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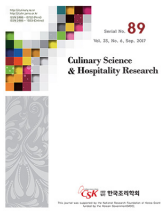

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A Study on Microbiological Hazard Analysis according to the Steaming Process of Various Rice Cakes

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KEYWORDS

Hazard Analysis(HA), Critical Control Point(CCP), Critical limit(CL), Rice cakes, Microbiological.

ABSTRACT

To guarantee the safety of rice cake production, the Hazard Analysis Critical Control Points system was applied to the production process. The purpose of this study was to analyze the microbiological hazards of the manufacture of rice cakes, and establish critical limits in the process of the manufacturing rice cakes. To control the microbiological hazards, the sterilization process was set to a critical limit. The process of manufacturing rice cakes can reduce these microbiological hazards during the steaming process. A microorganism test for each specimen was conducted three times and compared with before and after steaming processes. The finished product was conducted by microbiology experiment and the validity of the steaming process was verified. The results were determined to be capable of reducing the biological element of Critical Control Point via the steaming process. Microbiology such as aerobic plate count, coliform, *Escherichia coli(E. coli)*, *Listeria monocytogenes*, Enterohemorrhagic *E. coli*, *Salmonella* spp., *Bacillus cereus, Staphylococcus aureus* and *Clostridium perfringens* was evaluated by the experimental method of Korean Food Standards Codex. Aerobic plate count was reduced by steaming process, and no microorganism were detected. All rice cakes in the finished product were judged to be safe for both the *Escherichia coli* and general bacteria. In conclusion, it suggested that a HACCP plan was necessary for management standard and systematic approach in the establishment of critical limit, problem resolution, verification method, education, and records management. Based on this study, it is intended to provide a baseline for improving quality control standards and improving hygiene levels for small manufacturers.

1. INTRODUCTION

Rice is a staple food in Korea and it can be processed in a variety of ways, such as ordinary cooked rice, porridge, and rice cake. Rice cakes called "tteok" are one of the most popular of the Korean traditional food. Many types of rice cake can be prepared, via the use of different ingredients and different manufacturing process (Kim, & Lee, 2007; Yoon, & Oh, 2014). Rice cakes are made of raw materials such as rice, glutinous rice, potato, starch, or other cereals, which are added or cooked with salt, sugars, beans, vegetables, fruits, etc. Rice cakes are categorized as steamed and kneaded rice cakes according to the recipe method (KFDA, 2012; Lee, Doo, Kim, & Shim, 2010). Since water activity of rice cake is 0.96 or higher, the rice cake

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has a suitable condition for the rapid propagation of microorganisms (Koh, 1999; Oh et al., 2010). Korean traditional rice cakes are generally packaged by linear low-density polyethylene after steaming and cooling at room temperature, and then distributed throughout markets. Recently, many consumers have become interested in the convenience of use and safety characteristics of food and their concerns regarding the safety of the newer ready-to-eat or microwavable food products have been increased. As the consumption of rice cakes increases, buying and eating the commercial products is increasing instead of making rice cakes at home. However, consumers eat rice cakes without a separate cooking pro- cess (No, Han, & Yoon, 2007). According to the survey of Yim and Kim (1988), the most important thing to improve the rice cake product was in hygienic care, it accounted for 37% (Yim, & Kim, 1988). If improperly managed in manufacturing and distribution processes, risk factors will increase to the risk level and then the finished product will not be able to secure safety and hygiene (Lee, & Bae, 2011). In 2010, the Korea Consumer Agency conducted a survey of 30 products that were sold in large supermarkets and traditional markets, general bacteria were detected at 2.36~6.89, *Escherichia coli* 1.32~4.69 and *Bacillius cereus* 1.38~2.48 log CFU/g (KCA, 2010). As a result, the overall sanitary condition turned out to be poor.

