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The Design of HACCP Plan for Potato Chips Plant in Bangladesh

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Abstract

The purpose of this study is to design Hazard Analysis and Critical Control Point (HACCP) plan for potato chips production based on actual conditions in the plant. A specific model has been developed to boost the safety and quality of potato chips 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 potato chips production. The prerequisite programs (PRPs), operational prerequisite programs (OPRPs), hazards, 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 scrupulously for this HACCP plan.

Key words: HACCP, Hazard, Critical limit, Potato chips, Plant, Bangladesh

Introduction

HACCP is a short form for the Hazard Analysis Critical Control Point. It is a system that was developed for assuring pathogen-free foods. It provides precise 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 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. By 2000, there were many private and national food safety standards among them led to problems in third-party certifications that include ISO 22000: 2005 which is based on HACCP and is known as Food Safety Management System (FSMS).

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).A HACCP is a scientific system for process control that has long been used in food production to prevent problems by applying controls at points in a food production process where hazards could be controlled, reduced or eliminated (USDA, 2006). HACCP is a system of extensive evaluation and control over an entire food production process for the sole purpose of reducing potential food-related health risks to consumers. An HACCP program maintains safety and wholesomeness of meat and poultry because potential hazards that may occur during processing are anticipated, evaluated, controlled and prevented. Processing plants are required to have a HACCP plan for each product (Northcutt & Russell, 2010).

Potato chips Processing Technology is relatively new field of study, research and business strategy in Bangladesh. Currently several business groups are starting to develop the product and expanding their business in this field.

Potato is low acid food and moreover, in potato chips processing, problems associated with the presence of food borne pathogens like Fusarium solani, F. Roseum, Phytophthora erythroseptica and Pythium Species, Erwinia carotovora, Cornybaeterium sepedonieum, Verticillium albo-atrum and Fusarium oxysporum and others have been documented. The traditional quality testing and inspection used in the potato chips factory is applied to the product once a problem presents itself. It is thus difficult to maintain fully product inspection because of lack of trained and skilled manpower, human error in obtaining sufficient samples and so on. HACCP is a science-based system used to ensure that food safety hazards are controlled to prevent unsafe food from reaching the consumer (Bardic, 2001; Mortimore & Wallace 1997; Morris, 1997; IFST, 1998). To ensure safe consumption of potato products, the

design of HACCP plan is very essential and has great importance in Bangladesh. This study is specifically designed to develop HACCP plan based on the HACCP principles that can be applied in a potato processing plant to replace the traditional inspection and quality procedure in order to prevent the hazards in the product.

Materials and Methods

This study was conducted in Quasem Food Products Ltd. in Gazipur, Bangladesh which is categorized as medium scale plant as production capacity is twelve ton per day and no. of employees are around 100. 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.

Research method

This study did not use quantitative research. The purpose of this study was to design a HACCP model not to implement it in the actual situation. Therefore, there is no statistical data. This study matched a qualitative approach. It gives the intricate 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).

Research approach

This research was done for a potato chips 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
5. HACCP control chart.

