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Design of HACCP Plan for Biscuit Industry in Bangladesh.

Anis Alam Siddiqui[1] and Md. Abdul Alim[2]

[1]Deptartment of Food Engineering and Technology, Sate University of Bangladesh.

[2]Dept. of Food Technology & Rural Industries, Bangladesh Agricultural University.

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ABSTRACT

The purpose of this study is to design Hazard Analysis and Critical Control Point (HACCP) plan for biscuit production based on real conditions in the plant. A specific model has been developed to boost the safety and quality of biscuit product in this plant. The spread of some diseases by unsafe products due to pathogen reported makes it important to pay attention to the potential contamination in biscuit production. The prerequisite programs (PRPs), operational prerequisite programs (OPRPs), standard operating procedures (SOPs), hazards identification, critical control point, preventive measure, critical limits, monitoring procedure and corrective actions have been designed in this HACCP plan. The production process of the product was also analyzed carefully for this HACCP plan.

1. Introduction

HACCP is an acronym for the Hazard Analysis Critical Control Point. It is a system that was developed for assuring pathogen-free foods. It provides specific process control measures for each step of the entire food manufacturing process. HACCP concepts are now not new in food industries. HACCP was first developed in the late 1950s by a team of food scientists and engineers from The Pillsbury Company, the Natick Research Laboratories, and the National Aeronautics and Space Administration (NASA) in USA. The team developed a system designed to build quality into the product to ensure food safety for the manned space program (Surak, 2009). In 1993, the Codex Alimentarius Commission (CAC) issued its first HACCP standard, which provided the first international definition for HACCP.

HACCP has been recognized as an effective and rational means of assuring food safety from primary production through final consumption, using a "farm to table methodology". Now with the introduction of food quality and safety systems HACCP has become synonymous with food safety (Codex, 1993; FAO, 2001). It is a world-wide recognized systematic and preventive approach that addresses biological, chemical and physical hazards through anticipation and prevention, rather than through end-product inspection and testing and thereby reducing the food-borne illness (Gandhi, 2009).

Banat *et al.* (2004) stated that the assurance of safe production and the supply of adequately safe and healthy food products appear to be the main aims of the food industry. These aims can be achieved by adopting a systematic and organizational structure, controlling activities, procedures and resources according to the standards which constitute the basis for total quality systems, including ISO 9000 series and the Hazards Analysis Critical Control Points (HACCP).

HACCP system demands a high initial quality of financial resources. The initial input of this system requires additional resources for staff training, equipment and extra supplies, purchase as well as technical support (Morjajemi *et al.*, 1999)

2. Materials and Methods

This study was conducted in Nabisco Biscuit & Bread Factory Ltd. in Tejgaon Industrial Area, Dhaka, Bangladesh which is categorized as large scale plant as production capacity is forty five ton per day and no. of employees are around 1065. The restructuring was aimed at expanding the company's market. Consequently, the company plans for effective quality system to ensure safe and good quality products.

2.1. Research method

This research study did not use quantitative research. The purpose of this study was to design a HACCP model that is implementing in real situation. This study matched a qualitative approach. It gives the details of phenomena that are difficult to convey with quantitative methods. Qualitative research is exploratory and open-minded which is applicable to this study (Patton, 1987).

2.2. Research approach

This research was done for a biscuit plant. Based on the seven principles of HACCP, several models of HACCP system (Zhao, 2003; Burson,1998; Gandhi, 2008; Gandhi, 2009), guidelines (FAO, 2004; FAO, 2003; USDA, 2006) and HACCP requirements (SCV, 2006), the recordkeeping in this study were designed in the following manner. Hazard analysis chart and process step decision matrix (Table-2) is modified from Mortimore and Wallace (1997) model.

1. Prerequisite program
2. Product description.
3. Production Process with flow diagram.
4. Hazards Identification and Critical Control Point (CCP) Determination

Tele: +8801715164951

E-mail address: siddique@sub.edu.bd

5. HACCP control chart.

The purpose of this study was to design a HACCP model for possible implementation in an actual situation. The study matched a qualitative approach because it provides depth and careful scrutiny of the program situation. The study observed behavior was also recorded. Events, employee interaction and observed behavior. It gives the interacted details of phenomena that are difficult to convey with quantitative methods. Qualitative research is exploratory and open-minded which is applicable to this study (Patton, 1987).

