
13. SEAMED CAN WASHING	**Biological:** N/A	N/A	N/A	N/A	N/A	N/A	N/A		
	Chemical: Introduction of detergent residues	1	3	3	No	Not reasonably likely to occur	Use treated potable water	QA Inspector	Chlorination report
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A		
14. PACKING INTO RETORT BASKET	**Biological:** N/A								
	Chemical: N/A								
	Physical: N/A								

Table 9f: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

PROCESS STEP	POTENTIAL HAZARD	HAZARD ASSESSMENT AND EVALUATION				JSUTIFICATION FOR INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	WHAT PREVENTIVE MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
		LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)				

15. RETORTING OF SEAMED PRODUCTS	**Biological:** Microbial Survival of *C. botulinum* due to operator error, under sterilization resulting in insufficient lethality and process survival of *C. botulinum* due to faulty instrumentation	2	3	6	Yes	Improper thermal process may result in survival of *Clostridium botulinum*	Strict adherence to scheduled thermal process, Calibration of measuring instruments and Preventive Maintenance Program Training of personnel	Retort Supervisor and QA Supervisor	Thermal process records Calibration records Maintenance records Training records
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A		
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A		
16. RETORTED CANNED PRODUCTS COOLING	**Biological:** Post-process contamination of *Clostridium botulinum, Staphylococcus aureus* & *Listeria monocytogenes* from cooling water	2	3	6	Yes	Ineffective chlorine treatment of cooling water could introduce pathogens (*Clostridium botulinum, Staphylococcus aureus and Listeria monocytogenesis* into the cooling water to cause post-process infection of canned products	Chlorination of cooling water to 34ppm residual chlorine	QA Inspector	Chlorination report
	Chemical: Excess chlorine in cooling water	1	3	3	No	Not reasonably likely to occur	Best water treatment practices	QA Inspector	Chlorination report
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A		

Table 9g: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

		HAZARD ASSESSMENT AND EVALUATION		JSUTIFICATION FOR	WHAT PREVENTIVE		

PROCESS STEP	POTENTIAL HAZARD	LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)	INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
17. AMBIENT COOLING AND BULK INCUBATION	**Biological:** Crosscontamination of cans with *Fecal coliforms* and *Listeria monocytogenes* from personnel touching hot and wet cans because of strict compliance with GMP's	2	2	4	No	Not reasonably likely to occur	Good Manufacturing Practices	QA Inspector	Hygiene records Materials receiving and inspection reports
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A		
	Physical: Seam dents of canned product due to mishandling	N/A	N/A	N/A	N/A	N/A	N/A		
18. Examination	**Biological:** Crosscontamination of cans with *Fecal coliforms* and *Listeria monocytogenes* from personnel touching hot and wet cans because of strict compliance with GMP's	2	2	4	No	Not reasonably likely to occur	Good Manufacturing Practices	QA Inspector	Hygiene records Materials receiving and inspection reports
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Physical: Seam dents of canned product due to mishandling	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 9h: Hazard Analysis and Risk Assessment for Canned Palm Cream Concentrate

PROCESS STEP	POTENTIAL HAZARD	HAZARD ASSESSMENT AND EVALUATION				JSUTIFICATION FOR INCLUSION OR EXCLUSION OF SIGNIFICANT HARZARD	WHAT PREVENTIVE MEASURES CAN BE APPLIED TO PREVENT THE SIGNIFICANT HAZARD?	RESPONSIBILITY	RECORD
		LIKELIHOOD OF OCCURANCE	SEVERITY OF ADVERSE HEALTH EFFECT	RA= LIKELIHOOD X SEVERITY	IS HAZARD SIGNIFICANT? (YES OR NO)				
19. Labeling	**Biological:** N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20. Carton/shrink wrapping	**Biological:** N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20. Carton/shrink wrapping	**Biological:** N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21. Finished products storage	**Biological:** N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

22. Container stuffing and Dispatch	**Biological:** N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Chemical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Physical: N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