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

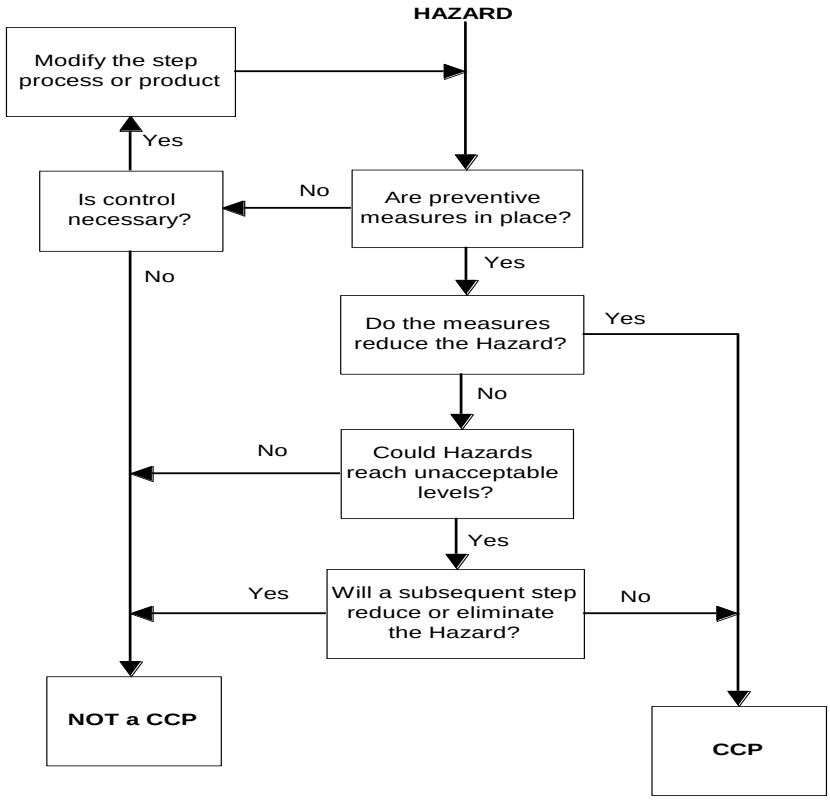

Figure-1: CCP Process Decision Tree

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 potato chips plant to produce the safe and quality end product.

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:

Location

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

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 15 cm deep and directly connected to the ETP plant. The floor is epoxy and a certain height of wall is also covered with epoxy for easy cleaning. The doors and windows are made of glass covered with finished aluminium structure and six exhaust fans 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 broom stick. The floor is cleaned daily before and after each shift of production.

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.

Water supply

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

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) 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 plant has thermia oil boiler to supply heated oil to heat exchanger that produce heated water has been used for proper cleaning and disinfecting of some equipments. The cleaning program also has been conducted as schedule of daily, weekly and monthly.

Pest control

The pest control activities have been contracted to Pest Guard Bangladesh which is professional in food industries. They conduct their activities at every month in presence of Human Resource Personnel.

Waste management

The company has its own waste treatment plant along with proper drainage and storage system which is combination of activated sludge method and aerobic treatment that contains equalization tank, gravity settle unit, flocculation unit, coagulation unit, tube settler, effluent discharge system and sand bath. The physical, chemical and biological specification based on national standard of entering waste and discharging waste water is also checked regularly.

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.

Personal Hygiene

All the personnel of production, packaging and storage areas use apron, hand gloves, mask, head covering and footwear. Liquid hand wash is used before starting their activities. 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 Human Resource personnel. The same instructions are also applied for visitors. All these things are properly monitored and inspected by Head of human resource (HR).

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. Proper transportation equipments are used where cleanliness, temperature and separation of food items and non food items are considered and monitored.

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) is also maintained for all raw and packaging materials.

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 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.

Product description

Product description mean a full description of the product including relevant safety information like composition, physical /chemical structure (pH, aw), microcidal treatment, packaging, shelf-life, storage condition, method of distribution and moreover, it includes intended use (SCV, 2006). The product description for potato chips is shown in Table-1.

Table-1: Product Description of potato chips

ITEM	**PRODUCT DESCRIPTION**
Product Description	Fresh Potato Chips. Potato Slices, 5 flavors Contents **Tomato Tango:** Potato, Edible olein, Sugar, Salt, natural spice mix (clove, pepper, turmeric) & Tomato. **Garlic & chili**: Potato, Edible olein, Sugar, Salt, natural spice mix (tomato, garlic, chili, Capsicum & Paprika. **Mix Masala**: Potato, Edible olein, Sugar, Salt, natural spice mix (Curry, Chili, Onion, Garlic, Cumin, Paprika) **Classic:** Potato, Edible olein, Sugar, salt & Natural spice mix. **Wasabi:** Potato, Edible olein, seasoning preparation.
Product Specification	**Composition**: Moisture: ≤ 2 % Fat: max 37% Acid Value of extracted fat , mg KOH/gm ≤ 1.5 Total ash, (dry basis)(including NaCl) 4% max Protein 6% min Iron mg/kg 10 min Lead mg/kg 0.5 max Arsenic mg/kg 0.1 max Salt as sodium chloride 2.0% max
Packaging (Primary & Secondary)	Potato chips are packed in food graded laminated bags. The quantity of potato chips will vary from 14g/16g/17g/20g small packs to 75g/80g family packs.
Method of Storage	Carton box are put on the wooden rack accordingly step wise.
Storage Conditions	Cartons are stored at normal room/ ambient temperature.
Distribution Method	Covered van, Track, Pick-up.
Shelf Life	4 months.
Customer Requirements	Direct consumption.
Intended Use	Ready for consumption.
Customer Preparation	No preparation required.

