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THE DESIGN OF HACCP PLAN FOR CHICKEN BALL 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 chicken ball production based on actual conditions in the plant. A specific model has been developed to boost the safety and quality of chicken ball product in this plant. The spread of some diseases by unsafe products due to *Listeria monocytogenes, Staphylococcus aureus, Salmonella enteritidis, Escherichia coli*, adulterants and chemical residue reported makes it important to pay attention to the potential contamination in chicken ball production.

The prerequisite program, 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, Chicken Ball, Plant, Bangladesh.*

1. 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. The team developed a system designed to build quality into the product to ensure food safety for the manned space program [15]. 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 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 [5]. 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 [9]. 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 [16]. 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 [12].

Meat & Poultry 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. Meat is low acid food and moreover, in chicken ball manufacturing, problems associated with the presence of food borne pathogens like *Listeria monocytogenes*, *Salmonella enteritidis*, *Staphylococcus aureus*, *Escherichia coli* and others have been documented. The traditional quality testing and inspection used in the meat ball 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

[1], [10], [11]. To ensure safe consumption of meat and poultry 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 chicken ball plant to replace the traditional inspection and quality procedure in order to prevent the hazards in the product.

2. Materials and Methods

This study was conducted in a chicken ball plant of C.P. Bangladesh Co., Ltd. in Dhaka, Bangladesh which is categorized as small scale plant as production capacity is one ton per day and no. of employees are around 100 [16]. 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 [13].

Research approach

This research was done for a chicken ball plant. Based on the seven principles of HACCP, several models of HACCP system [2], [8], [9], [17], guidelines [6], [7], [16] and HACCP requirements [14], the recordkeeping in this study were designed in the following manner. The record keeping form of hazards in ingredient and incoming material analysis chart (Table 2) are modified from Canadian Food Inspection Agency and material decision matrix (Table 4), hazard analysis chart (Table 3) and process step decision matrix (Table 5) are modified from Mortimore and Wallace model [3], [11].

1. Prerequisite program
2. Product description.
3. Production Process with flow diagram.
4. Hazard identification.
5. Critical control points (CCPs) determination.
6. HACCP control chart.

The decision tree (Figure 1) is used to identify Critical Control point (CCP) for raw materials and the decision tree (Figure 2) is used to identify CCPs for process [2], [17].

