MINISTRY OF FOOD AND DRUG SAFETY
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Risk Assessment of *Campylobacter* in meat

Introduction

Korean food culture incorporates consumption of raw meat, as in the case of Japan, which has been associated with foodborne illnesses. Recently, the number of food poisoning incidents caused by *Campylobacter* spp. has rapidly increased due to the rise in the consumption of meat, particularly poultry, both in Korea and abroad. *Campylobacter* is easily destroyed during distribution because it is a micro-aerophilic bacterium that is susceptible to oxygen letvle in the air. However, it has the capacity to survive in refrigerated meat, which is the standard condition utilized during meat distribution, or in meat that is eaten raw within several hours after slaughter, thereby causing food poisoning. Therefore, it is necessary to assess the risk of *Campylobacter* contamination of meat products that are distributed in Korea, in order to establish standard criteria for screening meat products and to reduce the occurrence of food poisoning by the bacterium.

Statement of purpose

The purpose of the risk assessment is to present risk management measures by analyzing the risks for *Campylobacter* contamination of meat and to prevent food poisoning and food accidents that occur through meat consumption by developing guidelines for the management of the bacterium in meat.

Hazard identification

Campylobacter spp.

Campylobacter spp. is an asporogenic, gram-negative bacillus that is 0.2–0.5 μm in width and 1.5–6.0 μm in length. Most bacteria that belong to this species have polar flagellation on one or both of their ends, are spiral-shaped, and show motility (Ketley, 1999). The temperature range for its growth is 30℃–45℃ (optimum temperature: 43℃) (Engberg et al., 1998), and it does not proliferate well at the growth temperature (25℃–30℃) of bacteria that cause food poisoning in general (Hazeleger et al., 1998). Although it becomes unstable and is easily destroyed at room temperature, it can survive for a long time in cold storage at 4℃ or in ultra-low (-80℃) conditions. It is susceptible to heat (destroyed in 1 min at 70℃), germicides, and acidic conditions (MFDS, 2013).

Campylobacter spp. can be found everywhere, and commonly exists in the intestinal tract of various wild animals and livestock as well as in humans. Its carrier rate is known to be high in cattle, pigs, mice, chickens, and turkeys, and it rapidly proliferates in the intestines of poultry (MFDS, 2004).

Campylobacter sometimes exists in a state where it is viable but non-culturable (VBNC). In this state, the bacterium shows metabolic activities but can hardly be cultured using general culture techniques (Cappelier et al., 1999). When it is exposed to extreme conditions such as water and subjected to continuous freeze-thawing, it enters the VNBC state and can sometimes change into the form of coccoid. *Campylobacter* in the VBNC state cannot easily be cultured in normal media, and its risks should not be overlooked because it can infect animals and human beings (Blackburn and McClure, 2002).

Exposure assessments

Exposure assessment of *Campylobacter* in meat was conducted by developing different scenarios involving chicken/duck and eating raw meat (beef liver/stomach, beef tartare, chicken tartare) and three meat processing stages such as the slaughter stage, sale/purchase stage, and consumption stage for the former scenario and two stages including sale/purchase stage and consumption stage for the latter scenario.

Exposure assessment of *Campylobacter* in meat

<Chicken/duck>

Contamination testing for *Campylobacter* detected the bacterium in 58 out of 240 chickens or ducks at the slaughter stage. Estimation of the initial contamination level using the Beta distribution indicated an average contamination level of -2.0 log CFU/g. The survival of *Campylobacter* in chicken/duck was predicted using an existing model (González et al., 2009).

Changes in bacterial count from the initial contamination levels (average: -2.0 log CFU/g) were estimated through simulation for risk assessment. The number decreased to -2.3 log CFU/g after moving from the slaughterhouse to the market, to -2.8 log CFU/g at the time of sales, and again to -3.1 log CFU/g when it arrived at the home of consumers. Finally, at the time of consumption, the contamination levels decreased to -11.8 log CFU/g. The average chicken/duck consumption, which was estimated using a questionnaire survey, was 110.02 ± 85.89 g and the frequency of consumption per day was 6.7%.

<Raw meat for eating: Beef liver/tripe>

Campylobacter was detected in 1 out of 80 samples of beef liver/tripe. Estimation of contamination level using the Beta distribution indicated an average contamination level of -3.1 log CFU/g. The survival model of *Campylobacter* in beef liver/tripe was developed using the Weibull model and the Davey model. Simulation was conducted separately for cases of consumption of beef liver/tripe at home and in restaurants.

Changes in bacterial count from the initial contamination levels (average: -3.1 log CFU/g) in the market (wholesale market for livestock products) were estimated through simulation for risk assessment. When beef liver/tripe was purchased in the market and eaten at home and in restaurants, the final bacterial count for *Campylobacter* consumed was -3.1 log CFU/g and -3.2 log CFU/g, respectively, showing no significant change. The average intake amount of beef liver/tripe was 58.00 ± 31.09 g, and the frequency of consumption per day was 0.15%.