Production Process

Graded Potatoes (45mm to 70mm diameter) to be fed into feeding elevator with a uniform speed of feeding. This process, wash the adherence material i.e. soil, mud, sand etc. coming from field during harvest. Also make peel / skin softer to facilitate easy peeling in continuous peeler. Peeling is done by a process abrasive peeling where Potatoes move in different speed on abrasive rollers, running in different speed which can be controlled. Cleaned /destoned Potatoes are to be inspected for any disease, foreign material, greenish Potatoes, small size potatoes, if so then it is to be sorted out and removed. Oversize Potatoes can be cut into two halves for proper slicing. Single feeding ensures the Potatoes feeding to slicer – uniformly one by one. Slicer should be set for thickness around 1.20 to 1.70 mm. After cutting slice washer clean/wash the surface starch from the slices as starches oozes out when the Potatoes cut. Washed slices passed through a vibratory shaker where surface water removed and also small nubbins / slice pieces separated out. In a continuous Blancher, time, temperature and flow of water can be regulated / controlled depending upon the requirement of slices. Slices are then properly distributed on high speed belt for proper uniform feeding to fryer. Frying temperature is set in the range of 175 ±10 ^{0}C and time of fryer is 1.5 to 3 minutes with holding time 2 to 4 minutes. When the slices comes out from take out belt, it should be perfectly cooked, after cooling, it will be crisp but it can be examined on Inspection belt – cooking process is continued till the product cooled & achieve room temperature. Inspection Belt fed the fried chips to the seasoning drum should feed the chips uniformly. Since this system work on gravity, there is no force spraying hence the above characteristics in seasoning is required. Seasoned products directly go into the hopper of elevator for packaging machine to feed the multihead weighers .Temperature and humidity in the packaging room should be around 20-25 ^{0}C and 40- 60% respectively. Equal quantity of Potato Chips should feed to the weighers, so that weighers should not over flow. Proper sealing (Top, bottom & central seal) and proper N_2 must be ensured during packaging. The process flow diagram is shown in Figure-2.