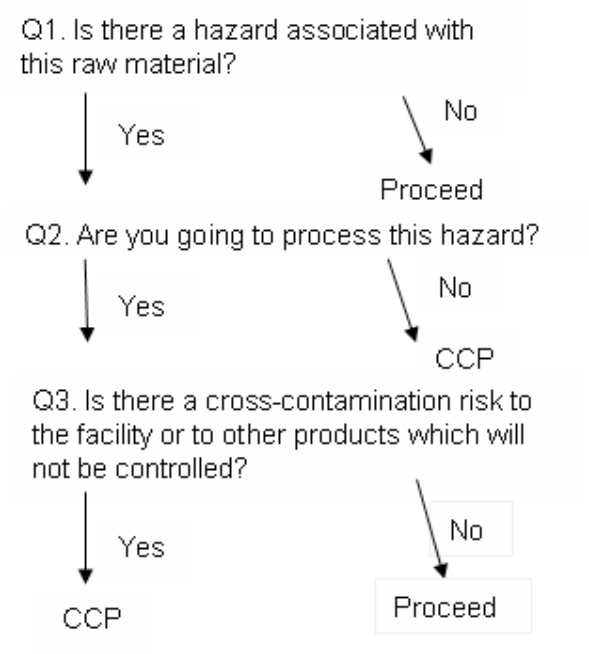

Figure 1. CCP Raw Material Decision Tree

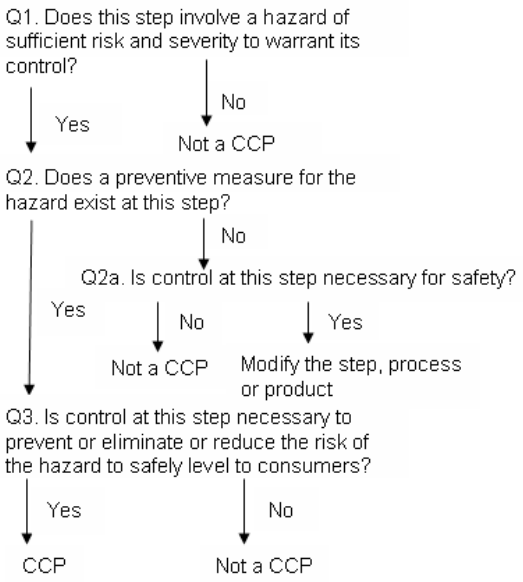

Figure 2. CCP Process Decision Tree

3. Results and Discussion

Based on the principle of the HACCP and several generic models, the HACCP model was designed to suit the real situation of the Chicken Ball 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 (NBHE, 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 or suitability 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 premise is 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 sloped (0.1 m per 6 m) for liquid to drain and the doors are inside self-closing. There are also have floor drain (0.03 m deep) and gutter drain (0.02 m x 0.03 m, slope: 1 in 100). The floor is mosaic and a certain height of wall is covered with tiles for easy cleaning. The door is made of stainless steel and windows are unbreakable material which is placed incline for easy cleaning. It is routinely cleaned and sanitized by a professional housekeeper. The floor is cleaned after each shift of production and daily.

Equipment

The equipment is stainless steel and other materials that are suitable for food industries and designed and constructed that ensure easy disassemble, cleaning, disinfection and avoid contamination of food. 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 treatment plant and storage system to provide adequate potable water supply 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 Taski Spiral (Blended liquid detergent) and equipment cleaner SU 727 Oxofoam (chlorinated foam cleaner) of Johnsondiversey India Pvt. Ltd. are used as cleaning and disinfectant agent. A documented cleaning and disinfection method has been maintained for this purpose. The plant has water tube boiler to supply steam that has been used for proper cleaning and disinfecting of some equipments. The cleaning program also has been conducted at every three month.

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 weekend in presence of Quality Assurance Manager (QAM).

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 anaerobic treatment that contains grease tank, sump or pit tank, equalization tank, anaerobic tank, bio centre tank, holding tank, recycling tank and discharge system. 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 microbial sampling of food contact surface and swab test.

Personal Hygiene

All the personnel of production, packaging and storage areas use apron, mask, head covering and footwear. Liquid hand wash and alcohol solution are 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 twice per week. The personal cleanliness is monitored on regular basis before entering into processing areas by QA and Production Officer. The same instructions are also applied for visitors. All these things are properly monitored and inspected by QA Manager.

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 3 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), microbicidal treatment, packaging, shelf-life, storage condition, method of distribution and moreover, it includes intended use [14]. The product description for chicken ball is shown in Table 1.

Table 1. Product Description of chicken ball

1.	**Product Name**	Chicken Ball
2.	**Product Description**	A precooked small (12 - 13 g) ball shaped product prepared from chicken meat, salt, sugar, spice, flour etc
3.	**How it is to be used?**	Ready to eat but 1 - 2 min. fry in oil or 2 min boil in hot water or 30 second in oven is recommended
4.	**Packaging**	Poly bag, Vacuum sealed
5.	**Shelf life**	2 weeks
6.	**Where it will be sold?**	Retail store
7.	**Labeling Instruction**	Keep chilled (0 - 4 ^{0}C)
8.	**Distribution condition**	Chilled (0 - 4 ^{0}C)

Production Process

The incoming dressed whole chicken is washed in chilled water and stored after grading with tube ice in large size ice box that maintain the temperature of the chicken at 0 - 4 ^{0}C. The chickens are then deboned manually with knife and temperature is maintained below 12^{0}C keeping the flesh on flake ice. The flesh and skin of chicken is mechanically ground at Ø5 mm. After grinding, the meat and skin are chopped with all the ingredients in a mechanical chopper (silent cutter). This paste is then formed in round or ball shape and boiled in hot water for 10 minutes at 75 ^{0}C. The meat balls are air cooled, vacuum packed in high density color package and stored at chilling temperature (0 - 4 ^{0}C). Finally, the products are distributed thorough refrigerated van after keeping the product overnight in the factory chiller. The process flow diagram is shown in Figure 3.