The decision tree (Figure-1) is used to identify Critical Control Point (CCP) for process (CAC/RCP 1-1969, Rev. 4-2003).

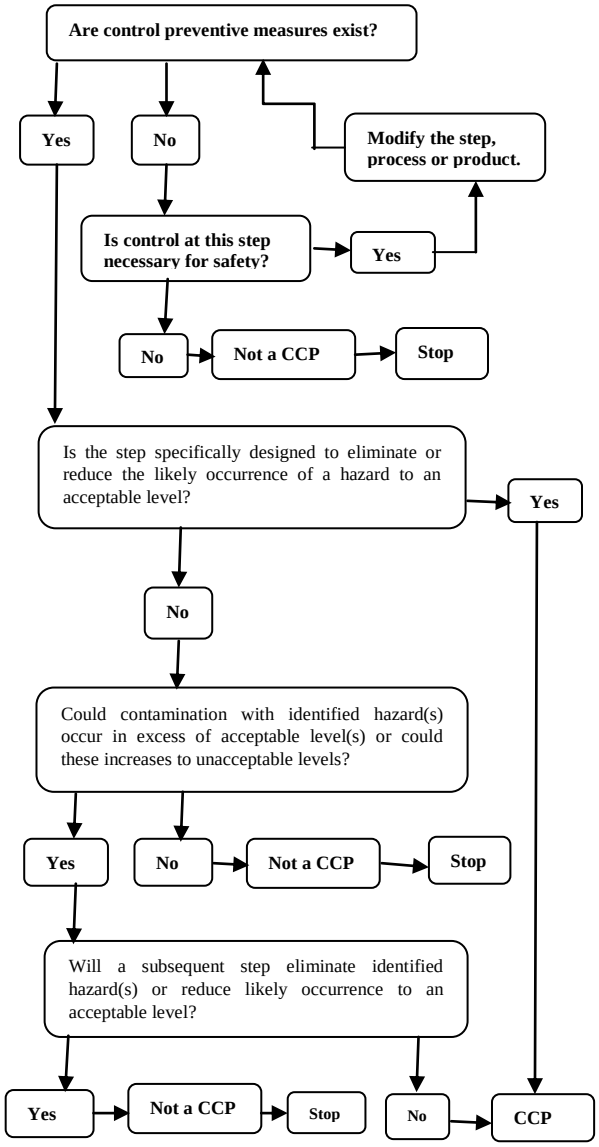

Figure 1. Decision Tree to Identify CCPs.

3.Results & Discussion

Based on the principle of the HACCP and several generic models, the HACCP model was designed to suit the real situation of the biscuit plant to produce the safe and quality end product.

3.1.Prerequisite program

Prerequisite program (PRP) is implemented in accordance with codex general principle of food hygiene and good manufacturing practice to establish basic conditions that are suitable for the production and handling of safe food at all stages of the food chain (SCV, 2006). There are several programs used in this plant:

3.2.Location

The plant is located at the area that there is no threat to food safety as it is away from environmentally polluted. It is situated in well established industrial area that has sufficient safeguard against flooding, not prone to infestation of pests.

3.3.Premises and Room

The premises are designed in such a manner that permits good food hygiene practices and protect cross contamination. The walls are water, insect and rodent proof. Wall angles, corners and junctions of walls and floors are sealed and rounded to facilitate cleaning. The floor of the production area is established with the covered drain for liquid to drain and the netted doors are inside auto-closing. There are also have floor drains are 30 cm deep and directly connected to the municipal waste management plant. The floor is tiled and a certain height of wall is also covered with tile for easy cleaning. The doors and windows are made of glass covered with finished aluminium structure and 15 exhaust fans with air filter that maintain fresh airflow which reduce heated vapor and thus maintain relative humidity and temperature. It is routinely cleaned and sanitized by a professional cleaner with vacuum cleaner and broom stick. The floor is cleaned daily before and after each shift of production.