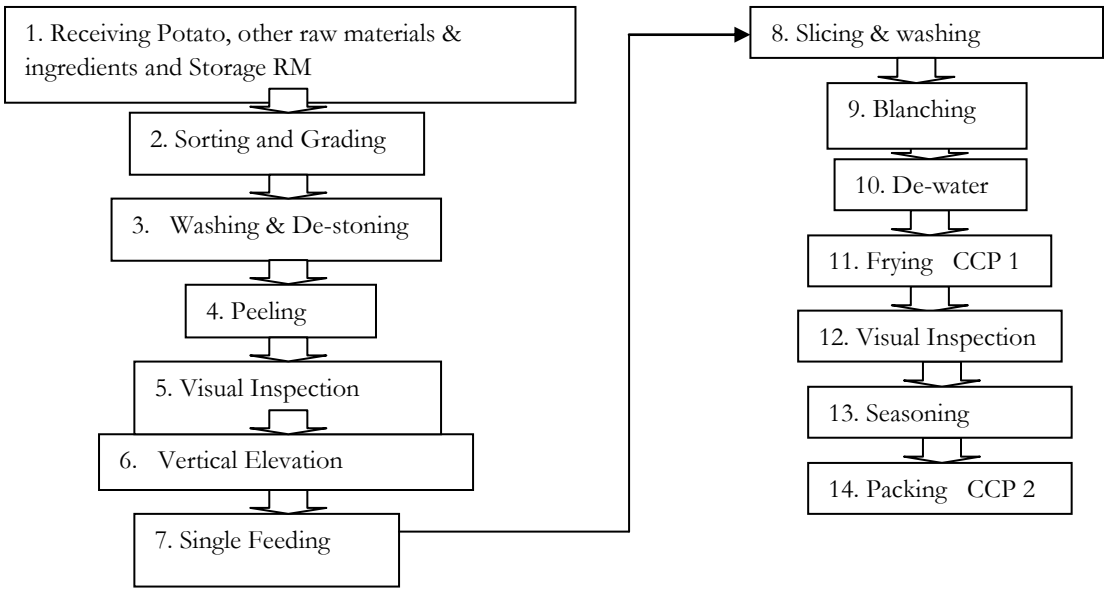

Figure-2: Process flow diagram of Potato Chips

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 potato products as those products are processed. The hazards associated with processing line for potato chips process 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.

Table-2: Hazards in Process and CCP Decision Matrix Chart analysis

STEP NO.	PROCESS STEP		HAZARD	CONTROL MEASURES (SOP's or Work Instructions)	Q-1 : Do Preventive Measure Exist For BCP	*Q-2 Does This Step Eliminate/Reduce The Likely Occurrence Of BCP Hazard To An Acceptable Lev1el?*	Q-3 Could Unacceptable BCP Contamination Occur?	*Q-4 Will Subsequent Step Eliminate BCP Hazard?*	OPRP/ CCP
1.	Receiving Potato, other raw materials & ingredients and Storage RM	B	Biological hazard content in potato and other Raw Materials.	Microbiological and chemical test of raw materials,ingredients and other product contact materials. Standard operating procedure (SOP) for raw potato and other raw materials storage . Suppliers of materials	Y	N	Y	Y	OPRP
		C	Chlorpropham (CIPC) gas during over fumigation. Additive and heavy metals. Residue of chemicals						
		P	Foreign Particle						
2.	Sorting and Grading of potatoes	B	Biological hazard due to rotten and diseased potatoes	SOP for selecting /sorting potato. SOP for sorting of potato in inspection belt. SOP for sorting and grading of potatoes	Y	N	Y	Y	OPRP
		C	Chemical hazard due to glycoalkaloids formation in potato						
		P	Physical hazard due to foreign particle						
3.	Washing and de-stoning	B	Introduction of microbiological hazard from raw water	Control & Regular checks of raw water quality. Personal training and maintenance	Y	N	Y	Y	OPRP
		C	Introduction of pesticides from raw water						
		P	Introduction of heavy metals from raw water Stone fragments in potato due to poor operation						
4.	Peeling	B	Microorganisms from equipment and water	Control & Regular checks of raw water quality. Clean in place (CIP)machines as PRP. Properly peeling. Proper lubricant . Maintenance of equipment	Y	N	Y	Y	OPRP
		C	Residue of cleaning agents and lubricants						
		P	Foreign particles						
5	Vertical Elevator	B	Microbial contamination from machine surface	CIP machines as PRP. Proper maintenance	Y	N	Y	Y	OPRP
		C	Residue of cleaning agents						
		P	Foreign materials						
6	CC Feeder	B	Microorganism from equipment and water	Control & Regular checks of raw water quality and	Y	N	Y	Y	

