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Application of ISO 22000 in comparison with HACCP on industrial processing of milk chocolate

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Abstract

Hazard analysis was conducted to identify critical control points (CCPs) during cocoa processing and milk chocolate manufacture and applied into a hazard analysis and critical control point (HACCP) plan. During the process, the different biological, physical and chemical hazards identified at each processing stage in the hazard analysis worksheet were incorporated into the HACCP plan to assess the risks associated with the processes. Physical hazards such as metals, stones, fibres, plastics and papers; chemical hazards such as pesticide residues, mycotoxins and heavy metals; and microbiological hazards such as *Staphyloccous aureus*, coliforms, *Salmonella*, *Aspergillus* and *Penicillium* were identified. ISO 22000 analysis was conducted for the determination of some pre-requisite programmes (PrPs) during the chocolate processing and compared with the HACCP system. The ISO 22000 Analysis worksheet reduced the CCPs for both cocoa processing and chocolate manufacture due to the elimination of the pre-requisite programmes (PrPs). Monitoring systems were established for the CCPs identified and these included preventive measures, critical limits, corrective actions, assignment of responsibilities and verification procedures. The incorporation of PrPs in the ISO 22000 made the system simple, more manageable and effective since a smaller number of CCPs were obtained.

Introduction

Food safety is linked with food-borne hazards present in food at the point of consumption. Since food safety hazards can occur at any stage in the food chain it is essential that adequate control measures be put in place to avoid or minimize food safety hazards (Prati and McIntyre, 2004). ISO 22000 is a standard developed by the International Organization for Standardization (ISO) as a requirement for the food chain organization to enhance food safety (Blank, 2006). It was developed as an improvement to ISO 9000. In comparison with ISO 9000, the standard is more procedure-orientated than principle-based. The ISO 22000 international standard specifies the requirements for a food safety management system. It involves the elements of interactive communication, system management, pre-requisite programmes and HACCP principles. According to ISO (2010), ISO 22000 can be applied independently of other management system standards or integrated with existing management system requirements.

The Hazard Analysis and Critical Control Points (HACCP) system is science based and systematic. It identifies specific hazards and measures for their control to ensure the safety of food. Any HACCP system is capable of accommodating change, such as advances in equipment design, processing procedures or technological developments (Codex Alimentarius Commission, 1999). Its concept permits a systematic approach to the identification of hazards and an assessment of the likelihood of their occurrence during the manufacture, distribution and use of a food product, and defines measures for their control (van Schothorst, 2004). The resulting HACCP plan can be integrated in a more general quality and safety assurance plan.

Within the last 20 years, chocolate products have been the cause of many salmonellosis outbreaks involving mainly children (Cordier, 1994). The main reason has been the very low levels of Salmonella found in such contaminated chocolate products. Additionally, chocolate may contain other spoilage organisms such as yeasts and molds, Staphylococcus aureus and other coliforms. Molds may spoil chocolate by hydrolyzing lipids present to fatty acids. This results in the rancid taste of chocolate. It is therefore necessary to take preventive measures during processing to avoid re-contamination of the product after the roasting step which represents the only barrier for Salmonella and other spoilage microorganisms (Case, 2010). HACCP systems are

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therefore designed to prevent re-contamination. The control of hazards in chocolate processing is essential since the consequences of its failure can be illustrated by a number of serious and high profile incidents and recalls over the past decade. Such incidents can cause illness, injury or in the most severe cases, death to the consumer (Burndred, 2009).

Hazard Analysis and Critical Control Points (HACCP)

The basis of HACCP are that it is a process control rather than a product control procedure and that it focuses on controlling steps in the processing system that are critical to consumer health (Arvanitoyannis and Varzakas, 2008).

HACCP is a structured approach to the identification, assessment of risk (likelihood of occurrence and severity), and control of hazards associated with food production process or practice. It addresses the root causes of food safety problems in production, storage, transportation, and is preventative (FDA, 1994). It aims to identify possible problems before they occur and establish control measures at stages in the production process that are critical to product safety. One of the purposes of HACCP is to design safety into the process, thereby reducing the need for extensive microbiological testing of inline samples and finished products (Silliker, 1995).

There can hardly be HACCP without Good Manufacturing or Management Practices (GMP). GMP is a description of all the steps in a processing facility, while HACCP is a documentation that the steps important to consumer health are under control (Arvanitoyannis and Varzakas, 2009). Sanitation standard operating procedures (SSOPs) are also a needed pre-requisite to HACCP. Pre-requisites are advisory not mandatory. GMPs differ from HACCP in a number of ways. First, they are not designed to control specific hazards. Second, they do not provide methods for monitoring hazards and third, they do not require specific recordkeeping procedures (Arvanitoyannis and Varzakas, 2008).

HACCP principles

The HACCP principles are clearly defined and they are considered to be one of the most useful tools for proactive identification and control of hazards in foods. According to the Codex Alimentarius Commission (1999), the HACCP system consists of seven principles which have been well outlined by Arvanitoyannis and Varzakas (2009).