Hazard Analysis Critical Control Point (HACCP) is a world-recognized, effective, and preventive food hygiene management system. At present, the HACCP system has been widely adopted by many countries such as the United States, Japan, the United Kingdom, and member states of the European Union, as well as international organizations such as the World Health Organization, Food and Agriculture Organization, and Codex Alimentarius Commission (CAC). HACCP is defined as a “Food Safety Control System” in Korea (KFDA, 2009). HACCP is a further feature of the presented quality guarantee method based on standard operating procedures. It has two major components: hazard analysis and critical control. Hazard analysis is primarily about systematically identifying and assessing the food production process, and selecting any “biological”, “chemical”, and “physical” characters or factors that may render the food unsafe (Zhu, Yuan, & Zhang, 2003). Critical control is mainly about basing on the results of hazard analysis, and formulating and managing the controllable points or procedures during the process to minimize the safety hazard of final products.

Traditional quality ensuring methods, which simply require inspecting the final products, can no longer satisfy the consumers' needs. Implementing HACCP is helpful in gaining consumers' trust and establishing a good corporate image (Department of Statistics, Ministry of Economic Affairs, 2012). Moreover, many countries such as the United States, member nations of the European Union, and Japan have strict requirements regarding food imports. The application of HACCP enables corporations in Korea to break down trade barriers and participate in international business, thereby effectively expanding their markets and increasing profits (Euromonitor International. Packaged food, 2013). Additionally, a logical and applicable HACCP plan can help food factories improve their management level and enhance their staff's safety consciousness.

HACCP is evaluated in the proper way to ensure the safety of food but rice cake's application for HACCP is being applied only to large company. However, the 96% of the manufacturers of rice cakes are thought to be a small company with fewer than 10 employees and are thought seriously to be a problem with hygiene management (Jeong et al., 2012).

The purpose of this study is to analyze the microbiological hazards of the manufacture of rice cakes, and establish critical limit in the process of the manufacturing rice cakes. Based on this study, it is intended to provide a baseline for improving quality control standards and improving hygiene levels for small manufacturers.

2. MATERIALS AND METHODS

2.1. Preparation of Sample

The materials used in this study were collected by K Corporation in May 2015. Each material was collected in a sterilized plastic pack to prevent secondary contamination and was transported to the sample box quickly and used for testing. Samples for microbiological analysis have been treated aseptically at the clean bench, and all samples are used with sterile reagents and scissors.

2.2. Microorganisms Analyses by Manufacturing Process

It was categorized as “Tteokbokki tteok”, “Injeolmi”, “Injeolmi for ice flake”, “glutinous rice cake” depending on how the rice cakes were manufactured. The overall manufacturing process is summarized in Table 1. Different kinds of rice cakes

had different steaming times (Table 1). To apply the HACCP system, all manufacturing stages should be identified from the preparation of the materials from preparation of the materials. Microbiological hazard factors should be identified by each step of the sequence and recorded the major processing conditions (Food and Drug Administration, 2009; Choi et al., 2012; Lee, 2006).

2.3. Microbiological Evaluation

Microbiology such as aerobic plate count, coliform, *Escherichia coli (E. coli)*, *Listeria monocytogenes*, Enterohemorrhagic *E. coli*, *Salmonella* spp., *Bacillus cereus, Staphylococcus aureus* and *Clostridium perfringens* was evaluated by the experimental method of Korean Food Standards Codex (Korea Food and Drug Administration, 2014).

2.4. Establishment of Critical Limits

To control the microbiological hazards, the sterilization process was set to a critical limits. The process of manufacturing rice cakes can reduce these microbiological hazards during the steaming process. A microorganism test for each specimen was conducted three times and compared to before and after steaming processes. The finished product was conducted by microbiology experiment and the validity of the steaming process was verified.

3. RESULTS AND DISCUSSION

3.1. Changes in Number of General Bacteria and Coliform for Process of Steaming

HACCP is a systematic approach used in the food industry for the identification, assessment, and control of biological, chemical, and physical hazards, providing an effective way to advance food quality/safety, focusing on preventing hazards and improving processes (KFDA, 2009). Critical limit is the processing requirement that needs to be fulfilled at every corresponding control points. The HACCP system is applied in the present study as a preventive food safety approach to control the potential hazards appearing in the rice cakes (Lee, & Kwon, 2013; Kang, Lee & Kim, 2015).