3.4.Equipment

The equipment is stainless steel and other materials that are suitable for food industries and design construction is easily maintainable. All the equipments are checked routinely to ensure a smooth running system and free of cracks, rust and dents.

3.5.Water supply

The plant has own water supply system and storage system to provide adequate potable water for the process. The water portability is tested at every three month and complied with the national water quality standard of Bangladesh.

3.6.Maintenance and Cleaning

The establishment and equipment are kept in appropriate state of repair and condition to facilitate all sanitation procedures. The floor cleaner (basic detergent), bench top cleaner (steam sterilizer) and equipment cleaner (chlorinated foam cleaner and diluted caustic soda) are used as cleaning and disinfectant agent. A documented cleaning and disinfection method has been maintained for this purpose. The cleaning program also has been conducted by master cleaning schedule of daily, weekly and monthly.

3.7.Pest control

The pest control activities have been contracted to Scorpion Services which is professional in food industries. They conduct their activities at every week in presence of Human Resource Personnel.

3.8.Waste management

The company has not any effluent treatment plant but municipal waste treatment plant is near about industrial area. The proper drainage system was introduced inside and throughout the factory which cover total manufacturing compound.

3.9.Sanitation system

The sanitation facilities have been properly set up to eliminate possible hazards from equipments, containers etc. The sanitation system is monitored for effectiveness and periodically inspected by proper cleaning of equipments.

3.10.Personal Hygiene

All the personnel of production, packaging and storage areas use apron, hand gloves, mask, head covering and

footwear. Hands free hand washing facilities with liquid hand wash with hot air blowers are used before starting their activities and work interval. Medical checkup of every employee is done by registered medical officer at regular interval and any sick and injured person is not allowed to enter and work in processing areas. The dresses are properly cleaned at least a week. The personal cleanliness is monitored on regular basis before entering into processing areas by administrative personnel. The same instructions are also applied for visitors. All these things are properly monitored and inspected by Manager (Administration).

3.11.Storage and transportation

The storage rooms are cleaned, temperature and humidity controlled and some are air conditioned that is monitored by hygrometer and data logger. Daily inspection of the conditions ensured a consistent environment to prevent the hazards and produce quality products. The company has 15 covered vans for safe transportation of raw and finished product. Proper transportation equipments are used where cleanliness, temperature and separation of food items and non food items are considered and monitored.

3.12.Traceability

Lot no, Batch no, incoming date, production date, premix making date etc. are properly maintained for proper identification and traceability. First In First Out (FIFO) system is also maintained for all raw and packaging materials.

3.13.Training

Training of employee is designed as three categories such as Fresher's training for newcomers, retraining for rejoin employee and staff and finally, periodic training and on job training for all employee and staff at an interval of three months. The training covers personal hygiene, occupational health and safety issues, production process and food safety issues including cleaning and sanitizing system.

3.14.Implementing process of HACCP

HACCP can be applied throughout the food chain from primary production to final consumption and its implementation should be guided by scientific evidence of risks to human health. As well as enhancing food safety, implementation of HACCP can provide other significant benefits, such as the application of HACCP can aid inspection by regulatory authorities and promote international trade by increasing confidence in food safety.

The successful application of HACCP requires the full commitment and involvement of management and the work force. It also requires a multidisciplinary approach; this multidisciplinary approach should include, when appropriate, expertise in production, microbiology, public health, food technology, environmental health, chemistry and engineering.

Prior to application of HACCP to any business the food business operator should have implemented the prerequisite food hygiene requirements. Management commitment is necessary for implementation of an effective HACCP. During hazard identification, evaluation, and subsequent operations in designing and applying HACCP, consideration must be given to the impact of raw materials, ingredients, food manufacturing practices, role of manufacturing processes to control hazards, likely end-use of the product, categories of consumers of concern, and epidemiological evidence relative to food safety.