Advantages of HACCP

HACCP offers a number of advantages over current systems. Most importantly according to Llano (2011) it;

i. Focuses on identifying and preventing hazards from contaminating foods.

ii. Permits more efficient and effective government oversight, primarily because the record keeping allows investigators to see how well a firm is complying with food safety laws over a period rather than how well it is doing on a given day.

iii. Places responsibility for ensuring food safety appropriately on the food manufacturer or distributor.

iv. Helps food companies compete more effectively in the world market.

v. Reduces barriers to international trade.

Also the advantages of HACCP according to Whitehead and Orris (1995) include;

i. The HACCP system is capable of accommodating change, such as advances in equipment design, processing procedures or technological developments.

ii. Provides a more effective use of resources and more timely response to food safety problems.

iii. The HACCP system is compatible with the implementation of quality management systems, such as the International Organization for Standardization's ISO 9000 series.

ISO 22000

ISO 22000 is a standard developed by the International Organization for Standardization as a requirement for the food chain organization to enhance food safety (Blank, 2006). The ISO 22000 international standard specifies the requirements for a food safety management system. This standard further clarifies the concept of pre-requisite programmes which are divided into two sub-categories: infrastructure and maintenance programmes and operational pre-requisite programmes. Infrastructure and maintenance programmes are used to address basic requirements of food hygiene, and accepted good practice of a more permanent nature, whereas operational pre-requisite programmes are used to control or reduce the impact of identified food safety hazards in the product or the processing environment (Faergemand and Jersperson, 2004).

Advantages of ISO 22000

According to the National Sanitation Foundation (NSF) (2004), and Arvanitoyannis and Varzakas (2008), the main advantages of ISO 22000 include:

i. Allows the organisation within the food chain to demonstrate their commitment to food safety.

ii. Enables the optimum distribution of resources inside the food chain organization.

iii. Improves the effectiveness of internal and external communication between suppliers, clients, authorities and other authorities involved.

iv. Focuses on the pre-requisite programmes, conditions and hygiene measures, planning of preventive actions with the aim of eliminating any possible failures.

v. Allows for better documentation.

vi. It improves the management processes and provision of resources and visual operations.

vii. There is the ability to show control of known food hazards

Hazards associated with chocolate processing

Hazards associated with foods may be defined as anything related to the food that might cause harm to the consumer. According to ISO 22000, a food safety hazards is a biological, chemical or physical agent in food or condition of food with the potential to cause an adverse health effect (Burndred, 2009).

Physical hazards

Physical hazards are foreign bodies that are hard and/or sharp. They may cause physical injury such as cuts to the mouth, throat or digestive system or may cause choking. Foreign bodies can be defined as matter that is present in a food but which whether of intrinsic or extrinsic origin is undesirable (George, 2004). Intrinsic foreign body is associated with the food itself, example the shells of the cocoa beans. An extrinsic foreign body is introduced from external sources and includes matter such as glass, metal, wood, plastic, insects and human hair. Sources of physical hazards during chocolate production and processing usually are from incoming raw materials, processing equipment and failures in pre-requisite programmes (Burndred, 2009).

Chemical hazards

Two main sources of chemical hazards exist during chocolate manufacture, the intrinsic contamination of raw materials and contamination that may occur during the process. At high doses, the exposure to chemical contaminants can cause toxicity to the consumer, for example acute poisoning from the ingestion of high levels of lead (Burndred, 2009). At lower doses there are generally long-term adverse health consequences that will affect the consumer such as kidney dysfunction, skeletal damage or productive deficiencies when cadmium builds up in the body for many years (European Economic Commission, 2001). Raw materials of plant and animal origin are potentially affected by a number of contaminants such as heavy metals, mycotoxins and pesticides.

Table 1. Grade standards of cocoa

Grade	Bean count per 100 g	Mouldy	Slaty	Defective Beans (germinated, insect-damaged etc.)
1A	≤ 100	3%	3%	2.5%
1B	101 – 200	3%	3%	2.5%
2A	≤ 100	4%	8%	5%
2B	101 – 200	4%	8%	5%
Substandard	> 120	> 4%	> 8%	> 5%

Source: (Afoakwa, 2010)

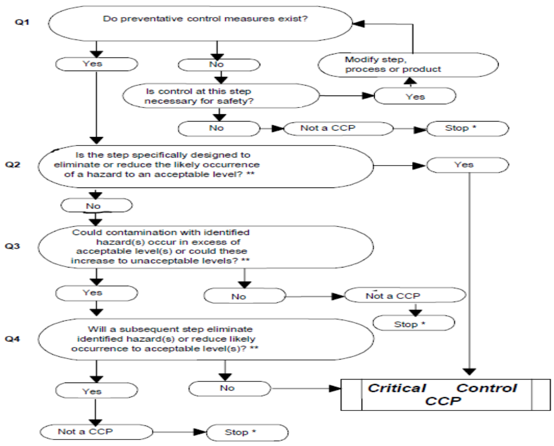

Figure 1. An example of decision tree to identify CCPs (Codex Alimentarius, 1999) (Answer questions in sequence)

*Proceed to the next identified hazard in the described process

**Acceptable and unacceptable levels needed to be determined within the overall objectives in identifying the CCPs of the HACCP plan

Microbiological hazards

Microbial hazards in cocoa processing and chocolate manufacture are mainly present during the incoming of raw materials and improper handling. According to Cordier (1994), chocolate should be tested for *Staphylococcus aureus*, coliforms, and *Salmonella. Aspergillus* and *Penicillium* however are responsible for mycotoxins.