4.7. CCP Determination Result Using Codex Decision Tree

Table 10a: Determination of CCP for canned palm cream concentrate

DETERMINATION OF CRITICAL CONTROL POINT FOR CANNED PALM CREAM CONCENTRATE

PROCESS STEP	**SIGNIFICANT HAZARD**	**Q1a:** Do control or preventive measure exist at this step? **YES: Go to Q2** **NO:** Is control necessary for safety? **YES: modify step, process or product and go to Q1a NO:** step is not a CCP for that hazard. Further step will control. Proceed to next identified hazard for the described process	**Q2: is this step specifically designed to eliminate or reduce the likely occurrence of the hazard to an acceptable level?** **YES: step is a CCP** **NO: step is not a CCP. Go to Q3**	**Q3.** Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels? **YES**: Go to Q4 NO: step is not a CCP for that hazard. Further step will control. Proceed to the next identified hazard for the described process	**Q4.** Will a subsequent step eliminate identified hazard(s) or reduce likelihood of occurrence to an acceptable level(s) YES: step is not a CCP for the hazard. Further step will control NO: step is a CCP for the identified hazard	**CCP YES OR NO**
RECEPTION OF PALM FRUITS	**Physical:** Presence of weed, sticks, glass or foreign materials **Biological:** Presence of *Staphylococcus aureus, Listeria monocytogenes, E. coli,* & *Fecal coliforms*	**YES**	**NO**	**YES**	**YES**	**NO**

WEIGHING OF PALM FRUITS	**Biological:** Introduction of E. coli from hands of personnel	**YES**	**NO**	**YES**	**YES**	**NO**
INSPECTION OF PALM FRUITS	**Biological:** Introduction of E. coli from hands of personnel	**YES**	**NO**	**YES**	**YES**	**NO**
SORTING OF FRUITS	**Biological:** Presence of *Staphylococcus aureus, Listeria monocytogenes, E. coli,* & *Fecal coliforms*	**YES**	**NO**	**YES**	**YES**	**NO**
WASHING OF PALM FRUITS	**Biological:** Introduction and cross-contamination of *E. coli, Staphylococcus aureus* & *Fecal coliforms* from hands of personnel and Presence of *Fecal coliforms* in water	**YES**	**NO**	**YES**	**YES**	**NO**

Table 10b: Determination of CCP for canned palm cream concentrate

DETERMINATION OF CRITICAL CONTROL POINT – CANNED PALM CREAM CONCENTRATE						
PROCESS STEP	**SIGNIFICANT HAZARD**	**Q1a:** Do control or preventive measure exist at this step? **YES: Go to Q2** **NO:** Is control necessary for safety? **YES: modify step, process or product and go to Q1a** **NO:** step is not a CCP for that hazard. Further step will control. Proceed to next identified hazard for the described process	**Q2:** **is this step specifically designed to eliminate or reduce the likely occurrence of the hazard to an acceptable level?** **YES: step is a CCP** **NO: step is not a CCP. Go to Q3**	**Q3.** Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels? **YES**: Go to Q4 NO: step is not a CCP for that hazard. Further step will control. Proceed to the next identified hazard for the described process	**Q4.** Will a subsequent step eliminate identified hazard(s) or reduce likelihood of occurrence to an acceptable level(s) YES: step is not a CCP for the hazard. Further step will control NO: step is a CCP for the identified hazard	**CCP YES OR NO**
COOKING OF PALM FRUITS	**Biological:** Introduction of microorganisms through water	**YES**	**NO**	**YES**	**YES**	**NO**

DEPULPING OF PALM FRUITS	**Physical:** Introduction of machine parts into the products	**YES**	**NO**	**YES**	**YES**	**NO**
STRAINING OF PALM CREAM	**Biological:** Introduction of *fecal coliforms* from personnel and straining machine	**YES**	**NO**	**YES**	**YES**	**NO**
BLENDING OF PLAM CREAM	**Biological:** Introduction of *Listeria monocytogenes, E. coli, Staphylococcus aureus and Salmonella sp*.	**YES**	**NO**	**YES**	**YES**	**NO**

Table 10c: Determination of CCP for canned palm cream concentrate

DETERMINATION OF CRITICAL CONTROL POINT – CANNED PALM CREAM CONCENTRATE

PROCESS STEP	**SIGNIFICANT HAZARD**	**Q1a:** Do control or preventive measure exist at this step? **YES: Go to Q2** **NO:** Is control necessary for safety? **YES: modify step, process or product and go to Q1a** **NO:** step is not a CCP for that hazard. Further step will control. Proceed to next identified hazard for the described process	**Q2:** **is this step specifically designed to eliminate or reduce the likely occurrence of the hazard to an acceptable level?** **YES: step is a CCP** **NO: step is not a CCP. Go to Q3**	**Q3.** Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels? **YES**: Go to Q4 NO: step is not a CCP for that hazard. Further step will control. Proceed to the next identified hazard for the described process	**Q4.** Will a subsequent step eliminate identified hazard(s) or reduce likelihood of occurrence to an acceptable level(s) YES: step is not a CCP for the hazard. Further step will control NO: step is a	**CCP YES OR NO**

