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FOOD SAFETY ASSURANCE IN FROZEN BONELESS BUFFALO MEAT THROUGH HACCP APPLICATION

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With the increasing demand and production of processed meat food, safety for the consumers is an aspect of great importance and it is a challenging task. It is well known that hazards (mainly pathogens) associated with food be the cause of food borne illness. Public health safety is a serious issue and can be prevented by adopting HACCP in food chain. HACCP program has been developed for consumer food safety as well as to protect manufacturer from food safety-related issues. The objective of this study is to determine the food safety measures related to the implementation of HACCP in frozen boneless buffalo meat manufacturing industry.

Key words: HACCP, CCPs, Meat food, food safety

Among the Indian livestock sector buffalo play a major role in India's economy. India has about 56% of world buffalo population. India stands 5th in the rank of world's meat production that is estimated 6.3 million tones annually and buffalo meat contributes about 31% of total meat production in India (Agricultural and Processed Food Products Export Development Authority, India).

Industrialization together with mass production lead to increased risks of food contamination and to considerably larger numbers of people affected in food borne diseases outbreaks as a result (Horchner *et al*., 2011) Microorganisms are good indicator concerning whether the meat has been processed in hygienic condition or not. Food hygiene includes all conditions and measures necessary to ensure the safety, suitability and wholesomeness of food at all stages of the food chain (Charisis, 2004). Meat foods are excellent substrates for microorganism's growth (Galvez *et al*., 2010). Food borne diseases remain one of the most widespread public health problems. Today illness resulting from food-borne pathogens has become one of the most widespread public health problems in the world (Mor-Mur and Yuste, 2010).

HACCP is a reliable system for the prediction of potential health risks and assurance of food safety based on the concept of prevention of problem, rather than on the identification of end product contamination (Gaaloul *et al*., 2011). HACCP system is a scientific, rational and systematic approach to identification, assessment and control of hazards during production, processing, manufacturing, distribution, preparation and use of food, to ensure that food is safe when consumed (Codex Alimentarius Commission, 2007). HACCP is also the most cost-effective approach to food safety because it focuses on the analysis and the identification of the critical control points in the production, processing and preparation of food, feed and water, before the product ever leaves the premises (Codex Alimentarius Commission, 2009a).

The purpose of this paper is to describe the key processes and application of HACCP approach to derive on line food safety control measures applicable at the industrial level for frozen boneless buffalo meat production.

MATERIALS AND METHODS

HACCP system is a basic approach to ensure the safety of food supply, providing a systematic procedure for the identification, evaluation and control of hazards in each operation. It puts controls in place at each point in the production system where safety problems could occur from biological,