Pre-processing operations

These include the quality determination of beans before purchasing from the warehouse to be brought to the factory for processing. At the warehouse samples of cocoa beans are taken by a horning process. The cut test, bean count and the free fatty acids test are performed on the dried fermented beans by the quality control department to assess the bean quality. The results of these tests are analyzed and given serious consideration before cocoa beans are bought from the warehouse. Table 1 gives details of grade standards of cocoa beans.

Cocoa processing into semi-finished products

Figure 2 shows the main flow scheme for the processing of fermented cocoa beans into semi-finished products, namely: cocoa liquor, cocoa butter and cocoa powder.

Bean receipt and cleaning – CCP_1

Raw cocoa beans are received from the warehouse

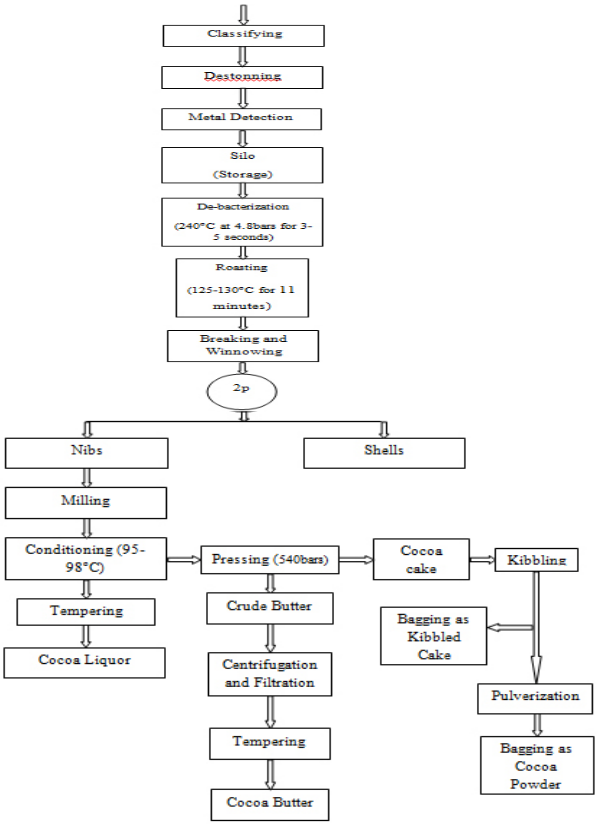

Figure 2. Flow chart for cocoa processing

and discharged onto the platform. Beans are thoroughly cleaned from all extraneous matter such as sticks, stones, fibers, glass, human hair, metal fragments as well as broken beans. The cleaning process starts with the classifier. It is a physical cleaning method based on terminal velocity. The second stage of cleaning is termed the destoning stage. The destoner separates the stones from the cocoa beans. The destoners have bores in the machine using counter current movement to separate the stones from the cocoa.

Silos (storage) – CCP$_2$

The cocoa beans are then passed through a metal detector before being stored in a silo. From the silo the beans move into the de-bacterization chamber.

De-bacterizer – CCP$_3$

The de-bacterizer uses super-heated steam in a stainless steel reactor, at 240°C and 4.8 bars for 3-5 seconds to sterilize and minimize contamination at the beginning of the production process. The steam treatment also loosens the shells from the nibs and facilitates the breaking and winnowing steps in the production process.

The roasting process – CCP$_4$

The roasting process has the objective to further improve microbial quality and reduce water content to facilitate the ultimate grinding process. During roasting there is the development of flavor from precursors arising from the correct fermentation and drying of the beans. The nibs become more friable and darken in colour after roasting. Roasting occurs in two stages, the first is a drying process in which the bean is subjected to low temperature heating. This dries and loosens the shell but has virtually no roasting effect on the nib as the temperature is unlikely to exceed 100°C. This initial heating is followed by higher temperature treatment, where the temperature may reach 125°C to130°C and this lasts for 7-11 minutes.

Breaking and winnowing

The roasted beans are broken down and the shells removed in a process called winnowing. The work of the winnower is to separate the shells as completely as possible from the nibs. This is checked by the quality assurance department by taking samples from each winnowing machine to determine the percentage of nibs in shells and shells in nibs, both should not exceed 1.5%. The separation by the winnowing process depends on the difference in the apparent density of the nibs in shell. The winnowing machines use a combine action of sieving and air elutriation.

