Food safety issues in industrialization of traditional Korean foods

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A B S T R A C T

Consumer concerns over food safety are ever increasing in Korea, and consumer demand for expanding the right to know is becoming an important challenge for the food industry. Consumers generally believe that traditional foods are safe. Most traditional foods in Korea are produced under varying scales, and food safety risk management and risk assessment are conducted primarily by the government. According to the result of risk assessment, safety regulations and standards of traditional foods (e.g. fermented soybean products, fermented fish products, Kimchi) are established. In this paper, safety concerns confronted during the industrialization of traditional foods and related studies to identify and minimize the hazards are discussed. Research results related to possible contamination with aflatoxin in fermented soybean products, biogenic amines and secondary amines in Kimchi, and biogenic amines in fermented fish products are mainly reviewed. It is suggested that more national risk analysis experts and related database are needed. The manufacturing processes of traditional foods need to be standardized and harmonized with international standards, such as CODEX.

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1. Introduction

As consumer concern on food safety increases in Korea, consumers are much more interested in not only “what foods to eat” but also “what foods to avoid”. This change was accelerated via the media, which makes it possible for people to get sufficient food information. Attention has turned to traditional Korean foods (TKF), which epitomize the slow food phenomena and the fermentation science. Generations ago, such foods were established as safe and healthy foods. Recently, Kimchi was presented in Health Magazine in 2006 as one of the world’s five healthiest foods.
Moreover, 14 types of Korean foods, such as fried Kimchi, hot pepper paste (Gochujang), Bulgogi (roasted beef marinated with soybean sauce), Bibimbap (cooked rice and vegetable mix), etc., were approved by the Russian Institute of Biomedical Problems (IBMP) as a space food in 2008 (Song et al., 2009). To be used for this purpose, more strict and science-based safety standards and quality assurance are needed. To strengthen its quality, it is necessary for safety regulations and standards of TKF to improve as manufacturing moves from small-scale to mass production. As part of an effort to upgrade the quality of KTF, the Ministry for Food, Agriculture, Forestry, and Fisheries (MIFAFF) set up the Quality Certification System in 1991. There are 54 items and 284 companies accredited by this system as of 2009. It is aimed at producing traditional foods of high quality to meet consumer needs.

This paper focuses on three major fermentation foods; fermented soybean products, Kimchi, and fermented fish products. Safety issues with these products appeared during industrialization, and studies to minimize hazards are discussed.

2. Safety issues related to traditional foods

The superiority of TKF has been represented primarily by fermented foods, such as Kimchi and fermented soybean products (Doenjang, Kanjang, Gochujang). They are a good source for essential amino acids, vitamins, and minerals. Even if there are numerous beneficial effects in traditional foods, safety issues have risen in the past (Table 1).

Food safety issues regarding TKF initiated with Dr. Seel, who did missionary work in Korea at the end of 1960's and suggested that the high incidence of stomach cancer among Koreans and other Far Eastern peoples may be related to a mold called aflatoxins produced in the preparation of soybean paste (Crane, Rhee, & Seel, 1970). Since aflatoxin is one of the most powerful carcinogenic substances, it was a sensational report worldwide. This report made scientists in Korea and Japan eager to verify whether or not the culprit of stomach cancer is a carcinogenic substance, it was a sensational report worldwide. Considering these results, a discrepancy seems to exist between epidemiological and scientific data on this issue. It is well known that results of epidemiological studies are difficult to interpret because other dietary factors including high salt in soybean products are involved. In fact, Wu, Yang, and Pike (2000) meta-analyzed epidemiological studies examining the relationship between fermented soybean foods and the risk of stomach cancer. The results stressed that etiology cannot be understood until the roles of salt, fruit/vegetables, and other dietary sources are determined. Additionally, the target organ of aflatoxin is not the intestine but the liver. Consequently, research to verify a relationship between the intake of soybean products and occurrence of gastric cancer should adopt a different approach. Numerous research papers regarding soybean products highlighted that anticancer effects are much stronger than a possibility of carcinogenicity determined by epidemiological studies.