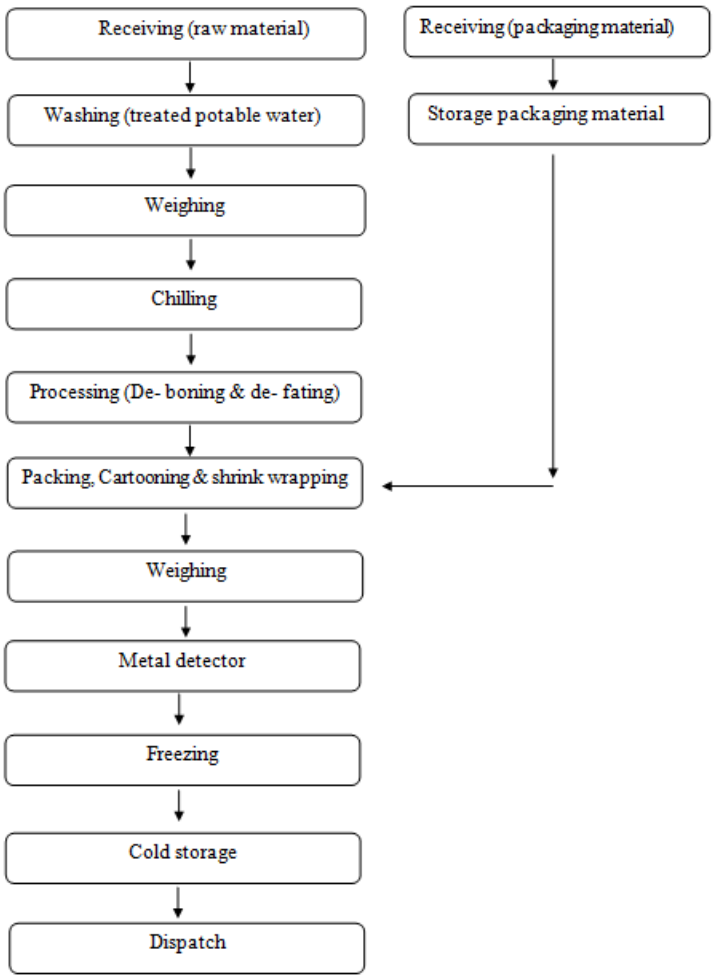

Figure: 1. Flow diagram for processing of boneless buffalo meat

Table: 1. Product description and intended use

Product	**Quick Frozen Boneless Buffalo Meat**
Common name	Boneless Meat
How is it to be used	Cooked by purchaser
The type of package	Wrapper packing, cartooning and shrink wrapping
Length of shelf life	9 months
Where will it be sold	Wholesale to distributors
Labeling instructions	Keep frozen below -18°C
How is the product(s) distributed	Keep frozen below -18°C

chemical, or physical hazards. This study was carried out at M D Frozen Food Exports, a meat processing plant situated in national capital region, India.

Developing a HACCP plan: A HACCP plan is a document prepared in accordance with the principles of HACCP in order to ensure control over hazards, which are significant for food safety in a segment of the food chain under consideration. The application of HACCP consists of a logical sequence of 12 steps, 5 preliminary steps and then the 7 HACCP principles.

Assemble the HACCP team (Step 1)

It is a group of people responsible for elaborating and implementing the HACCP Plan. HACCP team is familiar with overall food operation processes included in the plan. The team is committed to the study, development, establishment and review of all problems concerning the safety and management of their products. Indeed, the

members are well-acquainted with the finished products, the used raw materials, supply specificities, production methods and all related problems.

Describe product and Identify intended use (Steps 2 and 3)

The HACCP team gives a complete description of the product, this include the instructions concerning composition, safe use, packaging, shelf life, storage, transport and distribution conditions. The product description and intended use is shown in table 1.

Construct process flow diagram and On-site confirmation (Steps 4 and 5)

The HACCP team developed a process flow diagram that easily identifies routes of potential contamination. Fig. 1 presents all the steps used to prepare the product from receiving of raw material to the distribution of final product. Verification of this process flow diagram is confirmed by an on-site inspection for accuracy and completeness.

Principle 1 - Conduct a hazard analysis (Step 6)

HACCP team conducted hazard analysis step by step from starting to end point as in process flow diagram. A 'hazard' is 'a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect' (Codex Alimentarius Commision, 2009b). Hazard analysis carried out by two activities - brainstorming and risk assessment. All potential hazards were obtained after brainstorming and analysis of the risks. The severity of each of the hazard was used to determine the significance of the food safety hazards. HACCP team established a list of significant hazards that are likely to result in an unacceptable health risk to consumers as shown in table 2. Preventive measures are