					CCP for the identified hazard	
CANS AND ENDS RECEPTION AND WASHING	**Biological:** Presence of *Staphylococcus aureus, Listeria monocytogenes, E. coli,* & *Fecal coliforms*	**YES**	**NO**	**YES**	**YES**	**NO**
FILLING OF CANS WITH PALM CREAM	**Biological:** Introduction and cross-contamination of *E. coli, Staphylococcus aureus* & *Fecal coliforms*	**YES**	**NO**	**YES**	**YES**	**NO**
SEAMING OF FILLED CANS	**Biological:** Introduction of *fecal coliforms* from personnel and straining machine	**YES**	**YES**	**-**	**-**	**YES** **CCP#1**
SEAMED CAN WASHING	**Chemical:** Introduction of detergent residues	**YES**	**NO**	**YES**	**YES**	NO
PACKING INTO RETORTBASKET	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	N/A

Table 10d: Determination of CCP for canned palm cream concentrate

DETERMINATION OF CRITICAL CONTROL POINT – CANNED PALM CREAM CONCENTRATE						
PROCESS STEP	**SIGNIFICANT HAZARD**	**Q1a:** Do control or preventive measure exist at this step? **YES: Go to Q2** **NO:** Is control necessary for safety? **YES: modify step, process or product and go to Q1a** **NO:** step is not a CCP for that hazard. Further step will control. Proceed to next identified hazard for the described process	**Q2: is this step specifically designed to eliminate or reduce the likely occurrence of the hazard to an acceptable level?** **YES: step is a CCP** **NO: step is not a CCP. Go to Q3**	**Q3.** Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels? **YES**: Go to Q4 NO: step is not a CCP for that hazard. Further step will control. Proceed to the next identified hazard for the described process	**Q4.** Will a subsequent step eliminate identified hazard(s) or reduce likelihood of occurrence to an acceptable level(s) YES: step is not a CCP for the hazard. Further step will control NO: step is a CCP for the identified hazard	**CCP YES OR NO**
RETORTING OF SEAMED PRODUCTS	**Biological:** Presence of *Staphylococcus aureus*, *Listeria monocytogenes*, *E. coli*, & *Fecal coliforms*	**YES**	**YES**	-	-	**YES** **CCP#2**
RETORTED PRODUCTS COOLING	**Biological:** Introduction and cross-contamination of *E. coli*, *Staphylococcus aureus* & *Fecal coliforms* from hands of personnel and Presence of *Fecal coliforms* in water	**YES**	**NO**	**YES**	**YES**	**YES** **CCP#3**

POST PROCESS HANDLING (AIR COOLING, WIPPING , LABELING & CASING AND DISPATCH)	**Biological:** Introduction of *fecal coliforms* from personnel and straining machine	**YES**	**NO**	**YES**	**YES**	**NO**

4.8. CCP MONITORING PLAN

Table 11a: HACCP Plan for Canned Palm Cream Concentrate

COMPANY NAME: **PRODUCT DESCRIPTION:** ***CANNED PALM CREAM CONCENTRATE***

COMPANY ADDRESS: ……... **METHOD OF STORAGE AND DISTRIBUTION:** ***AMBIENT TEMPERATURE***
……...

INTENDED USE AND CONSUMER: ***FOR PREPARATION OF SOUP BY THE GENERAL PUBLIC***

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Critical Control Point (CCP)	**Significant Hazard(s)**	**Critical Limits for each Control Measure**	**Monitoring**				**Corrective Action(s)**	**Records**	**Verification**
			What	**How**	**Frequency**	**Who**			