A microorganism test for each specimen was conducted tree times and compared to before and after steaming processes. The results of the changes in aerobic plate count and the *E. coli.* by steaming are shown in Table 2. The 'Tteokbokki tteok' showed that aerobic plate count ranged from 8.1×10^5 to 8.5×10^5, 'Injeolmi' ranged from 3.7×10^4 to 4.5×10^4, 'Injeolmi for ice flake' ranged from 2.7×10^6 to 4.2×10^6, and 'glutinous rice cake' ranged from 6.8×10^3 to 7.8×10^3. The 'Tteokbokki tteok' showed that coliform ranged from 3.4×10 to 5.0×10, 'Injeolmi for ice flake' ranged from 2.0×10^2 to 3.4×10^2, and it was not detected in 'Injeolmi' and 'glutinous rice cake'. After steaming, aerobic plate count and coliform were not detected in all kinds of rice cakes.

The results of the changes in pathogenic microorganisms such as *E. coli*, *Listeria monocytogenes*, Enterohemorrhagic *E. coli*, *Salmonella* spp., *Bacillus cereus, Staphylococcus aureus* and *Clostridium perfringens* by steaming are shown in Table 3. The pathogenic microorganisms were not detected before and after the steaming process in all types of rice cake. As shown in these results, all microorganisms are reduced to decrease the risk of microbiological hazards after the steaming process, so that the steaming process is judged to be a CCP.

The results of the microbiological evaluation of finished

Table 1. Microorganisms analyses by manufacturing process

Order	Process	Microorganisms analyses
1	Raw materials	
2	Washing	• Aerobic plate count
3	Soaking	• Coliform
4	Milling & sieving	• *Escherichia coli*
5	Mixing	• *Listeria monocytogenes*
6	CCP: Steaming at 100℃ steaming time: 'Tteokbokki tteok' 11 min, 'Injeolmi' 20 min, 'Injeolmi' for ice flake' 25 min, 'glutinous rice cake' 30 min	• Enterohemorrhagic *E. coli* • *Salmonella spp.* • *Bacillus cereus* • *Staphylococcus aureus* • *Clostridium perfringens*
7	Cooling and cutting	
8	Packaging	
9	Storage	

Table 2. Changes in number of aerobic plate count and coliform for process of steaming

Sample	Microorganism	Before steaming			After steaming		
		1st	2nd	3nd	1st	2nd	3nd
Tteokbokki tteok	Aerobic plate count	8.2×10^5	8.1×10^5	8.5×10^5	ND	ND	ND
	Coliform	5.0×10	3.4×10	4.6×10	ND	ND	ND
Injeolmi	Aerobic plate count	4.5×10^4	3.7×10^4	4.1×10^4	ND	ND	ND
	Coliform	ND	ND	ND	ND	ND	ND
Injeolmi for ice flake	Aerobic plate count	3.9×10^6	4.2×10^6	2.7×10^6	ND	ND	ND
	Coliform	3.4×10^2	2.9×10^2	2.0×10^2	ND	ND	ND
Glutinous rice cake	Aerobic plate count	7.8×10^3	6.8×10^3	7.0×10^3	ND	ND	ND
	Coliform	ND	ND	ND	ND	ND	ND

* Unit: CFU/g, ND : Not detected.

products are shown in Table 4. The rice cakes correspond to the "frozen food and rice cakes without heating in 2014-no.117 of Korean Food Standards Codex (Korea Food and Drug Administration, 2014). Based on the specifications of Korean Food Standards Codex, the rice cakes shall satisfy the following microbiological test results ; Number of bacteria : n=5, c=2, m=100,000, M=500,000, M=500,000, coliform: n=5, c=2, m=10, M=100, *E. coli* : n=5, c=1, m=0, M=10.