2.1. Aflatoxin in fermented soybean products

Samples of soybean sauce and soybean paste were collected from various markets in Korea to detect aflatoxin levels. Aflatoxin B1 was detected by ELISA/HPLC in one out of seven soybean sauce (Kanjang) samples, two of fifty six soybean paste (Doenjang) samples, and none of forty six hot soybean paste (Gochujang) samples. The detected levels of Kanjang and Doenjang were 1.81 ppb and 0.05–0.17 ppb, respectively. They were shown to be less than the permitted level (10 ppb) of the Korea Foods Standards (KFDA, 2008) (Chun, Ok, Kim, Hwang, & Chung, 2006, pp. 1795–1809). Although they are within safe levels, proper manufacturing process and management practices (including cultivating and storage technology) are important to minimize contamination of aflatoxin, ochratoxin, biogenic amines, and Bacillus cereus at each stage of production.

Several factors can be considered for degrading aflatoxin during fermentation. NH3 produced during the fermentation, light, microbial competitions with Bacillus spp., and addition of charcoal or vitamin C help reduce aflatoxins from soybean products (Kang, Park, & Cho, 2000; Park et al., 2003; Park & Lee, 1989; Park, Lee, Moon, & Cheigh, 1989). In addition, increasing concentrations of CO2 or N2 can suppress the formation and growth of aflatoxin because aflatoxin-producing molds are aerobic organisms, requiring O2 (Park, 1984). The primary goal is to block aflatoxin from producing because it is hard to remove, even after heating. It was suggested that storage temperature should be maintained at 0–7.5 °C because the optimum temperature range for aflatoxin production is 25–30 °C (Park, 1984). Therefore, food industries are producing refrigerated soybean products to enhance safety. Current refrigerated soybean paste accounts for 16% of the entire brand. This method also was reported to remove off-flavor and to improve taste.

2.2. Nitrate, nitrite, secondary amines, and biogenic amines in Kimchi

There have been several controversial debates on the safety of Kimchi related to nitrate, nitrite, secondary amines, and biogenic

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amines. According to Lee's (1987) study, the amount of nitrate in the vegetable decreases rapidly during four days of fermentation at 20 °C, while the levels of nitrite and secondary amines increase slightly before decreasing. The changes in nitrate reductase activity during Kimchi fermentation follow the same pattern as the changes in nitrate concentration (Yang & Kwon, 1982). This result indicates that Kimchi fermentation reduces the nitrate level in vegetables through the action of microorganisms without increasing the concentrations of nitrite or secondary amines to any significant level.

The formation of nitrite and secondary amines during Kimchi fermentation was of great concern to many researchers in Korea in the 1970s. However, it was determined that the amounts of nitrite and secondary amines in Kimchi were very low compared to those in sausages and fish (Yim, Yoon, & Kwon, 1973). The possibility of nitrosamine formation during fermentation was investigated because fresh cabbage contains large amounts of nitrate varying from 55 to 2500 ppm. However, it was reduced rapidly after one week of Kimchi fermentation; thus, it is not a factor. Nitrite content in Kimchi ingredients was very low, ranging from 0 to 0.56 ppm, and increased slightly during the first three to five weeks of fermentation at 5 °C before decreasing rapidly (Park & Choi, 1994).

To examine the biogenic amine content in commercial Kimchi, eight different types of Kimchi products were analyzed by HPLC. The biogenic amine content was between 0 and 150 mg/kg, which is an acceptable level for human health (Mah, Kim, No, & Hwang, 2004). The putrescine and cadaverine levels were slightly higher in the 'baechu-kimchi' sample than in other samples. To reduce these amines, addition of jeot-gal can be adjusted because the biogenic amines in jeot-gal are transferred to Kimchi.