CCP#1 Seaming of filled cans	**Biological:** Microbial Infection of *C. botulinum, Staphylococcus aureus and E. coli* due to poor double seams	Seams are closed to comply with critical limits included within data sheet DS/CCP3/01 for relevant size of can. Critical values for seam acceptability include those for: BHB >75%, Tightness Rating > 75% and Actual Overlap > 1.1mm. Free space and % overlap to comply with can manufacturer's specification on DS/CCP3/01	Seam evaluation compliance checks (Visual seam checks, Body Hook Butting, Tightness Rating)	Visual and tactile seam checks and teardown using seam micrometer	Visual checks every 15 minutes and teardown every 1 hour	QA Officer, Seamer Mechanics	Seamer Mechanics to reset seaming machine and recheck previous cans seamed. Q. A. Supervisor Isolate and investigate suspect cans.	Seaming Records, Preventive Maintenance Records	Daily review of all records including process deviation records by Q.A Manager and approval.

Signature of QA MANAGER _____ ***Page***

Table 11b: HACCP Plan for Canned Palm Cream Concentrate

COMPANY NAME:

COMPANY ADDRESS: ……..
……..

PRODUCT DESCRIPTION: ***CANNED PALM CREAM CONCENTRATE***

METHOD OF STORAGE AND DISTRIBUTION: ***AMBIENT TEMPERATURE***

INTENDED USE AND CONSUMER: ***FOR PREPARATION OF SOUP BY THE GENERAL PUBLIC***

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Critical Control Point (CCP)	**Significant Hazard(s)**	**Critical Limits for each Control Measure**	**Monitoring**				**Corrective Action(s)**	**Records**	**Verification**
			What	**How**	**Frequency**	**Who**			
CCP#2 Retorting of seamed product	**Biological:** Microbial Survival of *C. botulinum* due to operator error, under sterilization resulting in insufficient lethality and process survival of *C. botulinum* due to faulty instrumentation.	**120°C - 122°C for 60 minutes**	**1.** Monitoring of process temp. and time by trained retort operator. **2**.Check all instruments for apparent serviceability and currency of calibration prior to start-up **3**. Check and record that the inkjet codes on lids and heat sensitive tags and autoclave tapes have changed colour, confirm reconciliation of cooked and uncooked products	Recording of monitoring charts values and cross checking with measuring instruments (for temp. time, pressure) during retorting on monitoring log sheet.	Record ETI and pressure values at the start of each cook. Continuously monitor chart and ETI Temp. readings during each sterilization cook/batch and record values every 15 minutes for small cans and 30mins for big cans (refer to procedure for retorting).	Trained QA Supervisor Trained retort operators	Retort Operators refer to process deviation and alternative procedure instructions and inform QA Manager to confirm the appropriate process deviation to follow. Document all actions on log sheet. Notify Q. A /Prod. Managers and Maintenance Manager as required Re-training of staff	Retorting Records, Calibration Records, Microbiology Lab Results	Daily review of all records including process deviation records by Q.A Manager and approval.

Signature of QA MANAGER_____

Page

Table 11c: HACCP Plan for Canned Palm Cream Concentrate

COMPANY NAME: **PRODUCT DESCRIPTION:** ***CANNED PALM CREAM CONCENTRATE***

COMPANY ADDRESS: ……... **METHOD OF STORAGE AND DISTRIBUTION:** ***AMBIENT TEMPERATURE***

……..

INTENDED USE AND CONSUMER: ***FOR PREPARATION OF SOUP BY THE GENERAL PUBLIC***

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Critical Control Point (CCP)	**Significant Hazard(s)**	**Critical Limits for each Control Measure**	**Monitoring**				**Corrective Action(s)**	**Records**	**Verification**
			What	**How**	**Frequency**	**Who**			

CCP#3 Retorted Canned Product Cooling	**Biological:** Microbial reinfection of *C. botulinum*, Staphylococcus *aureus, E. coli* from cooling water	Incoming cooling water chlorinated to 3ppm and discharge water should have min. free residual chlorine of 0.5ppm	Residual chlorine checks	Use of Chlorine test kits	Every batch / cook.	QA Supervisor	Q. A. Supervisor to adjust chlorine levels if parameters are not met and increase the frequency of checking residual chlorine level until results within specification and consistent. Quarantine affected batches and put on hold. Notify Q. A. Manager to assess risk.	Retort Cooling water Records	1. Daily review of records by QA Manager. 2. Monthly microbial analysis of incoming cooling water 3. Once a year heat penetration test

Signature of QA MANAGER _____

Page

Table 12: Operational Prerequisite Plan Form for Canned Palm Cream Concentrate

COMPANY NAME: **PRODUCT DESCRIPTION:** ***CANNED PALM CREAM CONCENTRATE***

COMPANY ADDRESS: ……..
……..