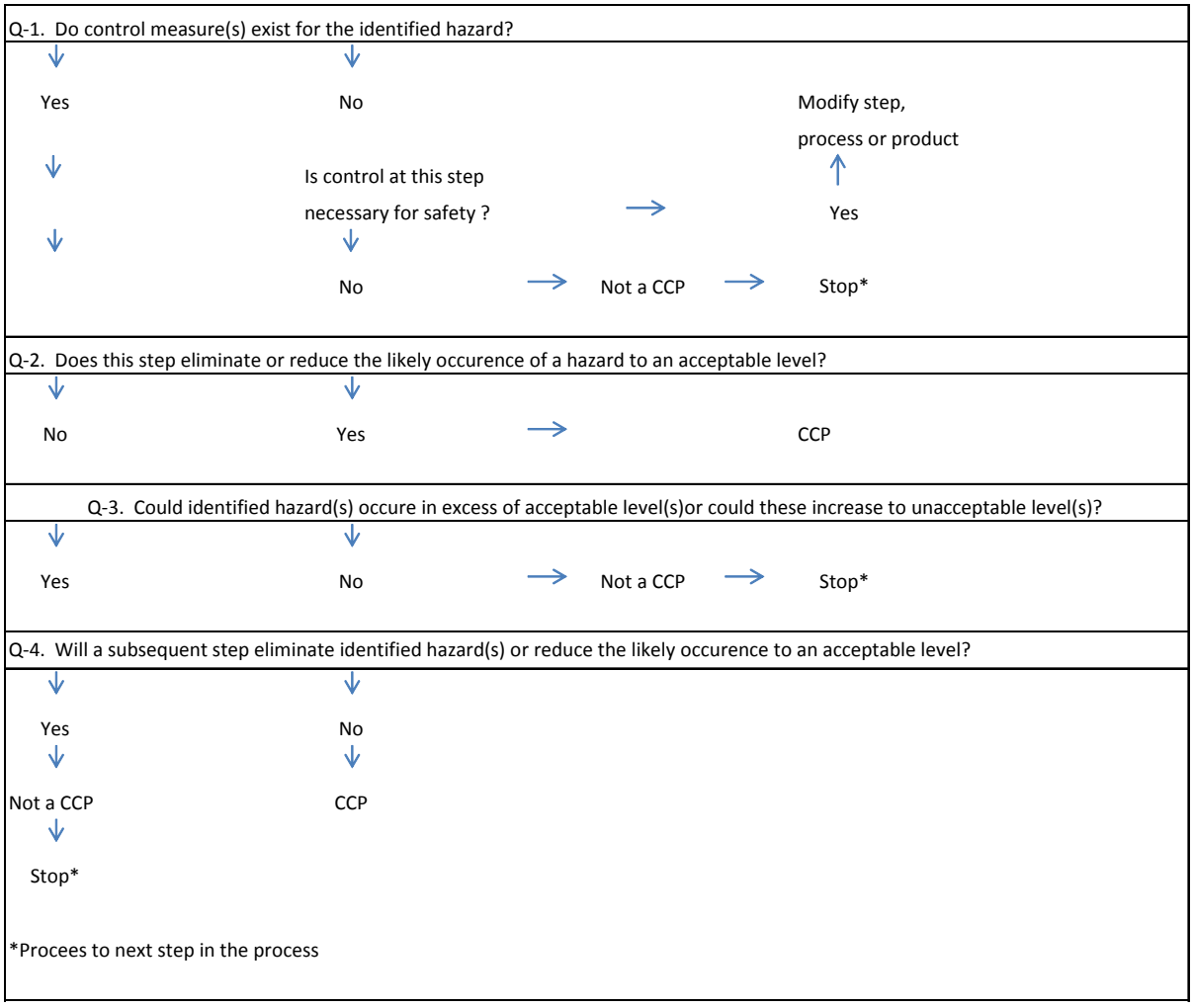

Figure: 2. Decision tree

Adapted from - Recommended international code of practice. General principles of food hygiene. CAC/RCP 1–1969. Food Hygiene (Basic Texts)