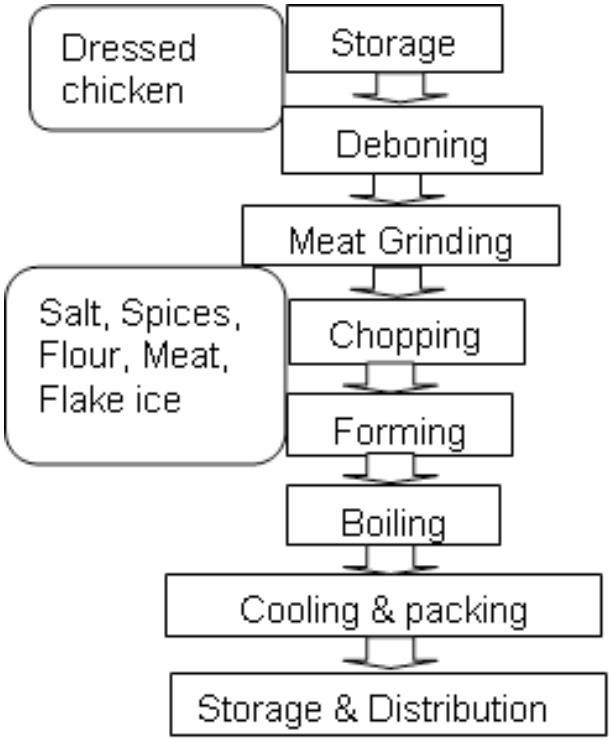

Figure 3. Process flow diagram of chicken ball

Hazards Identification

A hazard is defined as any biological (B), physical (P) or chemical (C) property that could cause a product to be unsafe for consumption [12]. 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 meat and poultry products as those products are produced. The hazards associated with raw materials and incoming materials and processing line for chicken ball production are shown in Table 2 and 3.

Table 2. Hazards in ingredient and incoming material Analysis chart

Ingredients and Materials	Hazards		Preventive Measure
Chicken Meat and skin	*B *C *P	*B - L. monocytogenes, E.coli, Salmonella sp., S.aureus C - Allergen, antibiotic residue P - Bones >7 mm	Store at chilled temperature 0-4 ^{0}C Sanitize equipment Proper personal hygiene and handling
Salt	P	P - any foreign materials	Quality product supply, Store at room temperature Maintain FIFO
Sodium Tri Poly Phosphate (STPP)	C P	C - adulterants P -any foreign materials	Quality product supply Store below 20 ^{0}C Proper personal hygiene and handling
Spice powder	B C P	B - Pathogens C - Adulterants, allergen P - Foreign particles	Quality product supply Store below 20 ^{0}C Proper personal hygiene and handling
Wheat Flour as binder	B C	B - Pathogen: Total Count and *S. aureus* C - adulterants	Quality product supply Store below 20 ^{0}C Proper personal hygiene and handling Maintain FIFO
Ice		No Hazard as potable water is used for ice making	Assure/Use quality water for ice making Proper personal hygiene and handling
Vegetables (Onion, garlic)	B C	B - Pathogens C - pesticide residue	Quality product supply Proper washing by water
Packaging Materials	C P	C - Ink P - any foreign particle inside	Quality product supply Ink & material should be food grade

*B = Biological hazard

*C = Chemical hazard

*P = Physical hazard

Table 3. Hazards Analysis Chart for process step

Process Step	Hazards		Preventative Measure
Raw Material Meat Storage	B C	B - *L. monocytogenes, E.coli, Salmonella, S.aureus* C - Allergen, antibiotic residue	Proper equipment setting Sanitize all the transfer equipment 0-4 ^{0}C
Deboning	B P	B - Pathogen by contamination: *S.aureus* P - Bone	Proper Personal Hygiene and handling Clean and Sanitize associated equipment < 12 ^{0}C
Grinding	B C P	B - Pathogen from grinder P - Sanitizer, cleaning agent P - Bone > 7mm	Proper Personal Hygiene and handling Clean and sanitize associated equipment < 12 ^{0}C
Chopping	B C P	B - Pathogen from chopper P - Sanitizer, cleaning agent P - Part of ingredient packaging materials	Proper Personal Hygiene and handling Clean and sanitize associated equipment < 12 ^{0}C, 9 min
Forming	B P	B - Pathogen from chopper P - Sanitizer, cleaning agent	Personal Hygiene Clean and sanitize forming machine and associated equipment
Boiling	B	B - Pathogen if not killed	78 ^{0}C, 10 min CT> 70 ^{0}C
Cooling	--	No hazard	Air Cooling system Using clean and sanitized equipment
Packing	P	P - Any foreign particle enter	Proper vacuum packer setting Sanitize the container, scale and tools Proper personal hygiene and handling
Storage & Distribution	B	B - Growth of pathogen	0-4 ^{0}C Proper storage and distribution condition setting