It is well known that Kimchi has strong antipathogenic and antimicrobial activities. In fact, Clostridium perfringens disappeared after two days of Kimchi fermentation; Staphylococcus aureus and Salmonella typhimurium after four days; and Listeria monocytogenes, Vibrio parahaemolyticus and Escherichia coli after five days; however, the number of lactic acid bacteria increased from 10^5 to 10^6 (Ha, 1994). This antimicrobial effect of Kimchi appears to result from the combined effects of the organic acids and bacteriocin produced during fermentation and in Kimchi ingredients (garlic, onion, ginger, etc.).

Contamination with parasite eggs and lead of Kimchi imported from China was a large scandal in Korea in 2005. Although parasite eggs, like microorganisms, are primarily inactivated in Kimchi juice, which contains 3–5% salt, 0.8% organic acids (mainly lactic acid and acetic acid), and carbon dioxide, the Korea Food and Drug Administration (KFDA) considered this issue a safety incident. It created a severe trade conflict with China, and the import and export of Kimchi were severely damaged. Lead contamination can hardly be an issue in Kimchi since Kimchi does not have any significant possibility of lead contamination in the raw materials and in the common processing lines. However, the pertinacious request of a parliament member resulted in establishing a standard on lead in Kimchi.

2.3. Biogenic amines in jeot-gal

Jeot-gal is the generic name for high-salt fermented fish products, which are used not only for side dishes but also for additives in Kimchi. Jeot-gal contains large amounts of precursor amino acids of biogenic amines because it is made from the muscles and viscera of seafood and salts. International Agency for Research on Cancer (IARC) has reviewed that salted fish and fish sauce have sufficient evidence for carcinogenicity (IARC, 1993). Therefore, it is important to reduce biogenic amine content. Several studies suggested that addition of garlic and glycine can inhibit amino acid decarboxylase activity in Myeolchi-jeot (made of anchovies). The levels of cadaverine and tyramine were reduced by 18.4% and 30.9%, respectively, in the culture treated by garlic extract (Mah, Kim, & Hwang, 2009). In particular, glycine demonstrated the greatest inhibition of biogenic amine production. The levels of putrescine, cadaverine, histamine, tyramine, and spermidine were reduced by 32.6%, 78.4%, 93.2%, 100%, and 100%, respectively, compared to those of the control (Mah & Hwang, 2009a). Therefore, there is no doubt that these findings can help improve safety.

3. Reduction policy of hazards in traditional foods

Overall conclusions to minimize the hazards can be summarized in three factors.

First, selected good starter can be applied. For example, Koji has been used to make soybean paste in Korea since the 1960s. Koji contains Aspergillus oryzae rather than Aspergillus flavus, which produces aflatoxin. Industries have used Koji, but its taste and flavor are not as rich as soybean paste made in traditional ways. Therefore, both preparation methods are worthwhile to present in the food market for consumer preference. Another example is Leuconostoc–Kimchi, which maintains the highest quality of Kimchi for a long time. Since bacteria groups and yeasts change during fermentation, Leuconostoc sp. is applied intentionally for fermentation because it provides superior flavor with rich organic acids, and it can delay yeast formation at later stages as well. In addition, the methods using microbial competition can minimize hazards because of the characteristics of fermented foods. According to Mah and Hwang’s report (2009b), the addition of Staphylococcus xylosus as a competitor reduced biogenic amines 16% and histamine 38%.

Second, changing the fermentation conditions is a great challenge. We considered temperature, salt concentration, light, and air ventilation. At temperatures below 10 °C fermentation, storage, and distribution procedures significantly reduced hazards (decreased production of aflatoxin and biogenic amines), improved taste, and reduced salt, which is added to extend storage period (Mah, Ahn, Park, Sung, & Hwang, 2003). Currently, a large percentage of population is trying to eat less sodium because they are paying attention to health and well-being. Consequently, companies are investing in a cooling system to produce refrigerated products.

