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Application of HACCP System in the Production of Dried Beef

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Abstract: The Hazard Analysis Critical Control Point (HACCP) System was applied to the processes of dried beef. Raw material acceptance, dressing, mincing, vacuum packing, high temperature sterilization, gradient cutting were regarded as Critical Control Points (CCPs). To ensure the best processing parameter, an effective method was established to monitor the dried beef security hazard, most of the improvements focused on improving the process environment. There was significant difference between the total number of bacterial colony (2×10^3 cfu g^{-1}) and coliform group (20 MPN 100 g^{-1}). The excellent sanitation environment, perfect food safety policy and the implementation of the HACCP System are the crucial factors in dried beef processing.

Key words: Security hazard, bacterial colony, coliform group, environment, HACCP System

INTRODUCTION

HACCP, a tool that is currently used as a means of food safety in general was initially developed to ensure the safety of meals produced for the first US manned space programs in the 1960 (Gilling *et al*., 2001). The application of HACCP to food production was pioneered by the Pillsbury Company with the cooperation and participation of the National Aeronautic and Space Administration (NASA), Natick Laboratories of the US Army. In the succeeding years, HACCP was recognized worldwide as an effective system of controls for food safety (Huleback and Schlosser, 2002). It was introduced in China in 1988. The application of HACCP System to food safety control is based on the premise that potential food hazards and faulty practice can be detected at an early stage, leading to measures to prevent or reduce risks to the health of consumers or to relieve the economic burden on the food trade due to spoilage your recall of market items (Ehiri and Morris, 1996).

Kerchin grassland is well known as the hometown of yellow cattle and it is the breeding base of Kerchin cattle and Simmental cattle in Inner Mongolia. Simmental are a versatile breed of cattle originating in the valleys of the Simme river in the Bernese Oberland of Western Switzerland. In the recent 50 years, Simmental has been largely popularized and raised in Kerchin grassland and forming Chinese Simmental steppe community as advantaged cattle source for beef industrialization. The dried beef is the most favorite food for Mongolian people living in pasturing area. However, due to the restriction of processing condition and religious taboo, Dried beef process industry has been lagging behind (Ruijun, 2003) and most meat food factory belong to small or middle enterprise, they has not paid much attention to the research on the detail of good quality yak meat with good price. With the development of global marketing of foods, China will be the biggest exporter of meat food product, US and other international countries are becoming stricter about the products they import so it is necessary to mandate the use of HACCP in beef industry.

MATERIALS AND METHODS

Experimental site and materials: The experiment was conducted in the beef processing factory, located in Tongliao city Inner Mongolia, production line of dried beef were chosen as target processes for the HACCP System. The HACCP System mainly focused on microbiological, chemical, physical and biological hazards, hygiene training. Processing flow diagram carton of dried beef after acceptance is given in Fig. 1.

HACCP plans for the processes: The HACCP plans for the processes were made up in accordance with the seven principles for HACCP implementation (CAC, 1997; King, 1992). In these studies, GMP (Good Manufacturing Practices) considerations such as a hygiene plan, personnel hygiene instruction, higher quality management are included in the HACCP studies.

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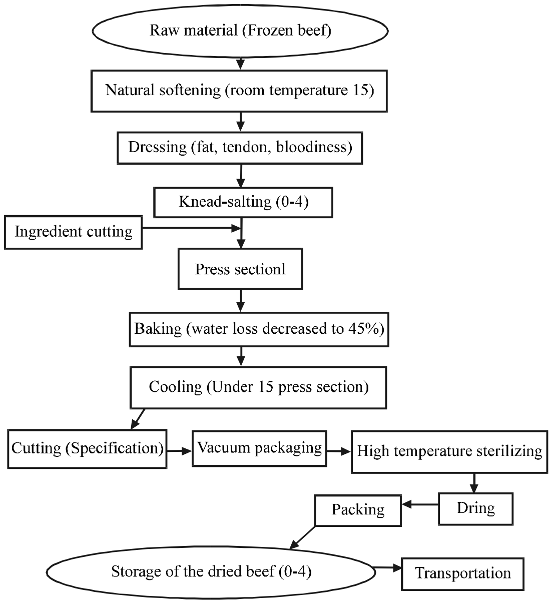

Fig. 1: On-site confirmation flow diagram of the carton of dried beef

Hazard analysis, determination of Critical Control Points (CCPs): All the processes of production such as the acceptance of the raw material ingredient cutting, cooling, etc. as a whole were analyzed and determined CCP. This principle involves identifying potential hazards (chemical, physical or biological) associated with production and measures to control those hazards. It involves preparing a list of steps in the process where significant hazards occur. The flow diagrams were verified by the HACCP teams (Sjoberg *et al*., 2002) who supervised on-site confirmations. The potential hazards research lists in beef production are shown in Table 1.