METHOD OF STORAGE AND DISTRIBUTION: ***AMBIENT TEMPERATURE***

INTENDED USE AND CONSUMER: ***FOR PREPARATION OF SOUP BY THE GENERAL PUBLIC***

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Operational Prerequisite program (oPRP)	**Significant Hazard(s)**	**Critical Limits for each Control Measure**	**Monitoring**				**Corrective Action(s)**	**Records**	**Verification**
			What	**How**	**Frequency**	**Who**			
Water treatmentchlorination	Biological: (Microbial contamination or presence of *C. botulinum, S. aureus* and *E. coli* from inadequately treated water from borehole	Processing water chlorinated to 1.0 ppm for general factory usage, 3.04.0 ppm, retorted can cooling and discharge water should have at least 0.5ppm free residual chlorine	Residual chlorine checks for in-coming water in taps for general use on factory floor, retorted can cooling and discharge water after cooling	Use of Hach Test Kits.	Prior to start of processing and subsequentl y Every 2 hours for in-coming water and Every batch/cook for discharge water	Trained QA inspectors and supervisors	Q. A. Supervisor to adjust chlorine levels and increase the frequency of checking residual chlorine level until results is consistent. Quarantine affected batches and put on hold. Notify Q. A. Manager to assess risk.	oPRP Records	1. Daily review of records by QA Manager. 2. Monthly microbial analysis of incoming cooling water

Signature of QA MANAGER _____	*Page*

CHAPTER FIVE

5.0. DISCUSSION AND CONCLUSIONS

5.1. Summary of Results

The study realized its principal objective of developing a generic HACCP system for the palm cream concentrate industry in Ghana using Praise Export Services Limited as a model by applying the seven preparatory stages and the seven principles of HACCP as recommended by Campden BRI (2009).

5.1.1 Summary of the Seven Preparatory Stages implemented

Management commitment and Food safety and quality polices were developed and signed by the Managing Director of the company and communicated to all the employees. The HACCP team has been appointed by senior management and a well-trained and competent HACCP team capable of updating and reviewing the HACCP plan is now in place at Praise Export Services Limited. The HACCP team defined the terms of reference of the HACCP system and described the product and process. The intended use has been identified and a detailed process flow diagram has been designed, reviewed and verified on-site to be accurate and implemented.

5.1.2 Summary of the application of the seven principles of HACCP

The hazard analysis showed that most of the physical, microbiological and chemical hazards that are associated with palm cream concentrate canning are controlled by Prerequisite Programmes (PRPs).

This study identified additional PRPs such as pest control, customer complaints management, material identification and traceability, product withdrawal and recall procedures and personnel training and integrated them into the company's existing PRPs

to assure the prevention, elimination, and reduction of food safety hazards significant to palm cream concentrate canning. The PRPs were implemented and effective monitoring is an ongoing activity in the company. APPENDIX 3 shows pictures of the factory floor indicating that PRP's have been implemented and are functioning properly in the factory. Apart from the PRPs, an operational PRP (chlorination) was used to manage an important step that introduces a utility (water) into the flow diagram. The study identifies chlorination step as an operational pre-requisite programme (oPRP). Refer to Table 12: Operational Prerequisite Plan Form for Canned Palm Cream Concentrate. The study identified a lot of physical, chemical and microbiological hazards associated with each processing step and listed them in the hazard analysis and risk assessment work sheet as shown in Table 9. A three-point scoring system was then employed to do the hazard analysis by assigning scores for likelihood and severity for each hazard. Hazards with total scores of 6 were considered significant and those below 6 were deemed insignificant. For instance, process step 1: reception of palm fruits, the presence of micro-organisms such as *E. coli*, *Staphylococcus aureus* and *Fecal coliforms* in the palm fruits from the farms and introduction of same microorganisms from personnel or packaging by cross-contamination was identified and listed as biological hazards. A score of 3 was assigned to its likelihood of occurrence meaning it is highly probable and true that palm fruits received will be contaminated with these micro-organisms. However, a score of 1 was assigned to its severity since the adverse health impact at this stage is low because palm fruits are not supposed to be eaten raw but will be boiled or cooked and further processed. A total score of 3 was then realized by multiplying likelihood by severity. Thus, biological hazards are not significant at this process step. The chemical hazard identified and listed at this step 1 is diesel/petrol or fuel contamination from transporting vehicles. A score of 1 was assigned to its likelihood since it is rare to see fuel contaminating the palm fruits in sacks in the