Table 2: Principle 1 - Hazard Analysis

Process Step	**Potential hazard introduced, controlled or enhanced at this step B= Biological, C= Chemical, P= Physical**	**Is the potential food safety hazard Significant?**	**Justification for the decision**	**What control measures can be applied to prevent the significant hazard?**
Receiving (Raw material)	B-Pathogens	YES	Raw meat is a known source of pathogen	Maintained the temperature below 15^{o} C
	C-Antibiotics, Pesticides residues	NO	Plant Sanitation SOPs and GMPs	
	P-Foreign material	NO	Plant Sanitation SOPs and GMPs	
Receiving (Packing material)	B-Pathogens	NO	Not occur due to plant GMPs & GHPs	
	C-Chemical contaminants	NO	Only food-grade packaging materials are used	
	P-Foreign material	NO	Not occur due to plant GMPs & GHPs	
Storage (Packing material)	B-Pathogens	NO	Not occur due to plant GMPs & GHPs	
	C-Chemical contaminants	NO	Only food-grade packaging materials are used and not occur due to plant GMPs & GHPs	
	P-Foreign material	NO	Not occur due to plant GMPs & GHPs	
Washing	B-Pathogens	YES	Treated potable water used	Microbiological analysis
	C-Pesticides, heavy metal	NO	Treated potable water used	
	P-Foreign material	YES	Plant Sanitation SOPs and GMPs	Wearing gloves, mask, cap & not wear any ornament
Weighing	B-Pathogens	NO	Personnel handling follow GHPs	
	C-Pesticides	NO	Personnel hygiene & equipment sanitation	
	P-Foreign material	YES	Cross contamination from personnel & environment	Wearing gloves, mask, cap & not wear any ornament

Process Step	Potential hazard introduced, controlled or enhanced at this step B= Biological, C= Chemical, P= Physical	Is the potential food safety hazard Significant?	Justification for the decision	What control measures can be applied to prevent the significant hazard?
\Chilling.	B-Pathogens	YES	Proper time and temperature	Maintained the temperature at 0°C to 4°C
	C-Chemical residue	NO	Plant Sanitation SOPs and GMPs	
	P-Foreign material	NO	Plant Sanitation SOPs and GMPs	
Processing (De boning & de fating)	B-Pathogens	YES	Cross contamination from personnel & equipments	Wearing gloves, mask, cap and cleaned equipments
	C-Chemical residue	NO	Plant sanitation SOPs and GMPs	
	P-Foreign material	YES	Removed during subsequent steps of de boning	Wearing gloves, mask, cap & not wear any ornament
Packing, cartooning & shrink wrapping	B-Pathogens	YES	Cross contamination from personnel & equipments	Wearing gloves, mask, cap and cleaned equipments
	C-Non Identified			
	P-Foreign material	YES	Removed during subsequent steps of packing	Wearing gloves, mask, cap and cleaned equipments
Weighing	B-Pathogens	YES	Cross contamination from personnel & equipments	Wearing gloves, mask, cap and cleaned equipments
	C-Chemical residue	NO		
	P-Foreign material	YES	Removed during subsequent steps of weighing	Wearing gloves, mask, and cleaned equipments
Metal detector	B-Non identified			
	C-Non identified			
	P-Metal	YES	Metal	Metal detection

Process Step	Potential hazard introduced, controlled or enhanced at this step B= Biological, C= Chemical, P= Physical	Is the potential food safety hazard Significant?	Justification for the decision	What control measures can be applied to prevent the significant hazard?
Freezing	B-Pathogens	YES	Proper time and temperature	Maintained temperature -40^{o}C
	C-Chemical	NO	Plant sanitation SOPs and GMPs	
	P-Foreign material	NO	Plant sanitation SOPs and GMPs	
Cold storage	B-Pathogens	YES	Proper time and temperature	Maintained temperature. -18^{o}C
	C-Chemical	NO	Plant sanitation SOPs and GMPs	
	P-Foreign material	NO	Plant sanitation SOPs and GMPs	
Dispatch	B-Pathogens	YES	Proper time and temperature	Maintained temperature -12^{o}C to -14^{0}C
	C-Non Identified			
	P-Foreign material	NO	Removed during subsequent steps of dispatch	