Establishment of critical limits and monitoring systems and corrective actions for each CCP: Critical limits are control procedures and standard that apply to each critical point. They describe the difference between the safe and unsafe products at the CCPs. Critical limit: a maximum and/or minimum value to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate or reduce to an acceptable level the occurrence of a food safety hazard. Monitoring is the

Table 1: The potential hazards research list in beef production

Flow sheet	Hazard analysis	Is hazard severe	Basis for judging severity	Measures for preventing hazard	Determined whether it is CCP
Acceptance of the raw material	Biological: pathogenic bacteria Chemical: drug residue, heavy metals,toxins	Yes	Sickness and contamination in the slaughtering process if product is not handled correctly Mistakenly eating, post-drug cycle, handled improperly after the slaughter	Prevent zoonoses, implement the raw material SSOP management, take a high-temperature sterilization Promise by manufacturers, test Aflatoxin M1, antibiotic, etc. in factory, Spot-check to prevent microbial hazard	Yes
	Physical: yak dung, fur, etc.	No	Sensory evaluation	Carry out good manufacturing practices	
Natural softening	Biological: pathogens	No	Existence in the raw meat	Take a high-temperature sterilization in the inspection	
	Chemical: detergent and disinfectant Contamination during washing research surface	No		Clean up disinfectant or wash more to avoid	
	Physical: yak hair and plastic, etc.	No	Sensory evaluation	Carry out good manufacturing practices	
Dressing	Biological: pathogens	Yes	Microbiological examination	Take a high-temperature sterilization	Yes
	Chemical: detergent and disinfectant contamination	No		Clean up or wash more to avoid	
	Physical: hair, buttons, etc.	Yes	Sensory evaluation	Take good manufacturing practices	
Knead- salting	Biological: pathogenic bacteria, bacillus	No	Microbiological examination	Take a high temperature sterilization, add Sodium nitrite in the kneading process	No
	Chemical: residual detergent anddisinfectant	No		Clean up or wash more to avoid	Yes
	Physical: no	No			
Ingredient cutting	Biological: pathogenic bacteria, bacillus and other bacteria reproduction	No	Microbiological examination	Be eliminated by taking a high temperature	Yes
	Chemical: residual detergent and disinfectant	No	Clean up or wash more to avoid		
	Physical: no	No			
Press section I	Biological: pathogenic bacteria, bacillus and other bacteria reproduction	No	Microbiological examination	Be controlled by taking a high temperature	No
	Chemical: residual detergent and disinfectant	No			

Table 1: Continue

Flow sheet	Hazard analysis	Is hazard severe	Basis for judging severity	Measures for preventing hazard	Determined whether it is CCP
	Physical: no	No			
Baking	Biological: pathogenic bacteria, bacillus and other bacteria reproduction	No	Existence in the raw meat can be examined	Be eliminated in the high temperature sterilization process	No
	Chemical: pesticide residues, heavy metals	No		Promise by suppliers, refuse to accept if microbial indicator exceeds	
	Physical: no	No			
Cooling	Biological:pathogenic bacteria,bacillus	No	Microbiological examination	Be eliminated in the high temperature sterilization process	
	Chemical: polluted by air	No		Be avoided by the air disinfectant	No
	Physical: no	No			
Cutting	Biological: pathogenic bacteria,bacillus	No	Microbiological examination	Be eliminated in the high temperature sterilization process	No
	Chemical: residual detergent anddisinfectant	No	Clean up or wash more to avoid		
	Physical: no	No			
Vacuum Packaging	Biological:pathogenic bacteria,bacillus	Yes	Microbiological examination	Be eliminated by taking a high temperature	Yes
	Chemical: polluted by food-packaging material	No		Promise by suppliers, refuse to accept if microbial indicator exceeds	
	Physical: no	No			
Sterilizing in high temperature	Biological: pathogenic bacteria, bacillus and other bacteria reproduction	Yes	Be not propitious to spoilage microorganism growing and propagating		Yes
	Chemical: no	No			
	Physical: no	No			
Drying	Biological: residual bacteria	No		Use the method of lower temperature drying to inhibit the growth of some bacteria species	No
	Chemical: no	No			
	Physical: no	No			
Packing and	Biological: residual bacteria	No		Box Packing and spraying code operate below 15 spraying code centigrade	No
	Chemical: no	No			
	Physical: no	No			