vehicle unless there was fuel leakage or malicious contamination. A score of 3 was assigned to its severity because should it happen the adverse health impact will be serious since cooking or further processing might not be able to eliminate diesel/petrol contamination from the final product. However, multiplying likelihood by severity gave us 3 which is below 6 meaning it is not a significant hazard at this process step. Also, stones, glass, plastic, metals, dead insects, leaves and sticks were identified as physical hazards at same step 1. A score of 3 was assigned to its likelihood implying that the palm fruits will certainly come with all these hazards but a score of 1 was given to its severity since all these hazards will be taken care of during sorting and washing and its health impact is low. Multiplying likelihood by severity resulted in 3 meaning it is insignificant hazard at this process step.

However, with process step 12: seaming of filled cans, microbiological infection of *C. botulinum, S. aureus* and *E. coli* due to poor double seams has been identified and listed as biological hazards. A score of 2 was assigned to its likelihood of occurrence because it is possible that if adequate controls are not in place improper quality seams could lead to post-process growth of these micro-organisms in the can product and definitely will happen one day if care is not taken. A score of 3 was assigned to its severity because if poorly formed seams lead to growth of *C. botulinum* it will result in botulism which is deadly. A total score of 6 was realized by multiplying likelihood by severity making it a significant hazard at this process step. For chemical hazards, grease contamination of products from the seamer machine was identified and listed, a score of 1 was assigned to its likelihood since its occurrence is low because the company uses only food grade lubricants. A score of 3 was assigned to its severity because the adverse health impact is serious if the grease is not a food grade one. However, a total score of 3 was realized by multiplying likelihood with severity making it insignificant hazard. For physical hazards

at this process step, only metal pieces were identified and listed. A score of 1 was assigned to its likelihood because the product is unlikely to be contaminated since there are covers on the line to prevent metal pieces or bolts and nuts falling into the filled cans prior to seaming. But a score of 3 was assigned to its severity because if it happens, the adverse health implication will be serious for a consumer and the fact that the company currently has no metal detector. A total score of 3 was realized making it insignificant hazard. This study applied the three-point scoring system to analyze all the 21 process steps and found only 3 of them to have significant hazards while the remaining 18 process steps have nonsignificant hazards. These results are indicated in the hazard analysis and risk assessment worksheet in Table 9.

The study identified three processing steps as CCPs for the palm cream canning process at Praise Export Services Limited. The CCPs were determined using the Codex decision tree and based on this the Seaming step was identified as CCP#1, Retorting or Sterilization step was identified as CCP#2 and Retorted canned product cooling in the retort step was identified as CCP#3.

Critical Limits were set for each of these CCPs based on industry standards, codes of best practices, regulatory and market requirements, guidelines and company's own in-house trials and experiments. Monitoring systems including forms and worksheets were designed to monitor the control measure of each CCP identified. Corrective action was established to be taken when monitoring indicates that a particular CCP is not under control and Verification plan was put in place to confirm that the HACCP plan was working effectively. Documentation and Record keeping were established based on the CCP monitoring forms developed during the study as shown in APPENDIX 4 and 5 to capture results in real time.

5.2. CONCLUSIONS

There were three CCPs identified from the twenty-one (21) process steps using Codex decision tree. The remaining steps were controlled by Prerequisite Programmes (PRPs) to reduce biological, chemical and physical hazards with water treatment for its portability being controlled by an operational Prerequisite Programme (oPRP). The three CCPs identified in this study: can seaming, retorting and retorted can cooling are critical to canned food safety because they are microbiological food-poisoning hazards (Bratt, 2010). The critical limits for CCP#1 are Body Hook Butting >75%, Tightness Rating > 75% and Actual Overlap > 1.1mm. That of CCP#2 are 120-122 degree Celsius for 60 minutes for both 400g and 800g can sizes and that for CCP#3 are 3-4ppm residual chlorine in incoming water and ≥ 0.5 ppm residual chlorine content in discharge water after retorting. This study also reveals that for a HACCP plan to be effectively implemented, PRPs must be implemented as the foundation for the HACCP system.