Result of analyzing microorganisms for finished products, it appeared as follows. The 'Tteokbokki tteok' showed that aerobic plate count ranged from 7.0×10 to 1.2×10^2, 'Injeolmi' ranged from 2.2×10^2 to 3.2×10^2, 'Injeolmi for ice flake' ranged from 7.4×10^2 to 1.2×10^3, and 'glutinous rice cake' ranged from 9.8×10^2 to 1.6×10^3. The 'Injeolmi' showed that coliform ranged from 0 to 2.0×10, 'Injeolmi for ice flake' ranged from 0 to 1.0×10, 'glutinous rice cake' ranged from 0 to 2.0×10, and it was not detected in 'Tteokbokki tteok'. The pathogenic microorganisms such as *E. coli*, *Listeria monocytogenes*, Enterohemorrhagic *E. coli*, *Salmonella* spp., *Bacillus cereus, Staphylococcus aureus* and *Clostridium perfringens* were not detected in all types of rice cakes.

To control the microbiological hazards, the sterilization process was set to a critical limits. The process of manufacturing rice cakes can reduce these microbiological hazards during the steaming process. Steaming time was set differently depending on the type of rice cake. The Steaming time was decided by 11 minutes of 'Tteokbokki tteok', 20 minutes of 'Injeolmi', 25 minutes of 'Injeolmi for ice flake', and 30 minutes of 'glutinous rice cake'. The reason why steaming time varies depending on the type of rice cake is because there is a difference in time between the sterilization results and the time it does not affect the product. The steaming time specified in each product can be determined by showing the decrease in the number of microorganisms. If exceeding the specified heating time, quality of the product may deteriorate.

In order to prevent unsafe products from reaching consumers, a corrective action is carried out when there is a deviation from any established CCP. During this procedure, problems will be corrected and production will be put back in control. Any unqualified product will be further tested to determine its safety. A complete HACCP plan also requires a verification procedure, such as random sampling and testing, to examine whether HACCP can effectively control food safety. Additionally, the implementation of the HACCP system should be well documented. Documentation usually includes the content of hazard analysis and CCP determination, and record keeping includes CCP monitoring activities, deviation and associated corrective actions, and verifications. These procedures help to verify that HACCP controls are in place and are being appropriately maintained.

4. CONCLUSIONS

The purpose of this study is to analyze the microbiological hazards of the manufacture of rice cakes, and establish critical limit in the process of the manufacturing rice cakes. The rice cake manufacturing process was developed prior to this study. During the manufacturing process, One of the CCPs is the process of removing metallic debris, and the other is the process of reducing the risk of hazardous microorganisms. This could be determined by the CCPs such as in several studies, which can reduce biological hazards and physical hazards

Table 3. Changes in number of pathogenic microorganisms for process of steaming

Sample	Microorganism	Before steaming			After steaming		
		1st	2nd	3nd	1st	2nd	3nd
Tteokbokki tteok	*Escherichia coli*	ND	ND	ND	ND	ND	ND
	Listeria monocytogenes	ND	ND	ND	ND	ND	ND
	Enterohemorrhagic *E. coli*	ND	ND	ND	ND	ND	ND
	Salmonella spp.	ND	ND	ND	ND	ND	ND
	Bacillus cereus	ND	ND	ND	ND	ND	ND
	Staphylococcus aureus	ND	ND	ND	ND	ND	ND
	Clostridium perfringens	ND	ND	ND	ND	ND	ND
Injeolmi	*Escherichia coli*	ND	ND	ND	ND	ND	ND
	Listeria monocytogenes	ND	ND	ND	ND	ND	ND
	Enterohemorrhagic *E. coli*	ND	ND	ND	ND	ND	ND
	Salmonella spp.	ND	ND	ND	ND	ND	ND
	Bacillus cereus	ND	ND	ND	ND	ND	ND
	Staphylococcus aureus	ND	ND	ND	ND	ND	ND
	Clostridium perfringens	ND	ND	ND	ND	ND	ND
Injeolmi for ice flake	*Escherichia coli*	ND	ND	ND	ND	ND	ND
	Listeria monocytogenes	ND	ND	ND	ND	ND	ND
	Enterohemorrhagic *E. coli*	ND	ND	ND	ND	ND	ND
	Salmonella spp.	ND	ND	ND	ND	ND	ND
	Bacillus cereus	ND	ND	ND	ND	ND	ND
	Staphylococcus aureus	ND	ND	ND	ND	ND	ND
	Clostridium perfringens	ND	ND	ND	ND	ND	ND
Glutinous rice cake	*Escherichia coli*	ND	ND	ND	ND	ND	ND
	Listeria monocytogenes	ND	ND	ND	ND	ND	ND
	Enterohemorrhagic *E. coli*	ND	ND	ND	ND	ND	ND
	Salmonella spp.	ND	ND	ND	ND	ND	ND
	Bacillus cereus	ND	ND	ND	ND	ND	ND
	Staphylococcus aureus	ND	ND	ND	ND	ND	ND
	Clostridium perfringens	ND	ND	ND	ND	ND	ND

* Unit: CFU/g, ND : Not detected.