Critical Control Point (CCP) Determination

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 [14]. 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 raw materials shown in Table 4 and the decision tree (Figure 2) is used to identify CCPs for process steps shown in Table 5.

Table 4. Material Decision Matrix

Instruction:

Q1: Is there a hazard associated with the raw materials? If No (N), not a CCP, if Yes (Y), proceed to Q2.

Q2: Are you going to process this hazard? If No, CCP, if Yes, proceed for Q3.

Q3: Is there a cross-contamination risk to the facility or to other products which will not be controlled? If No, not a CCP, if Yes, CCP.

Raw material	Hazard	Q1	Q2	Q3	CCP	Notes
Chicken Meat & Skin						
B	Pathogen	Y	Y	N	No	Steam cooking will deal with the microbial hazard of meat
C	Antibiotics	Y	Y	N	No	Proper washing, water quality
P	Foreign Materials	N	--	--	No	Personal Hygiene and Physical Inspection
Salt						
P	Insect fragment, hair etc	Y	Y	N	No	Personal hygiene, sieving and physical inspection, pest control
STPP						
C	Adulterant	Y	N	--	Yes	Quality Product supply is critical
P	Foreign materials	Y	Y	N	No	Personal hygiene and physical inspection
Spices Powder						
B	Pathogen	Y	Y	N	No	Personal Hygiene, food storage and final cooking process
C	adulterants	Y	N	--	Yes	Quality Product supply is critical
P	Foreign materials	Y	N	--	Yes	Quality Product supply is critical
Wheat Flour						
B	Organism	Y	Y	N	No	Personal Hygiene, food storage and final cooking process
C	adulterants	Y	N	--	Yes	Quality Product supply is critical
Packaging Material						
C P	Toxic ingredient, foreign materials	Y	N	--	Yes	Quality Product supply is critical

Table 5. Process Step decision matrix

Instruction:

Q1: Does this step involve a hazard of sufficient risk and severity to warrant its control? If Yes (Y), proceed for Q2, if No (N), not a CCP.

Q2: Does a preventive measure for the hazard exist at this step? If Yes, Proceed for Q3, if No, proceed for Q2a.

Q2a: Is control at this step necessary for Safety? If Yes, modify the step, process or product, if No, not a CCP.

Q3: Is control at this step necessary to prevent or eliminate or reduce the risk of the hazard to safely level to consumers? If Yes, CCP, if No, not a CCP.

Process Step	Hazard	Q1	Q2	Q2	Q3	CCP	Notes
RMM Storage							
B	Pathogen	Y	Y		Y	Yes	Correct storage Time & temperature is critical
C	Antibiotics	N				No	PRP: Sanitation system, water quality
P	Foreign particles	Y	Y		N	No	PRP: Personal Hygiene, pest control
Deboning							
B	Pathogen	Y	Y		N	No	Proper Temperature inhibit the bacterial growth
C	Sanitizer and Cleaner	N				No	PRP: Sanitation system, maintenance & cleaning
P	Foreign Materials	Y	Y		N	No	PRP: Personal Hygiene, pest control
Grinding							
B	Pathogen	Y	Y		N	No	Proper Temperature inhibit the bacterial growth
C	Sanitizer and Cleaner	N				No	PRP: Sanitation system, maintenance and cleaning
P	Foreign materials	Y	Y		N	No	PRP: Personal Hygiene, pest control
Chopping							
B	Pathogen	Y	Y		N	No	Proper Temperature inhibit the growth
C	Sanitizer & Cleaner	N				No	PRP: Sanitation system, maintenance and cleaning
P	Foreign Materials	Y	Y		N	No	PRP: Personal Hygiene
Forming							
B	Pathogen	Y	Y		N	No	PRP: Sanitation system
P	Foreign Materials	Y	Y		N	No	PRP: Personal Hygiene, pest control
Boiling							
B	Pathogen	Y	Y		Y	Yes	Correct boiling temperature and time is critical, PRP: water quality
Packing							
B	Pathogen	N				No	Proper personal hygiene and handling
P	Foreign Particles	Y	Y		Y	Yes	Presence of foreign materials is critical
Storage & Distribution							
B	Pathogen	Y	Y		Y	Yes	Storage & distribution temperature and time is critical