Third, various ingredients can be applied as less as changing in taste because garlic and glycine powerfully reduced biogenic amines in jeot-gal.

4. Food standards for traditional Korean fermented foods

Food standards for TKF are controlled under the Food Sanitation Act, 2008. Each of the three groups of fermented foods has specific criteria (Table 2).

Jangryu (fermented soybean products): aflatoxin should be less than 10 ppb, and Coliform group should not be detected in fermented soybean products. These aflatoxin B1 levels (<10 ppb) were required for cereals, beans, peanuts, snacks, and soybean products until 2009. Since September 2009, KFDA has included total aflatoxin levels (sum of B1, B2, G1, G2) to enforce management of molds increasing due to an increase in imports from subtropical regions and global warming.

Kimchi: since red pepper powder is a source of aflatoxin contamination, aflatoxin levels in red pepper powder is restricted to less than 10 ppb. Safety accidents have frequently been instrumental in establishing food standards of Kimchi. For example, standards for heavy metals in Kimchi were set after the “Lead Kimchi” incident happened in 2005.
Jeot-gal (fermented fish products): standards for aflatoxin, B. cereus, and heavy metals are not as high as in fermented soybean products and Kimchi. This may be due to the high salt concentration.

5. Food safety management system in Korea

Two government agencies, KFDA and MIFAFF, are in charge of risk analysis. The MIFAFF is responsible for raw materials, and the KFDA is responsible for imported/processed foods. Currently, food safety risk assessment in Korea is not separated organizationally from risk management and is conducted under the same roof as the KFDA. KFDA focuses on the professional development and infrastructure toward an appropriate system. The KFDA established the Guidance for Risk Assessment Methods and Procedure in 2007, amended it in 2009, and published the Guidance for Risk Assessment and Guidance for Human Exposure Assessment in 2007. Further studies on food safety risk assessment procedure and harmonization of the procedures within the country as well as with other nations are needed.

6. Conclusions

Increasing liberalization of international trade will contribute to move food, ingredients, and feed in the global village. As the global demand of TKF grows, several factors need to be considered. First, their safety issues need to be defined. The KFDA plays a key role in risk analysis in Korea. Since risk analysis of traditional foods performed by KFDA is aflatoxin B1 for hot pepper, seasoned red-pepper sauce (Dadaegi), and Kimchi; ethyl carbonate for fermented soybean products, Kimchi, and Jeot-gal; nitrosamine for seven items including Jeot-gal; and biogenic amines for Kimchi, fermented soybean products, and Jeot-gal, risk analysis should be extended to more foods (Lee, Hwang, Ryuem, Jang, & Yang, 2009). To do this job, more national risk experts are required. Whenever safety accidents occur, an established database would be useful for providing the right information and steps to follow.

Second, the manufacturing process needs to be standardized because quality can be inconsistent and a few soybean pastes contaminated with aflatoxin are found in small-scale production. To solve these safety problems, food safety assurance systems in the food supply chain should be applied. In fact, a large number of industries already have obtained certification schemes, such as Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP), International Organization for Standardization (ISO) standards, and Hazard Analysis Critical Control Points (HACCP). In addition, traceability systems using Radio-Frequency Identification (RFID) tag can be used in conjunction with the above certification systems. These certifications and secure systems should be encouraged and supported by government authorities. Personal training in sanitation principles and food safety control is required.

Third, international standards are required for global trade as well as for products meeting nationally or internationally agreed upon safety and quality standards. Kimchi was first registered in Codex in 2001, followed by Gochujang, Doenjang, and Ginseng in regional Codex in 2009. Tree onion, Korean black raspberry, Korean raspberry, Yuzu, Perilla seed, and five varieties of mushrooms are set to be registered in Codex in 2011. Having Codex standards for more traditional foods will facilitate exports because the standard has been applied primarily in international trade and commerce.

Acknowledgments

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References