most important step in the a food safety plan. There are variety of ways to monitor critical control points including analyzing the dried beef that requires extra care and following those processes through the acceptance, cutting, sterilizing in high temperature, etc. to pinpoint potential problems. If it is revealed that those processes do not meet the set limits then the procedures must be put in place to correct the situation. Ideally, testing and monitoring of CCPs should be done continually however when that cannot occur, operators need to prove that testing will be done frequently enough to prove that potential hazards are under control (King, 1992). Immediate corrective action must be taken when monitoring shows that a critical control point is not being controlled. Corrective action must be taken immediately when a critical limit has been exceeded, since there is then an increased risk of foodborne illness (McSwane and Linton, 2000). Specifications, critical limits, monitoring methods, frequency, responsibilities and corrective actions were discussed with the HACCP teams. The severity and probability of a hazard were scored from 1 (least) to 3 (most) and when the risks were evaluated as 3 the process step was considered as a CCP. This was a very practical way of decision making after a very profound discussion within a HACCP team bearing in mind that the HACCP Systems were applied in thirteen processes containing 40-150 process steps. It revealed the real situation in each process.

Hygiene training: Hygiene training was included in implementation of the HACCP plans in the processing. The training was divided into a general part and specific parts targeted to the personnel responsible for various activities, e.g., guidance in microbiologic hygiene control methods for laboratory workers. The general phase of the personnel training included lectures, demonstrations and group research on subjects such as basic general microbiology, principles of the HACCP System, determination of CCPs and the control parameters to be measured in the hygiene and safety management system and hygiene aspects in production, e.g., the effect of personal hygiene habits, food handing Do's and Don'ts, a pictorial copy of the six-step method for proper hand washing an explanation of product safety.

RESULTS

A summary of flow diagram of the carton of dried beef is presented in Fig. 1. The relevant hazards for CCPs, specifications, critical limits, monitoring methods and frequency, responsibilities and corrective actions recording-keeping system, verification of both processes are presented in Table 1 and 2. In fact, each of the overall real processes contained about 50-160 process steps and was discussed in detail by the HACCP teams.

The results showed that the critical limits of all control measures defined for this CCP in the processing of dried yak meat, pH of wash water (11-13), temperature of wash water (32-44°C), time (5 min), temperature of rinse water (41-49°C) and level (100-150 ppm), temperature of chlorine cleaning (10-15°C) time (10-15 min) were in accordance with those generally recommended by many related literature to ensure safe food production (Gilchrist, 2006; Shen and Zhang, 2012).

Ambient temperature was controlled at 15°C during natural softening, dressing and cooling, sterilizing pressure was 2.0-2.3 atmospheric pressure, thermal death point is 115±2°C, total number of bacterial colony (2×10^3 cfu g^{-1}) of dried beef after the application of HACCP System was significantly lower than that of original condition (1.22×10^5 cfu g^{-1}) ($p<0.01$), coliform group (20 MPN/100 g) was significantly lower than that of original condition (32 MPN/100 g) ($p<0.05$), pathogenic bacteria (salmonella, *Staphylococcus aureus*) are negative. Laminated aluminium foil package ranked first (Kadam *et al*., 2008), the products storage can maintain 6 months. Hence this CCP was judged to be valid.

Table 2: The program of HACCP in beef production (SSOP-Sanitation Standard Operating Procedures)