The intent of HACCP is to focus control at critical control points (CCPs). HACCP should be applied to each specific operation separately. The HACCP application should be reviewed and necessary changes made when any modification is made in the product, process, or any step. It is important when applying HACCP to be flexible where appropriate, given the context of the application taking into account the nature and the size of the operation.

A team consisting of six members was constituted, with one of them acting as a team leader. The team consisted of senior QA manager, production manager/food technologist, microbiologist, purchasing department, stores officer and maintenance engineer. The flow diagram is specific for the biscuit production in this plant. The details of the flow diagram are shown in Figure 1. The process flow diagram was verified to establish that the diagram accurately represents the actual activities and operations used in the manufacture of the product. This was done by observing each step of the manufacturing process. The description of product (Table 1) was used to alert the consumer of potential hazards in the final product.

Table 1. Product Description of High Energy Biscuit.

ITEMS	**PRODUCT DESCRIPTION**	
Product Description	High Energy Biscuit Eight biscuit each packet. Weight 75 grams. Flavour: soya flavor.	
Product Specification	**Minimum Nutrition Composition / 100 gm:**	
	a) Nutritional value **a) Nutritional value**	**b) Micronutrients Level:**
	•Energy: 450 kcal •Moisture: 4.5% maximum •Protein: 10-15 g •Fat: 15 g •Calcium: 212.5 - 287.5 mg •Magnesium: 127.5 – 172.5 mg	•Vitamin A-retinol: 212.5 – 287.5 mcg. •Vitamin D: 1.615 – 2.185 mcg. •Vitamin E: 4.25 – 5.75 mg. •Vitamin B1: 0.425 – 0.575 mg. •Vitamin B2: 0.595 – 0.805 mg. •Vitamin B3 (Niacin): 5.1 – 6.9 mg •Vitamin B5: 2.55 – 3.45 mg. •Vitamin B6: 0.85 – 1.15 mg. •Vitamin B12: 0.425 – 0.575 mcg. •Folic Acid: 680 -920 mcg •Vitamin C: 17.0 – 23.0 mg. •Iron: 9.35 -12.65 mg. •Iodine: 63.75 – 86.25 mcg. •Zinc: 7.00 – 8.00 mg.
Packaging (Primary & Secondary)	High energy biscuits are packed in food grade laminated aluminium foil bags. The quantities of biscuit will 73-76 grams. This is packaging by automatic packaging machine. Then the primary packet is put into secondary packet/carton which is made by 5 ply (2 corrugated & 3 plane papers).	
Method of Storage	Carton box are put on the wooden rack as like as brick wall.	
Storage Conditions	Cartons are stored at ambient temperature and below 40% RH.	
Distribution Method	Covered van, Track, Pick-up.	
Shelf Life	6 months.	
Intended Use	For malnourish school going children.	
Customer Preparation	No preparation required, direct consumption.	

3.15.Product description

Product description mean a full description of the product including relevant safety information like

composition, physical /chemical structure (pH, aw), microbial treatment, packaging, shelf-life, storage condition, method of distribution and moreover, it includes intended use (SCV, 2006). The product description for biscuit is shown in Table-1.

3.16.Manufacturing Process of Biscuit:

Water, ammonium bicarbonate, sodium bicarbonate, salt, vitamin & nutrient premix, soy flour, dalda and hydrogenated vegetable oil mixed initially by homogenization as premix. Final dough formation was done by final mixing with premix, wheat flour and sugar. After moulding and cutting, biscuit shape was formed. Baking was done with 200 – 350^0 C for 6 to 10 minutes. Cooling was done in room temperature. The biscuits were packed in food grade laminated aluminium foil bags using as primary packaging and stored in 5 ply corrugated cartons under ambient conditions (21-30^0 C and 40-60% RH).