5.3. RECOMMENDATIONS

This study recommends the following:

1. Further study should be done to monitor the implementation of the PRPs and CCPs identified in this study to evaluate its effectiveness to produce safe canned palm cream concentrate for consumption
2. Also, further study should be done to validate the CCPs identified and implemented at Praise Export Services Limited.

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APPENDIX 1

MANAGEMENT COMMITMENT POLICY

We, the board of Directors and Senior Management of the company are fully committed to the implementation and continual improvement of this food safety (HACCP) system document

To this end we shall provide adequate resources, effective communication, systems of review and actions taken to effect continual improvement.

Opportunities for improvement shall be identified, implemented and fully documented during the annual Management Review Meetings. Authority and responsibility to administer the objectives of this food safety management system document, hereby referred to as the HACCP system has been vested with our Quality Assurance Manager.

.....

(MANAGING DIRECTOR)

DATE: 12TH JUNE, 2018

Prepared by:	Quality Assurance Manager	Isaac Mensah
Approved by:	Managing Director	Godwin Adordie

APPENDIX 2

PRAISE®	Praise Export Services Limited	Doc No:	PESL-FSM-01
		Issue No:	01
		Issue Date:	June 12,2018
	HACCP MANUAL	Supersedes:	Dec. 13, 2017
		Page 8	

QUALITY AND FOOD SAFETY POLICY

"**PRAISE EXPORT SERVICES LIMITED**" is committed to:

- Providing our customers with Safe, Quality and Affordable products that meet stakeholders' requirements and are fit for their purposes;
- Effective implementation of business activities according to the established quality assurance system based on HACCP through effective communication;
- Enhancing the skills of management and staff through review and actively pursuing an on-going training policy, the objective of which is to prepare staff to perform their work more effectively;
- Promoting continual quality improvements and the philosophy of getting things "*right first time*";
- Promoting the quality assurance system and ensuring implementation is achieved by planned reviews, corrective and preventive action;
- Enhancing product excellence and regulatory compliance by leveraging on customer and consumer feedback;
- Ensuring periodic review and assessment of this Policy for continuous alignment with international best practices and the ever changing regulatory standards and market requirements and report the outcome to our Board of Directors on annual basis.

Everyone in the company is responsible for product safety and quality within the company by maintaining high hygiene standards.

.....

(MANAGING DIRECTOR)

DATE: 12TH JUNE, 2018

Prepared by:	Quality Assurance Manager	Isaac Mensah
Approved by:	Managing Director	Godwin Adordie

APPENDIX 3

Plate 1: Author visualizing raw material (palm fruits) brought in sacks from the supplier

Plate 2: Author checking the quality of palm fruits sorted

Plate 3: Author washing his hands ready to start work

Plate 4: Author drying his hands after washing prior to sanitizing his hands with an alcohol sanitizer

Plate 5: Author washing raw materials (Oil palm fruit)

Plate 6: A staff in charge of palm fruit washing

Plate 7: De-pulping of the palm fruit

Plate 8: Extraction of palm cream from the pulp

Plate 9: Filling of cans with extracted palm cream

Plate 10: Cans filled with palm cream concentrate ready for seaming

Plate 11: Seaming of filled cans

Plate 12: Author checking the weight of the seamed product to ensure specified net weight is met.

Plate 13: A staff arranging products into baskets prior to retorting

Plate 14: A standing autoclave(retort) used by the company for sterilization (retorting)

<u>Plate 15: Ellab Temperature Indicator</u> (Reference Temperature Indicator) device showing autoclave temperature readings.

Plate 16: Labeled products arranged in a tray

Plate 17: Stored finished goods ready for export

Plate 18: A picture depicting a clean and neat factory floor indicating effective implementation of PRPs

APPENDIX 4

SPECIFICATIONS **CCP #1: DAILY DOUBLE SEAM REPORT** PRODUCTION DATE: ……

VAC……. COVER HOOK …… Te ……. FREQUENCY: HOURLY CAN SIZE: …… LENGTH…… BODY HOOK…… Tb……

LINE: …….. THICKNESS …… TIGHTNESS …….. PRODUCT NAME(S):…….... AOL …… BHB

……FS ……. SUPPLIER/CODE(S):……

PRODUCT(S): ……..