Milling

After roasting, the nibs are grounded into paste. The heat generated by the process causes the cocoa butter in the nibs to melt. Nibs contain about 48-57% cocoa butter (Fowler, 2009). The milling reduces particle size of the non-fat constituent and the paste becomes progressively more fluid. The viscosity of the liquor is related to the degree of roasting preceding the grinding and the moisture content of the nib. The milling starts in SCS mills for coarse milling then Triple mills reduce the particle size further before finally milling with the Attritor mills. In the new system the Rheo mill is used first then the NOVAS. Specified storage tanks are used to store cocoa masse between each milling operation. The milled particles should have 90% of particles < 180 µm thus the fineness of the cocoa masse is tested in the laboratory by weighing 20 g of the masse, dissolving it in petroleum ether and sieving the dissolved masse in a sieve with a standard mesh size of 200 µm which allows only the fine particles to pass through. The percentage of the residue in the cocoa masse is calculated to know the fineness of the cocoa masse.

Storage and conditioning – CCP$_5$

The cocoa masse after milling is stored in large tanks called Jumbo Tanks. Cocoa liquor from the Jumbo Tanks may be tempered and used in chocolate manufacture or sold as a semi-finished product. The liquor to be pressed is sent to the hydraulic presses called Duyvis press that presses out cocoa butter separating out the cocoa solids. Prior to pressing, a Liquor Conditioning System (LCS) is used to condition the cocoa liquid from the Jumbo Tanks at 95-98^{o}C.

Pressing – CCP_6

The cocoa masse is pressed to obtain cocoa cake and cocoa butter. The press takes 70 minutes to press 200 kg of cocoa masse at a pressure of 540 bars with each pressing session to obtain cocoa cake and cocoa butter.

Centrifugation and filtration – CCP_7

The butter is filtered using a machine that functions like a centrifuge and filtered using special filter papers. The clarity and free fatty acid (FFA) content are tested by the quality assurance department. Clarity is tested using a polarimeter and its turbidity should not exceed 100 NTU. The percentage of free fatty acids in the cocoa butter is calculated by titration using cocoa butter, petroleum ether and sodium hydroxide.

Kibbling and pulverization

The cocoa cake obtained is kibbled and bagged for sale or further pulverized into cocoa powder and bagged for sale as semi-finished products or stored for later processing into finished cocoa products.

Milk chocolate manufacture

Figure 3 shows the main process flow scheme for processing semi-finished products into milk chocolate.

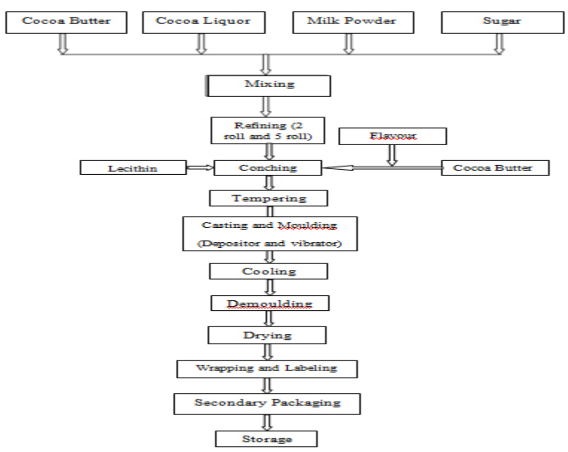

Figure 3. Flow chart for the processing of milk chocolate

Chocolate processing operations

Raw materials reception – CCP_1

The raw materials for chocolate processing such as cocoa liquor, cocoa solids and cocoa butter are received from the previous cocoa processing operation. Others such as milk powder, sugar, lecithin and vanillin are obtained from other sources for the chocolate factory's processing operation.

Mixing – CCP_2

This is the initial stage of ingredients homogenization. Mixing is done in a jacketed-pan called the kneader. Cocoa liquor, milk solids, sugar and cocoa butter are mixed in the kneader at about 45oC. The mixing takes about 6 minutes. The quantities of various ingredients used are detailed in Table 2 below. The fat content is between 20-25%. This allows coating of the surfaces of the solid particles with liquid ingredients for refining and due to the high temperature, moisture content is decreased slightly. A viscous paste is obtained after mixing and a conveyor belt transfers the mixture to the refiner.

Table 2. Quantities of ingredients used for milk chocolate per batch production

Ingredient	Quantity
Cocoa Liquor	110 – 120 kg
Milk Powder	140 – 180 kg
Sugar	180 – 350 kg
Cocoa Butter	70 – 100 kg
Lecithin	2 – 4 kg
Vanillin	300 – 400 g

Refining

This process breaks down further the tiny particles of milk, cocoa liquor and sugar within the mixture. The process is done in two steps. First step is crude refining which takes place in a two-roll refiner. This breaks down the particles to about 100-200 µm. and the mixture becomes semi-solid after this process. The second step involves the use of a five-roll refiner which reduces particle size to 18-35 µm (Afoakwa *et al.*, 2007a). Powdered crumbs are obtained after this process. This is because the reduction in particle size increases the surface area for the liquid phase to be absorbed. Particle size less 15 µm gives chocolate a clogging effect and particle size greater than 35 µm renders the chocolate sandy (Afoakwa *et al.*, 2007b).