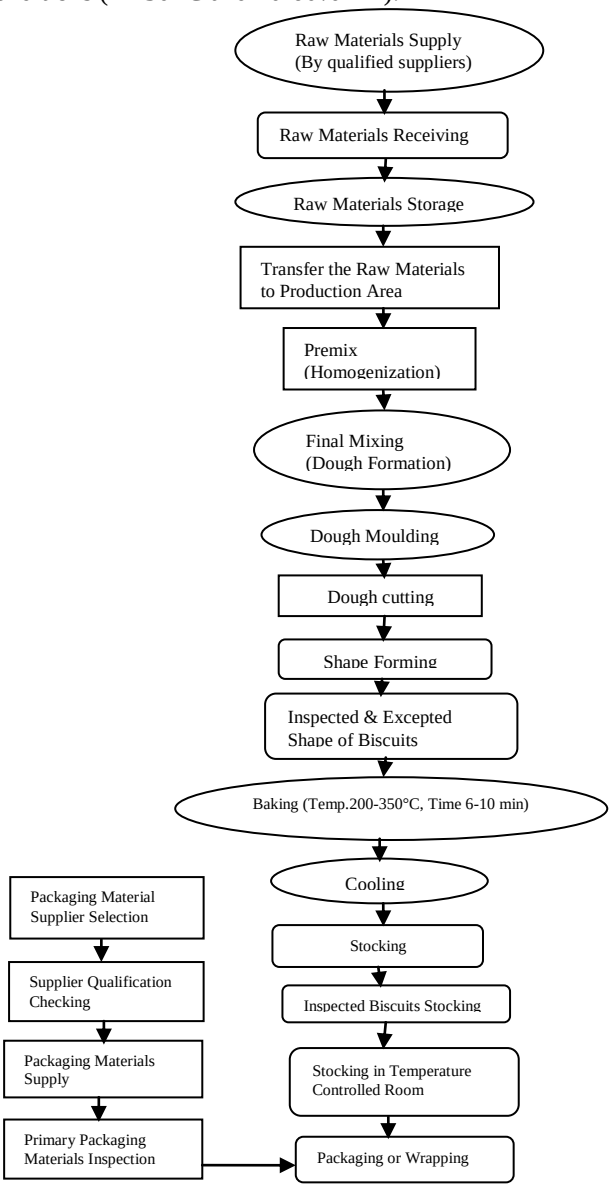

Figure 2. Flow diagram of fortified high energy biscuit.

3.17.Hazards Identification and Critical Control Point (CCP) Determination

A hazard is defined as any biological (B), physical (P) or chemical (C) property that could cause a product to be unsafe for consumption (Northcutt & Russell, 2010). Hazard analysis or identification is generally considered to be a two-step process.

The first step is to identify the threats to human health which might be introduced into biscuits as those products are manufactured. The hazards associated with processing line for biscuits manufacturing are shown in Table-2.

CCP is a step at which it is essential that a specific control measure is applied to prevent or eliminate a food safety hazard or reduce the risk to an acceptable level (SCV, 2006). The cooking temperature should be taken as a CCP as internal temperature of product verify the adequacy of the cook (Codex, 2005). The decision tree (Figure-1) is used to identify the Critical Control points (CCPs) for process shown in Table-2.

Quality deterioration of flours by microbial contamination is critical due to reduction of shelf life of flours for biscuits manufacturing. Gluten content in flours and sugar content in biscuit ingredients are important factor regarding quality attributes of biscuits. The presence of chemical contaminants in biscuits ingredients is critical due to possible heat stability of chemical contaminants and chemical changes after heating as adulteration is a very common factor in Bangladesh. Physical and microbial hazard in raw materials and chemical hazard in packaging material are also critical. The time and temperature of baking depend on which, are most critical point for biscuits manufacturing due to moisture reduction and microorganism destruction. Aluminium foil packaging system has advantages like retention of the product crispiness, colour, flavour and shelf life. Storage and distribution condition are critical to comply with consumer acceptability and shelf-life.

The HACCP control chart (Table-3) showed all the potential critical hazards that can occur during the processing steps in this biscuit plant along with no. of critical control point, Critical limits, monitoring procedure and frequency, preventive and corrective action, records and responsible person. The potential control points of the hazards appeared in both raw material and the process. Gandhi (2009) included hazard description, critical limit, observation procedure, responsible person, monitoring procedure and corrective action in his HACCP Control chart for production of soy milk where as Burson (1998) reported processing step, records and verification procedure in his control chart of meat product. Zhao (2003) reported processing step in HACCP control chart for cheddar cheese which is also similar to this proposed control chart. Two CCPs i.e. frying and packaging were found in manufacturing of high energy biscuits.