Table 3: Principle 2 - Identify critical control points

Process step	**Hazards B= Biological, C= Chemical, P= Physical**	**Q 1. Do preventative measures (s) exist?**	**Q 2. Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level?**	**Q 3. Could contamination with identified hazard (s) occur in excess of acceptable level (s) or could these increases to unacceptable levels?**	**Q 4. Will a subsequent step eliminate identified hazard (s) or reduce likely occurrence to an acceptable level?**	**CCP (Y/N)**
Receiving (Raw material)	B-Pathogens	Y	N	Y	Y	N
Receiving (Packing material)	No significant hazards					
Storage (Packing material)	No significant hazards					
Washing	B-Pathogens	Y	N	Y	Y	N
	P-Foreign material	Y	N	Y	Y	N
Weighing	P-Foreign material	Y	N	Y	Y	N
Chilling	B-Pathogens	Y	N	Y	Y	N
Processing (De boning & de fating)	B-Pathogens	Y	N	Y	Y	N
	P-Foreign material	Y	N	Y	Y	N
Packing, cartooning & shrink wrapping	B-Pathogens	Y	N	Y	Y	N
	P-Foreign material	Y	N	Y	Y	N
Weighing	B-Pathogens	Y	N	Y	Y	N
	P-Foreign material	Y	N	Y	Y	N
Metal detector	P-Metal	Y	Y	-	-	CCP-1
Freezing	B-Pathogens	Y	Y	-	-	CCP-2
Cold storage	B-Pathogens	Y	Y	-	-	CCP-3
Dispatch	B-Pathogens	Y	N	Y	Y	N

Table: 4. Principles 3, 4 and 5 - Critical Limits, Monitoring Procedures and Corrective Actions

CCPs	Critical Limits	Monitoring Procedures	Corrective Actions
Metal detector	No foreign material above 3mm (Fe 2mm & Non-Fe 3mm)	**What** - Foreign material **How** - By an in-line metal detector **When** - Each package **Who** - Plant supervisor	**Line** - Recalibrate the metal detector by passing standard probe **Product** - Package identified to have foreign material will be reverified and source of hazard identified. Product repacked if possible otherwise discarded **Who** -Operator
Freezing	-40 °C	**What** - Freezer temperature **How** - Calibrated digital thermometer **When** - At every batch **Who** - Plant Supervisor	**Line** - Stand by compressor is to be started to give result **Product** - Continue freezing till products temperature attains -18 °C **Who** –Operator
Cold storage	-15 °C	**What** - Product temperature **How** - Monitoring the digital temperature display **When** - Hourly **Who** - Plant supervisor	**Line** - Stand by compressor is to be started to give result **Product** -Refrigeration adjusted and product placed on hold for further microbiological evaluation, if fail then discarded **Who** - Microbiologist for evaluation and Plant operator for segregation & discarding

Table: 5. Principles 6 and 7 - Verification and Record Keeping

Process Step/CCP	Verification Procedures	Records
Metal detector	Plant engineer will audit the record daily and calibrate periodically with metal detector by passing standard probe HACCP coordinator will review the deviations, corrective actions and observe the implementation procedures	Metal detector record
Freezing	Plant engineer will audit the loading & unloading time & temperature record and calibrate the device periodically HACCP coordinator will review the deviations, corrective actions and observe the implementation procedures	Loading & unloading time & temperature record
Cold storage	Plant engineer will audit the temperature record daily and calibrate the temperature device periodically. HACCP coordinator will review the deviations, corrective actions and observe the implementation procedures	Deep freeze temperature record

applied to several identified hazards such as good manufacturing practices, good hygienic practices, standard sanitation practices, good personal hygiene etc.

Principle 2 - Identify critical control points (Step 7)

A critical control point (CCP) is defined as "A point, step, or procedure in a food process at which control can be applied and, as a result, a food safety hazard can be prevented, eliminated, or reduced to acceptable levels." However there is always a level below which the presence of an agent is considered to be acceptable. A decision tree (Fig. 2) was used for this task and some CCP have been set up as described in table 3.