Conching

The refined material is subjected to severe mechanical treatment of large heavy roller kneads which blends and grinds the mixture to produce a uniform smooth consistency. This process agitates the paste thus smoothing out the sugar grains to give the chocolate a silky texture. The paste is also aerated allowing acids and moisture to evaporate. This allows some of the natural volatile flavoring components that do not have a favorable effect on the taste of the chocolate to escape (DeZann, 2006). Vanillin is added at this stage to enhance flavor and lecithin is also added as an emulsifier. This process may last for 13-24 hours at temperatures 45-70°C. Conching takes place in three stages. The initial stage is the dry paste stage which lasts from the start to the finish of the filling operation of the conching machine. The tough plastic phase is next and this offers the highest resistance to the stirrers of the conche. The conche operates at full power and moisture is evaporated off at a high rate. As demoisturizing and beating proceed the mass becomes softer. The last stage is known as wet conching and extra cocoa butter is added to prevent the chocolate from spoilage and keep the chocolate solid at room temperature. From the conch the mixture is stored in a storage tank before feeding into the temperer for temperature management.

Tempering

Tempering is the process of cooling the melted chocolate to 50°C before it can be used to produce other products. Tempering involves pre-crystallization of a small proportion of triglycerides, with crystals forming nuclei (1-3% total) for the remaining lipid to set in the correct form. Tempering has four key steps: melting to completion (at 50°C), cooling to point of crystallization (at 32°C), crystallization (at 27°C), and conversion of any unstable crystals (at 29-31°C) (Talbot, 1999). Time-temperature combinations are of paramount importance in the process design and in continuous tempering, molten chocolate is usually held at 45°C then gently cooled to initiate crystal growth (Afoakwa *et al.*, 2008a,b). During tempering, the temperatures are precisely controlled and agitation provided enhances nucleation rates. As the viscosity increases, the chocolate is reheated again in the third stage to prevent runway solidification (Afoakwa, 2010). In the fourth stage, crystals are matured. This results in the final good surface gloss and colour, good snap, smooth and fast melting and good heat stability.

Casting and moulding – CCP_3

The temperer sends the tempered mixture to the Chocomaster, an automated system for moulding and demoulding of chocolate. The mixture first enters the hopper of the depositor which deposits chocolate into 20 g, 50 g and 100 g moulds depending on the selected mould type. The depositor automatically fills molten chocolate into moulds which are set to be of the same temperature as the chocolate. If the moulds are too hot, detempering would occur resulting in the product sticking in the impressions of the mould leading to poor gloss and bloom. If they are too cold, poor gloss and sticking in the mould can result with an increase in the number of air bubbles and markings on the finished product. Hence, a vibrator is made to shake each mould to level the liquid chocolate in the moulds to release the air bubbles.

Cooling

The moulds after vibrations pass through the cooling section which is a multi-tier cooler. This is a mechanised process that passes the moulds gradually layer by layer through the cooler reducing the temperature of the chocolate to about 12-15°C solidifying the chocolate into bars.

De-moulding

With optimized tempering and cooling, de-moulding becomes a minor part of the process resulting in good quality product. During demoulding, a small amount of force is needed to part the product from the mould and this is sometimes supplied by a hammer, aided by a mechanism that twists the moulds. Product is de-moulded onto a belt which conveys chocolate onto plastic trays. These trays are collected onto trolleys and wheeled to nearby wrapping plants. The period between the deposition on trays and wrapping is known as the drying stage where excess moisture on the surface of the products is lost.

Wrapping/packaging – CCP_4

At the wrapping plants, trays of chocolate are emptied onto a conveyor belt which transports chocolate into the wrapping machine. The wrapping machine, depending on the grams/size of the chocolate cuts aluminium foil and picks up a paper wrapper. The aluminium foil initially covers the chocolate before the paper wrapper. The foil provides the best barrier to water vapour, gas transmission, maintaining aroma and cool temperature of the chocolate. The paper material is also chosen because it is strong, easily printed and relatively inexpensive. The machine then labels the chocolate with the batch number as well as the production and expiry date. Wrapped chocolates without any defects are manually picked and boxed before sending to the warehouse for storage at temperatures between 18-20ºC.

Hazard analysis

The hazard analysis worksheets in Tables 3 and 4 show the different process steps which were each associated with different risk assessment values. These range widely from 1-16 with one being the least value. These values were obtained by multiplying the occurrences and severity values and they serve to choose among the hazards listed for a food product, especially those that are likely to or severe enough to warrant preventive action (Arvanitoyannis and Varzakas, 2008).