4.Conclusion

The study designed a HACCP plan model for a biscuit manufacturing plant to improve the safety and quality of products. The model is developed step-by-step based on the seven principles of HACCP system .The prerequisite program was provided to deal with some hazards before the production; therefore, to simplify the HACCP plan. The product description was used to alert the consumer to the potential hazards in the final products. Then, the potential control points of the hazards appeared in the process along with the prevention measures. By answering the questions in the decision trees, the critical control points were determined. Finally, the HACCP control chart was developed to include components of several HACCP principles which are critical limits, monitoring and corrective action. Three CCPs were found in the manufacturing of high energy biscuits. These are baking, metal detecting and packaging.

Table 2. Hazards in Process and CCP Decision Matrix Chart analysis.

Step Number	Process Step	Hazard Types	Hazard Description	Control Measures (SOP's or Work Instructions)	Q.1 Do Preventive Measure Exist in this step.	Q.2 Does This Step Eliminate / Reduced The Likely Occurrence Of Hazard To An Acceptable Lev1el?	Q.3 Could Unacceptable Contamination Occur?	Q.4 Will Subsequent step Eliminate BCP Hazard?	OPRP/CCP
1.	Receiving raw materials & ingredients	B	Biological hazard Content in flour and other raw materials.	Microbiological and Chemical test of raw materials, ingredients and other product. Standard operating procedure (SOP) for wheat flour and other raw materials receiving and also have on SOP on supplier's selection & inspection.	Y	N	Y	Y	OPRP
		C	Over fumigation during wheat storage. Additives induced in colour and Residue of chemicals						
		P	Foreign Particle						
2.	Storage area	B	Biological hazard due to excess moisture containing flour.	SOP for wheat flour receiving SOP for wheat flour sieving SOP for temperature & humidity control in storage area. SOP for pest control in storage area.	Y	N	Y	Y	OPRP
		C	Aflatoxin contamination of wheat flour due to higher humidity in store area						
		P	Physical hazard due to excess wheat bran & insect excreta.						
3.	Premixing	B	Introduction of microbiological hazard from raw water, flour etc	Control and Regular checks of raw material by mechanical shifter, magnets. Personal training and maintenance	Y	N	Y	Y	OPRP
		C	Introduction to chemical hazards from excessive use of food additives.						
		P	Introduction to physical hazards as iron chips yearns etc from sugar, wheat flour.						
4.	Mixing	B	Microorganisms from equipment, raw materials and water	Control & Regular checks of raw materials & water quality. Clean in place (CIP) machines as PRP. Proper lubricant & regular maintenance of equipment.	Y	N	Y	Y	OPRP
		C	Residue of cleaning agents and lubricants						
		P	Foreign particles						
5	Molding, cutting & forming of Dough	B	Microbial contamination from machine surface	CIP machines as PRP & proper maintenance	Y	N	Y	Y	OPRP
		C	Residue of cleaning agents & lubricants						
		P	Foreign materials						
6	Baking	B	Microorganism from equipment, raw material, workers etc.	Higher baking temperature can kill the entire microorganism.	Y	Y			CCP
		C	Lubricants from forming machine & residue of cleaning agent	CIP machines as PRP & proper maintenance	Y	N	Y	Y	