Principle 3 - Establish critical limits for each CCP (Step 8)

Critical limit is the maximum or minimum value to which a physical, biological, or chemical hazard must be controlled at a critical control point to prevent, eliminate, or reduce to an acceptable level. Simply it is the criteria which separate acceptability from unacceptability in terms of food safety risks for the consumers. CCPs are the standard and measurable parameters (table 4) which can demonstrate that the threshold level has not been exceeded.

Principle 4 - Establish monitoring procedures (Step 9)

Monitoring is the scheduled measurement or observation to assess whether a CCP is under control and to produce an accurate record for future use in verification. Monitoring is an essential element of "controlling hazards" and it can warn if there is a loss of control at the CCP (Oses *et al.*, 2012). Table 4 illustrates the monitoring procedures. If the results of monitoring at CCP indicate the loss of control then corrective action can be taken based on an analysis of the variation to bring your process back into control before a critical limit is exceeded. Monitoring must assure that a CCP is under control.

Principle 5 - Establish corrective actions (Step 10)

In the text of *Codex Alimentarius,* corrective actions are only those actions, which are taken when a CCP is out of control; thus, when a critical limit is exceeded. Specific corrective actions are developed for each CCP in the HACCP system in order to deal with deviations whenever they occur. Corrective actions followed when monitoring detect that a deviation failed to meet a critical limit. Table 4 shows the list of corrective actions.

Principle 6 - Establish verification procedures (Step 11)

Verification procedures are intended to check the effectiveness of the HACCP system whether the system is working correctly or not. These verification activities include auditing, review of procedures and in some cases tests including random sampling and analysis. The verification procedures are described in table 5 and frequency of verification should be enough to ensure that the HACCP system is working effectively.

Principle 7 – Establish documentation & record keeping procedures (Step 12)

Accurate and efficient record keeping (table 5) is essential for application of a HACCP system. Documentation examples include the hazard analysis, all the reference documents used in the risk assessment, CCP determination and critical limit determination. Record keeping examples include deviations and corrective action reports.

RESULTS AND DISCUSSION

The present study is aimed to maintain food safety through HACCP implementation at industrial level. Hazard analysis was conducted to determine each food safety hazard whether it is to be eliminated or reduced to an acceptable level. Each food safety hazard was evaluated according to severity of their occurrence and possible adverse health effects.

Identified critical control points and their control measures

On the basis of CCP decision tree (Fig. 2), the HACCP team identified three CCPs. The process of CCP determination is described in table 1 from receiving of raw material to dispatch of finished products. CCP-1 represents the occurrence of foreign materials as physical hazards in the product and eliminated with the help of metal detector. Microbiological quality of raw

material, hygienic condition in processing, food handler's hygiene and proper freezing condition affects the food safety. Freezing is second CCP and temperature maintained to -40 °C to control the microbial load and avoid chances of food safety risks associated with pathogenic hazards. Freezing also enhance the keeping quality of product as meat products are most perishable. The storage temperature consists of an important Critical Control Point (CCP-3), during cold storage conditions the temperature has to be maintained at -15 °C or less in order to ensure the microbiological safety of products. The application of HACCP resulted in the identification of only three CCPs and the required actions for their control are very important for the appropriate HACCP implementation. These are scientifically justifiable, resulting in a positive outcome with regard to minimizing food safety and trade-related food safety risks.

CONCLUSION

Meat foods are a potential source of major food-borne illnesses and thus health safety is a basic need for consumer. Microbial hazards are most common and likely to become a severe cause of food safety risks. HACCP system is a scientific approach designed to prevent the occurrence of hazardous or critical situations at any point in a food production system. HACCP prevents the food safety risks rather than cure. It has a scope of continuous improvement and should be regarded as a food safety problem solving technique. It provides the opportunity for raising the safety of food with respect to hazards, specifically those which may cause harm to the consumers. It requires adequate resources to conduct the study and associated training. Processed meat foods are widely accepted by consumers with the assurance of food safety and quality from industry and government regulation authorities.

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