(Kwon, 2011; Kwon, 2013). To control the microbiological hazards, the sterilization process was set to a critical limits. The process of manufacturing rice cakes can reduce these microbiological hazards during the steaming process. Microbiology such as aerobic plate count, coliform, *Escherichia coli (E. Coli)*, *Listeria monocytogenes*, *En*terohemorrhagic *E. coli*, *Salmonella* spp., *Bacillus cereus, Staphylococcus aureus* and *Clostridium perfringens* was evaluated. A microorganism test for each specimen was conducted tree times and compared to before and after steaming processes. The finished product was conducted by microbiology experiment and the validity of the steaming process was verified. To control the microbiological hazards, the sterilization process was set to a critical limits. The process of manufacturing rice cakes can reduce these microbiological

Table 4. Microbiological evaluation of the finished product

Microorganism	Tteokbokki tteok	Injeolmi	Injeolmi for ice flake	Glutinous rice cake
Aerobic Plate Count	n1=8.0×10 n2=1.2×10^2 n3=1.0×10^2 n4=7.0×10 n5=8.0×10	n1=3.2×10^2 n2=2.5×10^2 n3=2.2×10^2 n4=2.6×10^2 n5=3.0×10^2	n1=7.4×10^2 n2=1.2×10^3 n3=8.5×10^2 n4=8.0×10^2 n5=1.0×10^3	n1=1.6×10^3 n2=9.8×10^2 n3=1.4×10^3 n4=1.6×10^3 n5=1.5×10^3
coliform	ND	n1=ND n2=1.0×10 n3=2.0×10 n4=1.0×10 n5=ND	n1=1.0×10 n2=ND n3=ND n4=ND n5=ND	n1=ND n2=2.0×10 n3=2.0×10 n4=1.0×10 n5=ND
Escherichia coli	ND	ND	ND	ND
Listeria monocytogenes	ND	ND	ND	ND
Enterohemorrhagic *E. coli*	ND	ND	ND	ND
Salmonella spp.	ND	ND	ND	ND
Bacillus cereus	ND	ND	ND	ND
Staphylococcus aureus	ND	ND	ND	ND
Clostridium perfringens	ND	ND	ND	ND

* Unit: CFU/g, ND : Not detected.

hazards during the steaming process. Steaming time was set differently depending on the type of rice cake. The steaming time was decided by 11 minutes of 'Tteokbokki tteok', 20 minutes of 'Injeolmi', 25 minutes of 'Injeolmi for ice flake', and 30 minutes of 'glutinous rice cake'. The reason why steaming time varies depending on the type of rice cake is because there is a difference in time between the sterilization results and the time it does not affect the product. The steaming time specified in each product can be determined by showing the decrease in the number of microorganisms. If exceeding the specified heating time, quality of the product may deteriorate. It is judged that the temperature and time of the steaming process are suitable to removing pathogenic microorganisms. In conclusion, it suggested that a HACCP plan was necessary for management standard and systematic approach in the establishment of critical limit, problem resolution, verification method, education, and records management. Based on this study, it is intended to provide a baseline for improving quality control standards and improving hygiene levels for small manufacturers. In addition to the results shown in this study, there are several important things in hygiene management. Manufacturing facilities and equipment shall be cleaned and disinfected at regular intervals and shall be inspected for surface contamination. Analyzing the personal hygiene condition of employees is important to producing sanitary products. It is necessary to continuously manage personal hygiene because it is judged that *E. coli* has been contaminated indirectly by fecal matter. Food manufacturers are constantly required to undergo microbial tests, personal hygiene education and training.

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