		P	Foreign matter from machine surface						
7	Cooling	B	Microorganism from air, conveyor surface, equipment etc.	Strictly check the cooling conveyor area. Control, regular checks & cleaning the surface of conveyor.	Y	N	Y	Y	OPRP
		C	Residue of cleaning agent, lubricants.						
		P	Foreign materials from metallic surface						
8	Metal detecting	B	Microorganism from air, conveyor surface, equipment etc	Strictly check the metal detecting area. Control, regular checks & cleaning the surface of conveyor.	Y	Y			CCP
		C	Residue of cleaning agent, lubricants.						
		P	Foreign materials from metallic surface						
9	Staking	B	Microorganism growth from worker hand and staking equipment	Control & Regular checks of raw water quality and CIP machines as PRP	Y	N	Y	Y	OPRP
		C	Residue of cleaning agent						
		P	Foreign materials						
10	Packaging	B	Microbial growth due to leakage and moisture absorption from surrounding	CIP machines as PRP Leak test., Moisture test, Moisture control by ensuring temperature and humidity controlled room. Foil pack test. Personnel Hygiene Procedure, CIP for packaging machine and weighing machine.	Y	Y			CCP
		C	Residue of cleaning agent Chemical hazard from foil pack						
		P	Foreign particle present during forming.						

Instruction

Q-1 :Do Preventive Measure Exist For BCP If Yes (Y), proceed for Q2, if No (N),Is control necessary? If No, not a CCP. Q2: Does This Step Eliminate/Reduce The Likely Occurrence Of BCP Hazard To An Acceptable Lev1el?If No, Proceed for Q3, if Yes, that is CCP.

Q3: Could Unacceptable BCP Contamination Occur? If Yes, proceed for Q4, process or product, if No, not a CCP. Q4: Will Subsequent Step Eliminate BCP Hazard? If No, CCP, if Yes, not a CCP.

Table 3. HACCP Control Chart.

Step No.	Process Step	Hazard	Control Measure	Critical Limit	How	Who	Frequency	Record	Corrective Action	Verification
01	Baking	Microbiological hazard Chemical hazard (over burnt, Lubricants from forming machine & residue of cleaning agent) Physical hazard (Foreign particle)	Cooking time and temperature Control. Ensuring food grade lubricants Proper equipment setting, Sanitization of the equipment.	Lowest temperature min. 200^{0}C Highest temperature max. 350^{o}C (10 minutes) Lubricant's temperature range; dry film up to +550°C	Proper cooking & cooking temperature management (equipment setting)	QC and Production department	Every batch Every 2 hours	Oven temperature and time log book. Lubricants testing records. Maintenance records of equipment	a) Rejection of less or over baked biscuits b) Cooking temperature and time control	Review Per batch, Auditing

02	Metal detecting	Microbiological hazard (from air, conveyor surface, equipment etc.) Chemical hazard (residue of cleaning agent, lubricants.) Physical hazard (foreign materials from metallic surface)	Strictly check the metal detecting area. Metal detector control according to specification, regular checks and cleaning of the surface of conveyor. Ensuring food grade lubricants in metal detecting zone. MERV11 air filter.	Standard sensing object range: 0.3 to 5 mm Detectable objects: ferrous, non-ferrous and stainless steel contaminants. Lubricant's temperature range; dry film up to +550°C Air filter arrestance: ≥ 95%	Identify aperture distance and sensing object range. Proper maintenance of conveyor surface. Air filters maintenance in metal detecting premises.	QC and Production dept.	Every 1 hour	Metal detector log book. Lubricants testing records. Equipment maintenance records	a)Rejection of defected lot. b) Device Calibration	Review per batch; auditing
03	Packaging	Microbiological hazard (microbial growth due to leakage and moisture absorption from surrounding) Chemical hazard (packaging materials). Physical hazard (Foreign particles present during weighing and forming)	Leak test., Moisture test, Moisture control by ensuring temperature and humidity controlled room. Foil pack test. SOP of Personnel Hygiene , CIP for packaging machine and weighing machine.	Packing room temperature 21-300C, Relative Humidity 40- 60 %. Odorless and food grade laminated aluminium foil paper.	Auto packing and control of leakage under temperature controlled room. Proper curing of foil paper.	Packing operator & QC dept.	Packet checking - Every half hour interval. Temperature and Humidity: Every half hour interval. Foil Paper test- Every lot.	1) Leak Test report, Process log for temperature and humidity 2) Foil paper test result.	Rejection of foil paper, finished pack, rechecking whole batch and ensuring traceability	Auditing	

5. Acknowledgement

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