CCPs	Hazard	Specifications/ critical limits	Monitoring object	Method	Frequency	Responsibility	action	Corrective keeping system	Recording-Verification
Acceptance of the raw material	Microbiological (growth of potential pathogenic microbes and contamination of microbes, anaerobic conditions), chemical (drug residue, heavy metals and toxins)	Reports of biocide suppliers Critical limits are set according to results gathered in the processing	Cattle raw material after slaughter house	Microbio-logical laboratory	Every batch	Person responsible for daily monitoring	Refusing to purchase or changing / checking the dosages of used biocides taking a proper high-temperature sterilization	HACCP implementation manual on recording for acceptance of raw material in terms of	Log analyze implement SSOP management, suggestions and revisions were made feedback
Dressing	Microbiological (growth of potential pathogenic microbes and contamination of microbes, anaerobic conditions) Physical (hair, buttons, etc.)	Reports of biocide suppliers Reports, documents and instructions related to internal hygiene audits and cleaning	Beef after septation	Microbl-iologica laboratory, Visually monitoring	Every batch, constantly	Person responsible for daily monitoring, Person responsible for worker condition	Taking a proper high-temperature sterilization Checking of the cleaning schedules, hygiene	HACCP implementation manual on recording for dressing	Log analyze implement SSOP management, suggestions and revisions were made in terms of feedback
Gredient cutting	Biological (pathogenic bacteria, bacillus and other bacteria reproduction)	Reports of biocide suppliers	Gredient	Microbio-logical laboratory	Every batch	Person responsible for daily monitoring	Taking a proper high-temperature sterilization or return the goods	HACCP implementation manual on recording for ingredient selection	Log analyze, suggestions and revisions were made in terms of feedback
Vacuum packaging	(Biological pathogenic bacteria, bacillus and other pollution caused by food-pack-aging material)	Reports of packing beef suppliers and of biocide suppliers	Beef after mixing	Microbiolo-gical laboratory, Visually monitoring	Every packing bag, constantly	Person responsible for daily monitoring and for worker condition	Refusing to accept or changing temperature for sterilization	HACCP implementation manual on vacuum packaging	Log analyze, suggestions and revisions were made in terms of feedback
Sterilizing in high temperature	Microbiological (growth of potential pathogenic microbes and contamination of microbes anaerobic conditions)	Reports of biocide suppliers Critical limits are set according to results gathered in the processing	Yak meat after packing	Microbio logical laboratory	Every day	Person responsible for daily monitoring And hygiene manager	Refusing to sell or changing sterilization temperature	HACCP implementation, manual recording for factory	Log analyze implement SSOP management, suggestions and revisions were made in terms of feedback

DISCUSSION

Initially it appeared that implementation based on the seven principles of HACCP was straightforward. However, literature searches found no examples or investigations of theoretical frameworks that coincided with the HACCP principles. In fact, it was apparent that HACCP implementation was more complex resulting in a change beyond recommendations which were to develop, implement and evaluate a HACCP program (Shen, 2009). They gave each site manager an electronic file of all documents used in the HACCP manual as well as a blank copy of the HACCP recipe format. Each manager will then be able to adopt his/her recipes to this format as required and if recipes should change with alterations to the menu, the managers can update their files as needed. All managers were also given detailed descriptions of how their facility ranked according to the prerequisite programs as well as what should be set up and maintained according to the prerequisite programs. A copy of all standard operating were also provided in the HACCP implementation manual.

Education and training is key to the successful implementation of a HACCP program (McSwane and Linton, 2000) hygiene training of personnel in industrial companies in the application of the HACCP System has been shown to be an essential element for effective implementation of HACCP and an active hygiene and safety management system (Mayes, 1994; Shen, 2009). The aims of the training are to increase the motivation for changes in working practices stemming from the implementation of the HACCP System, to increase knowledge of the potential hazards threatening product safety and to inform factory personnel of activities to be carried out in the implementation of HACCP. Furthermore, during training courses the factory personnel were able to participate in and affect the improvement actions necessary for implementation of the hygiene and safety management system. The training course often encouraged participation in regular training events organized by the company itself and improved the commitment of personnel to implementation of the HACCP System. However, this research compares the effectiveness of risk reduction achieved by process and performance standards from the viewpoint of a regulator concerned about not only degree of compliance but also deviation among firms. The regulator has a limited ability to monitor compliance of individual firms due to most of people in west of China lacking of food safety regulation. In this environment it is feasible that the success of a food safety policy may be assessed through monitoring of examples of failures in risk control such as recalls or foodborne illness outbreaks. These are aggregate consequences of individual firm's compliance and/or deviation (Cho and Hooker, 2009; Shen *et al*., 2006).

The seven principles of the HACCP System can be summed up in three elements: hazard analysis, measures for hazard control and verification and documentation of the system. According to this study, some of the measures usually known as good manufacturing practices were handled here as CCPs because the factory pin pointed the importance of the measures as real hazards for product safety. As a result of the HACCP evaluations, a list of various product safety targets for process development was established.

CONCLUSION

After the implementation of the HACCP plans, it has become evident to processors as well as China Food Safety Inspection Service (CFSIS) officials that stand-alone regulations were not sufficient to assure quality of beef. The guarantee of meat product safety can be accomplished if the processor operates with standards for quality systems that support the regulation. A shift to total system thinking is necessary. Adopting the HACCP system will empower the staff to better control the process and comply with regulations and specifications. It will bring added value to the operation and provide a more cohesive corporate food safety system.

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