TIME ……. RE-CHECK TIME……. INSPECTOR …….. MECHANIC: ……CODE……..

CAN HEAD	VAC	COUNTERSINK DEPTH			SEAM LENGTH			SEAM THICKNESS			BODY HOOK LENGTH			END HOOK LENGTH			FREE SPACE			ACTUAL OVER LAP			BODY HOOK BUTT'G			TIGHTNESS RATING
NO.		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1																										
2																										
3																										
4																										

REMARKS: ……

TIME ……. RE-CHECK TIME……. INSPECTOR …….. MECHANIC: ……..

NO.		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	

REMARKS: ……

CODE……..

TIME ……. RE-CHECK TIME……. INSPECTOR …….. MECHANIC: ……. CODE……..

NO.		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	

REMARKS: ……																									

REVIEWED BY: …….. **DATE: ……**

APPENDIX 5

CCP # 2&3: DAILY CAN RETORTING / COOLING RECORDING

RETORT SUPERVISOR: …….

PRODUCTION DATE: ……

TEMP. CHART NO.	COOK OR BATCH NO.	RETORT NO.	CAN SIZE	BASKET NO.	CAN CODE COMPLETED	FIRST CAN CLOSED	TIME STEAM ON	VENTS CLOSE		TIME TEMP. UP	TIME STEAM OFF	ACTUAL COOK TIME (MIN)	SCHEDULED COOK TIME (MINS.)	TOP BOTTOM BLEEDS	ETI ^{O}C	CHART ^{O}C	PRESSURE GAUGE (BAR)	INITIAL TEMP.^{O}C	EXIT TEMP. ^{O}C
								TIME	TEMP										

Remarks:

Q. A. Dept. Reviewed	**Water source**	**Time**	**Chlorine level (ppm)**	**pH**	**Retort Operator**	**Prod. Dept. Review**
	Incoming Water					
	Discharged Water				**Retort Clerk**	
	Q. A. Inspector					

APPENDIX 6

Hazard Analysis & Critical Control Points (HACCP) Team members of Praise Export Services Limited who participated in the Hazard Analysis & Critical Control Points (HACCP) training awarded with HACCP Certificates by Partners in Food Solutions on 29th of June, 2018

PARTNERS IN FOOD SOLUTIONS

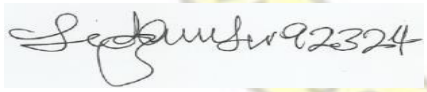
Certificate of Completion

Presented to:

Isaac Mensah

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.



Christian Dedzo

Ghana Program Manager, Partners in Food Solutions

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills

PARTNERS IN FOOD SOLUTIONS

Certificate of Completion

Presented to:

Mercy Kwablah

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.

Christian Dedzo

Ghana Program Manager, Partners in

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills

PARTNERS IN FOOD SOLUTIONS

Certificate of Completion

Presented to:

Mark Sepenoo

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.

Christian Dedzo

Ghana Program Manager, Partners in Food Solutions

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills

PARTNERS IN FOOD SOLUTIONS

Certificate of Completion

Presented to:

Clement Okai Addo

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.

Christian Dedzo

Ghana Program Manager, Partners in Food Solutions

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills

PARTNERS IN FOOD SOLUTIONS

Certificate of Completion

Presented to:

Kennedy Wemegah

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.

Christian Dedzo

Ghana Program Manager, Partners in

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills

PARTNERS IN FOOD SOLUTIONS

Certificate of Completion

Presented to:

Samuel Lanyo

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.

Christian Dedzo

Ghana Program Manager, Partners in Food Solutions

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills

PARTNERS IN FOOD SOLUTIONS

Certificate of Completion

Presented to:

Ali Yakubu

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.

Christian Dedzo

Ghana Program Manager, Partners in Food Solutions

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills

PARTNERS IN FOOD SOLUTIONS

Certificate of Completion

Presented to:

Agnes Narh

in Accra, Ghana on the 29th of June, 2018

for successfully completing all requirements of the Hazard Analysis & Critical Control Points (HACCP) Training at Praise Exports given by Partners in Food Solutions.

Christian Dedzo

Ghana Program Manager, Partners in Food Solutions

Jeff Dykstra

CEO, Partners in Food Solutions

GENERAL MILLS Cargill DSM BÜHLER HERSHEY Ardent Mills