		C	Residue of cleaning agent	CIP machines as PRP. Prper maintenance					OPRP
		P	Foreign matter from machine surface						
7	Slicing	B	Microorganism from equipment	CIP machines as PRP. Maintenance and personal training	Y	N	Y	Y	OPRP
		C	Residue of cleaning agent						
		P	Foreign materials from metalic surface						
STEP NO.	PROCESS STEP		HAZARD	CONTROL MEASURES (SOP's or Work Instructions)	Q-1 : Do Preventive Measure Exist For BCP	*Q-2 Does This Step Eliminate/Reduce The Likely Occurrence Of BCP Hazard To An Acceptable Lev1el?*	Q-3 Could Unacceptable BCP Contamination Occur?	*Q-4 Will Subsequent Step Eliminate BCP Hazard?*	OPRP/ CCP
8	Slice Washing	B	Microorganism growth from water and 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						
9	Blancher	B	Microorganism growth from water and 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	De-water	B	Microorganism contamination from high speed belt and air blower	CIP machines as PRP Maintenance of equipment.	Y	N	Y	Y	OPRP
		C	Residue of cleaning agent						
		P	Attachment of foreign particle on high speed belt						
11	Frying	B	Non Identified	Remove of burnt oil at planned interval and testing of Free Fatty Acid (FFA) value of fried oil at planned interval. Maintenance and lubricant properly Personal training	Y	Y			CCP 1
		C	Chemical hazard after heating of oil Chemical residue and lubricants						
		P	Foreign material contamination with fresh oil						
12	Visual Inspection	B	Biological hazard due from personnel contact and facility environment	Follow SOP for personnel hygiene and SOP facility sanitization. Sort out of undesired slices SOP for visual inspection	Y	N	Y	Y	OPRP
		C	Browning and discoloured slices						
		P	Foreign particle						
13	Seasoning	B	Bacterial content within seasoning material Biological hazard for person contact	SOP for seasoning mixing, SOP for quality inspection. Personnel Hygiene Procedure .	Y	N	Y	Y	OPRP

		C	Chemical contamination during seasoning preparation and hopping	.					
		P	Foreign particle present during seasoning preparation						
14	Packing	B	microbial growth due to leakage and moisture absrobtion from surrounding	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 2
		C	Chemical hazard from foil pack						
		P	Foreign particle present during weighing and 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.

Quality deterioration of potatoes by microbial contamination is critical due to reduction of shelf life of potatoes for processing. The presence of chemical contaminants in frying oil is critical due to the heat stability of chemical contaminants and development of chemicals after heating and the adulteration is very common facts in Bangladesh. Physical and microbial hazard in seasoning and chemical hazard in packaging material are also critical. The time and temperature of frying oil and frying depend on which, are most critical point for potato chips processing due to moisture reduction and microorganism destruction. Vacuum packaging system has advantages like retention of the product colour, flavour and shelf life. Storage and distribution condition are critical to comply with consumer acceptability and shelf-life.

Table 3: HACCP Control Chart

Step No.	Process Step	Hazard	Control Measure	Critical Limit	How	Who	Frequency	Record	Corrective Action	Verification
01	Frying	Microbiological hazard Chemical Hazard (FFA, tertiary butylhydroquinone (TBHQ), Citric acid, browning)	Maintain combination time & temp.Control FFA value; control % of TBHQ and Citric acid	Frying temp. range (175 ±10 ^{0}C) FFA value not more than 0.75%	Proper frying & Palm olein management	QC & Production dept.	Every batch Every 2 hours	PPM register. FFA test report	a) Rejection of less fried chips b) Palm olein change/replace/rejection of porduct	Review Per batch, Auditing

02	Packaging	Microorganism growth and moisture absorption due to leakage from high humid, heated condition and moist air. Oxidation of product due to O_2 present in packet. Chemical contamination through foil paper.	Nitrogen volume and O_2 level control . Leak test. Temperature and humidity control. Foil paper analysis.	Minimum N2 level 99%. No leakage, Packing room temperature < 30^0C, Humidity <60 %. Odorless foil paper.	Auto packing and control of leakage under temperature controlled room. Proper curing of foil paper.	Packing operator & QC dept.	Packet checks - Every half hour. Temp. & Humidity: Every half hour. Nitrogen level monitoring: Every ½ hr. O_2 % monitoring every half an hour. Every batch test of foil paper.	1) Leak Test report, Process log for temperature, humidity and nitrogen level. 2) Foil paper test result.	Reject the wrapper, finished pack and recheck whole batch	Auditing

The HACCP control chart (Table-3) showed all the potential critical hazards that can occur during the processing steps in this potato chips 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 the processing of potato chips.

Conclusion

The study designed a HACCP plan model for a potato chips 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. Two CCPs were found in the processing of potato chips. These are frying and packaging.

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