<Raw meat for eating: Beef tartare (Yukhoe)>

Campylobacter was not detected in any of the 40 samples of beef tartare tested. Estimation of the contamination level using the Beta distribution indicated an average contamination level of -3.3 log CFU/g. The survival model of *Campylobacter* in beef tartare was developed using the Weibull model and Davey model. In the case of beef liver/tripe, separate simulations were conducted for cases of consumption at home and in restaurants.

Changes in bacterial count from the initial contamination levels (average: -3.3 log CFU/g) were estimated through simulation for risk assessment. No significant difference in the number of *Campylobacter* taken through the consumption of beef tartare, which was purchased at the market, was observed in homes and restaurants. The average intake amount of beef tartare obtained through a questionnaire survey was 173.34 ± 104.71 g, and the

frequency of consumption per day was 0.74%.

<Raw meat for eating: Chicken tartare>

Approximately 6 out of the 60 samples of chicken tartare tested positive for *Campylobacter* contamination. Estimation of contamination level using the Beta distribution indicated an average contamination level of -2.3 log CFU/g. An existing model (González et al., 2009) was used as the survival model for *Campylobacter* in chicken tartare.

Changes in bacterial count from the initial contamination levels (average: -2.3 log CFU/g) were estimated through simulation for risk assessment. The number of *Campylobacter* that was calculated based on the consumption of chicken tartare decreased to -3.9 log CFU/g. The average intake amount of chicken tartare was 66.67 ± 32.79 g, and the frequency of consumption per day was 0.028%.

Hazard characterization

A review of literature indicates that approximately 50% of test subjects who each consumed at least 500–800 cells experienced food poisoning due to *Campylobacter* (Black et al., 1988; USDA, 2011). Other reports showed a minimum infective dose of 800–1,000 cells, although the infective dose of *Campylobacter* varies with the susceptibility of the host; for example, specific groups such as infants, children, pregnant women, and the elderly as well as people whose immune functions have declined due to disease are vulnerable to infection. Around 80% of *Campylobacter* food poisoning cases are caused by *C. jejuni*.

In the present study, the minimum infective dose was set within the range of 500–800 cells,

which was based on previous reports on the infective dose of *Campylobacter* and relevant international guidelines.

About 20 dose-response models have been developed for *Campylobacter* to date, with the Beta Poisson model (Teunis et al., 2000) as the most extensively used tool. Therefore, the present study utilized the Beta Poisson model in performing risk assessment for *Campylobacter* contamination in meat.

Risk characterization

***Campylobacter* in meat**

The inoculation rate of *Campylobacter* through meat consumption was estimated based on the contamination level of *Campylobacter* at the time of consumption, the amount of meat consumed, and the frequency of consumption, and the final results were subjected to 10,000 iterations using @RISK.

<Chicken/duck>

Risk estimation indicates that the probability of food poisoning due to the consumption of chicken/duck meat infected with *Campylobacter* in the present distribution environment and consumption level per person per day is 3.40×10^{-7}.

<Consumption of raw meat: Beef liver/tripe>

Risk estimation indicates that the probability of food poisoning due to the consumption of

beef liver/tripe infected with *Campylobacter* in the present distribution environment and consumption level per person per day is 4.11×10^{-7} at home and 6.13×10^{-7} in restaurants.

<Consumption of raw meat: Beef tartare>

Risk estimation indicates that the probability of food poisoning due to the consumption of beef tartare infected with *Campylobacter* in the present distribution environment and consumption level per person per day is 7.47×10^{-6} at home and 1.23×10^{-5} in restaurants.

<Consumption of raw meat: Chicken tartare>

Risk estimation indicates that the probability of food poisoning due to the consumption of chicken tartare infected with *Campylobacter* in the present distribution environment and consumption level per person per day is 1.37×10^{-9} at home and 8.37×10^{-7} in restaurants.

Key outcomes of the risk assessment

The results of the study indicate that proper hygiene management is essential for preventing food poisoning, which can occur through the consumption of raw meat (beef liver/tripe, beef tartare, chicken tartare), particularly the management of chicken tartare, as shown by its high *Campylobacter* bacterial count, and beef tartare, as this is the most frequently consumed raw meat.

Gaps in the data

The risk assessment was made using the results obtained from limited materials and under certain assumptions, and a reassessment may be performed with additional materials. It is believed that risk assessment should be regularly conducted in order to establish scientific and reasonable standard criteria in determining *Campylobacter*-related health risks and frequency of exposure via raw meat consumption.

Key words: *Campylobacter jejuni*, *C. coli*, Meat, Chicken, Poultry