The presence of chemical contaminants in STPP, spice powders and packaging material is critical due to the heat stability of chemical contaminants and the adulteration is very common facts in Bangladesh. Physical hazard in spice powder and packaging material and microbial hazard in packaging material are also critical. The storage temperature of raw meat is very important and critical to prevent the microbial growth and off-flavor. The time and temperature of water boiling, core temperature depend on which, is most critical point for cooked chicken ball due to killing of pathogens. Vacuum packaging system has advantages like retention of the product color and restriction of bacterial growth. The presence of foreign materials and storage and distribution temperature is critical to comply with consumer acceptability and shelf-life.

Table 6. HACCP control chart for chicken ball production

Process Step; CCP No	Hazards	Critical Limits	Monitoring Procedure	Frequency	Preventive measure	Corrective action	Record	Respons. person
Raw & Packaging Material; CCP#1	Microbio. Chem. & Physical Contamin.	No unqualifi. product to be used	Apply supply quality assurance	Each supply	Qualified raw material supply; Checked MSDS; Approved Supplier List; Specification	Change supplier or brand; Employee training	Materials Receiving report	Assigned receiver (QA)
RMM Storage; CP#1	Microbial growth	<4 ^{0}C Max. 3 days	Temperature log is properly running and monitored	Routinely (morning & evening)	Proper storage temperature and time	Reject the raw meat	Temperature log sheet; Discard register	Assigned Person (QA)
Water Boiling; CCP#2	Survival of Pathogens	CT ≥71 ^{0}C	Check the CT; Follow up the time and temperature and record keeping	Each Batch	Check The Core Temperature (CT) of product	Adjust the temperature and time by setting the equipment well; Call the engineer to repair	Time and CT log; Maintenance register	Assigned Person (QA)
Packing; CCP#3	Physical contam.	No foreign material; No leakage	Visual linspection by packing operator	Each Pack	Personal hygiene and physical inspection	Retain, rework or discard based foreign material identified	Inspection Report	Assigned Person (QA)
Storage & Distribution; CP#2	Microbial Growth	≤4 ^{0}C Shelf-life 14 days	Check the storage temperature and shelf-life and record keeping	Routinely	Check the time and temperature	Retain or reject based on product testing by panelist	Temperature log; Delivery report	Assigned Person (QA)

HACCP Control Chart

The HACCP control chart (Table 6) showed all the potential critical hazards that can occur during the processing steps in this chicken ball plant along with no. of critical control point and 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 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 reported processing step, records and verification procedure in his control chart of meat product [2],[9]. Zhao reported processing step in HACCP control chart for cheddar cheese which is also almost similar to my proposed control chart [17]. Codex gave importance to include monitoring and documentation of parameters in HACCP plan for meat and meat products [4]. Three CCPs and two CPs were found for this chicken plant. These are qualified supply of raw material and packaging material, Proper storage temperature and time for raw material meat (RMM), Proper temperature and time for boiling of chicken ball, Proper inspection during packing for foreign materials and Proper storage & distribution temperature and time of finished product.

4. Conclusions

- The study designed a HACCP plan model for a chicken ball 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 ap-

peared in both raw material and 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. Five CCPs were found in the production in this chicken ball plant, or more precisely: a) Supply of raw material and packaging material; b) Proper storage temperature and time for raw meat; c) Proper temperature and time for water boiling; d) Proper inspection during packing for foreign materials and e) Proper storage & distribution temperature and time of final product.

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