Table 3. Hazard analysis worksheet for semi-finished products

Product: Semi-Finished Cocoa Products

Process: Bean reception, Cleaning, Metal Detection, Silo (storage), De-bacterization, Roasting, Winnowing, Milling, Conditioning, Pressing, Centrifuging and Filtering, Tempering, Kibbling and Pulverisation

No.	Process step	Hazard	Category	Hazard Assessment O	S	RA	Control/Preventive Measure	Monitoring Procedure	Officer Responsible
1	Bean reception	Contamination with glass, fibres, wood plastic, human hair, ferrous and non-ferrous metals	Physical	4	4	16	Use of vibrating screens, classifier, destoner and an effective metal detection device.	Equipment cleaning every two hours during bean cleaning Check effectiveness of metal detector using 0.1mm Fe test piece	Factory / ProductionManager Quality Assurance Manager
		Insect infestation	Physical	1	4	4	1. Insistence on buying readily fumigated beans 2. Regular supply audits	Cut-test on every batch of cocoa beans received Every three months	Quality Assurance Manager
		Contamination with pesticide residue, heavy metals and mycotoxins	Chemical	4	4	16	Supply audits to ensure use of approved fumigants/insecticides and to ensure that adequate waiting period after application of chemicals was observed.	Before purchasing cocoa beans	Quality Assurance Manager
		Contamination with moulds.	Microbiological	1	4	4	Regular check for mouldy beans	Cut-test	Quality Assurance Manager
2	Silos (storage)	Mould growth	Microbiological	2	4	8	1. Effective air circulation and temperature management systems 2. Avoid long storage of cocoa beans.	With every batch of cocoa beans stored Every two hours	Factory / Production Manager
3	De-bacterization	Contamination with *Staphylococcus aureus*, coliforms, *Salmonella*, *Aspergillus* and *Penicillium*	Microbiological	1	4	4	1. Check steam boiler and pipes for adequate heat supply 2. Ensure that pressure system and delivery valves are functioning adequately	With every batch With every batch	Factory / Production Manager
4	Roasting	Contamination with *Staphylococcus aureus*, coliforms, *Salmonella*	Microbiological	1	4	4	Monitor roasting temperature of roasters.	Every thirty minutes	Factory / Production Manager
5	Breaking and Winnowing	Contamination of nibs with shells	Physical	4	1	4	Collect samples from winnowers to determine the shell in nibs as well as the nibs in shell ratio	Every thirty minutes	Quality Assurance Manager
6	Milling	Physical contamination of mass eg metal shavings or residues	Physical	1	4	4	Good maintenance practices	Every maintenance session	Factory / Production Manager
7	Conditioning	Microbial contamination	Microbiological	2	4	8	Regular checks of temperature of mass in the tanks	Every forty five minutes	Factory / Production Manager
		Contamination with metal residues	Physical	1	4	4	Good maintenance practices	Every maintenance session	Factory / Production Manager
8	Pressing	Hydraulic oils may spill into cocoa mass when pressing	Chemical	4	3	12	Use of food grade oils for the press machine	Every batch constantly	Factory / Production Manager
9	Centrifuging and Filteration	Physical contamination with cocoa solids	Physical	4	1	4	Check clarity with a polarimeter Good maintenance practices	Every thirty minutes With every batch	Quality Assurance Manager Factory / Production Manager
10	Tempering	Microbial contamination	Microbiological	2	4	8	Good maintenance practices and good hygienic practices	Every batch constantly	Factory / Production Manager
11	Kibbling and Pulverisation	Contamination of mixture with metal shavings	Physical	1	4	4	Good maintenance practices	Every maintenance session	Factory / Production Manager

Table 4. Hazard analysis work sheet for milk chocolate production

Product: Milk Chocolate

Process: Raw materials reception, Mixing, Refining, Conching, Casting and Moulding, Wrapping and Labelling, Secondary Packaging, Storage.

No.	Process step	Hazard	Category	Hazard Assessment O	S	RA	Control/Preventive Measure	Monitoring Procedure	Officer Responsible
1	Raw materials reception	Contaminated raw materials introduce *salmonella* and other microorganisms	Microbiological	4	4	16	Microbiological count of microorganisms present and perform regular supply audits	Every batch of raw materials received	Quality Assurance Manager
2	Mixing	Contamination with plastic, fibre, hair or metal	Physical	3	4	12	Ensure good manufacturing practices	Every time mixer is being filled	Factory / Production Manager
3	Refining	Contamination of mixture with metal shavings or residues	Physical	1	4	4	Good maintenance and sanitation practices	Every week	Factory / Production Manager
4	Conching	Contamination of mixture with metal shavings or residues	Physical	1	4	4	Good maintenance and sanitation practices	Every maintenance session	Factory / Production Manager
5	Casting and Moulding	Microbial contamination	Microbiological	2	4	8	1. Heat treatment of moulds 2. Good hygienic and maintenance practices	Just before casting Constantly	Factory / Production Manager
6	Wrapping and Labelling	Microbial contamination	Microbiological	2	4	8	Good hygienic practices and proper handling of wrapping materials. Check microbial counts	With every batch constantly Every batch produced	Factory / Production Manager
7	Storage	Odours, Sugar bloom and fat bloom	Physical	1	4	4	Effective air circulation and temperature management systems	Monitored every two hours	Factory / Production Manager

Key

No. – Number, O – Occurrence, S – Severity, RA – Risk Assessment

1 = Lowest Rank – 4 = Highest Rank in the occurrence and severity columns

The figure presented in the risk assessment columns is the product of the occurrence and severity values.

Table 5. Identification of Critical Control Points (CCPs) based on HACCP decision tree (Codex Alimentarius, 1999) for semi-finished products

Processing Step	Hazard	Do preventive control measures exist?	Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level?	Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels?	Will a subsequent step eliminate identified hazards or reduce likely occurrence to an acceptable levels?	Is the processing step a CCP?
Bean Reception	Physical	Yes	Yes	-	-	CCP1
	Chemical	Yes	No	Yes	No	CCP1
	Microbiological	Yes	No	Yes	No	CCP1
Silos (storage)	Microbiological	Yes	Yes	-	-	CCP2
De-bacterizer	Microbiological	Yes	Yes	-	-	CCP3
Roasting	Microbiological	Yes	Yes	-	-	CCP4
Breaking and Winnowing	Physical	Yes	No	No	-	Not CCP
Milling	Physical	Yes	No	No	-	Not CCP
Conditioning	Microbiological	Yes	Yes	-	-	CCP5
	Physical	Yes	No	No	-	Not CCP
Pressing	Chemical	Yes	Yes	-	-	CCP6
Centrifuging and Filtration	Physical	Yes	Yes	-	-	CCP7
Tempering	Physical	Yes	No	No	-	Not CCP
Kibbling and Pulverisation	Physical	Yes	No	No	-	Not CCP

Table 6. Identification of Critical Control Points (CCP) based on HACCP decision tree (Codex Alimentarius, 1999) for milk chocolate production

Processing Step	Hazard	Do preventive control measures exist?	Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level?	Could contamination with identified hazard(s) occur in excess of acceptable level (s) or could these increase to unacceptable levels?	Will a subsequent step eliminate identified hazards or reduce likely occurrence to an acceptable levels?	Is the processing step a CCP?
Raw materials reception	Microbiological	Yes	Yes	-	-	CCP1
Mixing	Physical	Yes	Yes	-	-	CCP2
Refining	Physical	Yes	No	No	-	Not CCP
Conching	Physical	Yes	No	No	-	Not CCP
Casting and moulding	Microbiological	Yes	Yes	-	-	CCP3
Wrapping and labelling	Microbiological	Yes	Yes	-	-	CCP4
Storage	Physical	Yes	Yes	No	-	Not CCP

A hazard such as the contamination of cocoa liquor with metal shavings or residue as well as other physical hazards such as loose screws, paper or plastics is low and the milling process step has an associated risk assessment of 4 because the likelihood of occurrence is low due to good maintenance practices. The risk assessment for microbial contamination associated with spoilage and pathogenic microorganisms with raw materials receipt for chocolate production was 16 because the various raw materials carry these microorganisms, for example, milk powder has been implicated in a large number of salmonellosis outbreaks (Bell and Kyriakides, 2009).

The major hazards identified in the processing of cocoa beans and chocolate manufacture were physical, microbiological and chemical in nature. The most predominant hazards for cocoa processing are physical hazards due to the high physical contamination of raw materials, physical contamination during processing and physical hazards due to failures of pre-requisite programmes (Burndred, 2009). The highest risk assessment for physical contamination was observed with the receipt of dried fermented cocoa beans which was 16 due to high risk of severity and occurrence. The most predominant hazards for milk chocolate manufacture were microbiological and physical hazards. The use of regular supply audits on raw materials reception, Good Hygienic Practices (GHPs), Sanitation Standard Operating Procedures (SSOPs) and good maintenance practices eliminate these microbial and physical hazards.

Determination of critical control points

Tables 5 and 6 show the determination of critical control points (CCPs) for production of

Table 7. ISO 22000 analysis worksheet for the determination of pre-requisite programmes for semi-finished cocoa products

Processing step	Are the technical infrastructure and the preventative maintenance programme adequate?	Is it feasible to evaluate them?	Do they contribute in the control of recognisable food safety hazards?	Does the effectiveness of the remaining control measures depend on them?	Is it a pre-requisite programme?
Bean reception	Yes	Yes	Yes	No	No
Silos (storage)	Yes	Yes	No	No	Yes
De-bacterization	Yes	Yes	Yes	Yes	Yes
Roasting	Yes	Yes	Yes	Yes	No
Breaking and Winnowing	Yes	Yes	No	Yes	Yes
Milling	Yes	Yes	No	No	Yes
Conditioning	Yes	Yes	No	Yes	Yes
Pressing	Yes	Yes	No	Yes	Yes
Centrifuging and Filtration	Yes	Yes	No	No	Yes
Tempering	Yes	Yes	No	Yes	Yes
Kibbling and Pulverisation	Yes	Yes	No	No	Yes

Table 8. ISO 22000 analysis worksheet for the determination of pre-requisite programmes for milk chocolate

Processing step	Are the technical infrastructure and the preventative maintenance programme adequate?	Is it feasible to evaluate them?	Do they contribute in the control of recognisable food safety hazards?	Does the effectiveness of the remaining control measures depend on them?	Is it a pre-requisite programme?
Raw materials reception	Yes	Yes	No	Yes	No
Mixing	Yes	Yes	No	Yes	Yes
Refining	Yes	Yes	No	Yes	Yes
Conching	Yes	Yes	No	Yes	Yes
Casting and moulding	Yes	Yes	No	Yes	Yes
Wrapping and labelling	Yes	Yes	No	Yes	Yes
Storage	Yes	Yes	No	No	Yes

Table 9. Comparative presentation of CCPs determined with HACCP and ISO 22000 analyses in conjunction with pre-requisite programmes for cocoa processing

Processing step	CCP according to HACCP	Pre-requisite programmes (ISO 22000)	CCPs according to ISO 22000
Bean reception	Yes CCP1	No	CCP1
Silos (storage)	Yes CCP2	Yes	No
De-bacterization	Yes CCP3	Yes	No
Roasting	Yes CCP4	No	CCP2
Breaking and Winnowing	No CCP	Yes	No
Milling	No CCP	Yes	No
Conditioning	Yes CCP5	Yes	No
Pressing	Yes CCP6	Yes	No
Centrifuging and Filtration	Yes CCP7	Yes	No
Tempering	No CCP	Yes	No
Kibbling and Pulverisation	No CCP	Yes	No

Table 10. Comparative presentation of CCPs determined with HACCP and ISO 22000 analyses in conjunction with pre-requisite programmes for chocolate production

Processing step	CCP according to HACCP	Pre-requisite programmes (ISO 22000)	CCPs according to ISO 22000
Raw materials reception	Yes CCP1	No	CCP1
Mixing	Yes CCP2	Yes	No
Refining	No CCP	Yes	No
Conching	No CCP	Yes	No
Casting and moulding	Yes CCP3	Yes	No
Wrapping and labelling	Yes CCP4	Yes	No
Storage	Yes CCP5	Yes	No

semi-finished cocoa products and milk chocolate manufacture respectively, based on the HACCP decision tree (Codex Alimentarius Commission, 1999). Seven critical control points were identified for the production of semi-finished cocoa products while four critical points were identified for the manufacture of milk chocolate.

Determination of pre-requisite programmes

The ISO 22000 analysis worksheet was used in the determination of the pre-requisite programmes for the processing of cocoa into semi-finished products and for the manufacture of milk chocolate. Tables 7 and 8 show the identified pre-requisite programmes for semi-finished cocoa products and milk chocolate respectively. Nine pre-requisite programmes were identified for production of semi-finished cocoa products while six pre-requisite programmes were identified for milk chocolate manufacture.

The questions frequently asked for each processing step involve those regarding the adequacy of the technical infrastructure and preventive maintenance, the feasibility for their evaluation, their contribution in the control of recognisable food safety hazards, whether the effectiveness of the remaining control measures depends on them (Mensah, 2010). The answers to these questions determine whether a process step is a pre-requisite programme step or not. Tables 9 and 10 present the comparison between the application of HACCP and ISO 22000 analysis worksheets to the processing of cocoa into semi-finished products and milk chocolate manufacture respectively.

Conclusion

During cocoa processing and chocolate manufacture, physical hazards such as metals, stones, fibres, plastics and papers; chemical hazards such as pesticide residues, mycotoxins and heavy metals; and microbiological hazards such as *Staphyloccous* *aureus*, coliforms, *Salmonella*, *Aspergillus* and *Penicillium* were identified. Good Manufacturing Practices (GMPs), Good Hygienic Practices (GHPs), Sanitation Standard Operating Procedures (SSOPs) and maintenance systems with written and well documented pre-requisite programmes were implemented to ensure the safety and quality of the processing of cocoa beans into liquor and cocoa powder, and in chocolate manufacture. The HACCP decision tree was employed to determine CCPs, and seven CCPs including bean reception, storage in silos, de-bacterization, roasting, conditioning, pressing, and centrifugation and filtration were identified for the cocoa processing operations. Four CCPs including raw materials reception, mixing, casting and moulding, wrapping and labelling, were identified for the chocolate manufacturing operations.

In the application of the ISO 22000 requirements, the seven CCPs identified for the cocoa processing operation using the HACCP system were reduced to two, namely bean reception and the roasting process steps; and only one CCP - the reception of raw materials was obtained for chocolate manufacture. The reduction in CCPs was due to the elimination of pre-requisite programmes from the cocoa processing and chocolate manufacturing steps. Thus, the application of ISO 22000 worksheet with HACCP in identifying CCPs makes the implementation of the HACCP system simple, more effective and manageable since less CCPs were obtained.

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