ABSTRACT

The custom of displaying Chinese-style barbecued meats at room temperature has been a controversial food safety issue in North America. This article is intended to facilitate development of a risk-based food safety policy for this unique food by providing a brief overview of the recent study findings and Canadian disease surveillance data. Despite the lack of temperature control after cooking, Chinese barbecued meats were rarely implicated in foodborne incidents in Canada between 1975 and 1993. This might be due to the food's ability to delay pathogen growth during the first 5 hours immediately after cooking, and the conventional trade practices of separating the retail area from the main kitchen (i.e., reducing risk of cross-contamination). However, recent studies also pointed out the high potential for cross-contamination during the retail stage (i.e., chopping and packaging the food) as a result of lack of proper hand-washing and equipment sanitation. A risk-based food safety policy is proposed.

ABRÉGÉ

L'habitude de présenter à la température de la pièce des viandes cuites au barbecue à la chinoise est une question qui suscite de la controverse en Amérique du Nord. Cette coutume représente-t-elle un risque pour la santé? Cet article a pour but de favoriser l'élaboration d'une politique basée sur la sécurité des aliments, pour ce qui est de cet aliment particulier, en donnant un bref aperçu des conclusions de récentes études et des données de surveillance des maladies au Canada. En dépit du manque de contrôle des températures après la cuisson, les viandes cuites à la broche à la chinoise sont rarement en cause dans des intoxications d'origine alimentaire au Canada entre 1975 et 1993. Cette situation peut résulter de la capacité de l'aliment de retarder la croissance de pathogènes durant les cinq premières heures qui suivent la cuisson et de la pratique commerciale qui consiste à séparer l'aire de vente au détail de la cuisine principale (ce qui a pour effet de réduire les risques de contamination croisée). De récentes études ont toutefois démontré le risque élevé de contamination à l'étape du détail (lors du découpage et de l'emballage des viandes) en raison du manque de désinfection de l'équipement et du fait que les préposés négligent de se laver les mains. Il est donc proposé d'adopter une politique de sécurité alimentaire basée sur les risques.

Chinese-style Barbecued Meats: A Public Health Challenge

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A crucial preventive measure against foodborne illness is the control of temperature to eliminate opportunities for incubation of pathogens. Potentially hazardous foods should be retained either below 5°C (refrigerated) or above 60°C (hot holding). Chinese-style barbecued meats, however, are conventionally displayed at room temperature in enclosed showcases. In North America some of these showcases may be equipped with a warming device, but it is rarely switched on during normal operation. The Chinese food industry in Canada has for years argued that hot or cold holding can render the products undesirable for their customers, and that the tradition of displaying at ambient temperature has been practised in Asia for many years without being known to cause any major foodborne outbreak.

This article will provide a closer examination of the food safety risk associated with Chinese-style barbecued meats and will discuss a risk-based public health approach to this particular food.

Brief overview of study findings

Although a number of studies have been undertaken to assess the food safety risk of Chinese-style barbecued meats, most of them are unpublished and thus their findings remain largely unknown. The following is a brief overview of both the published and unpublished studies and their findings.

The first study in Canada focussing on the Chinese-style barbecued meats dates

back to 1976 by Tiwari et al.¹ Among the total 138 meat samples collected from four retail outlets in Edmonton, the study found low levels of contamination in those taken within two hours after cooking, but substantial increases in the number of coliforms and other pathogens in those that had been stored at 22°C for 20 hours.

Stiles and Ng in 1977 conducted a laboratory study in which a number of enterotoxigenic bacteria (*Bacillus cereus*, 2 strains of *Clostridium perfringens*, *Escherichia coli*, *Salmonella typhimurium*, and *Staphylococcus aureus*) were inoculated onto Chinese barbecued chickens, ducks, and pork tenderloins purchased from two Chinese stores in Edmonton.² A number of unexpected results were found: after 2-3 hours of incubation at 30°C, the bacterial counts decreased to levels lower than the initial inoculation; at 5 hours, most bacteria showed little or no growth with the exception of one strain of *Clostridium perfringens*; the lag phase of most bacteria persisted up to 8 hours after incubation. Substantial growth was noted among all organisms after 20-22 hours of incubation at 30°C. Figure 1 shows the growth rates for three *E. coli* replicates. Stiles and Ng concluded that Chinese barbecued products should be stored at temperatures outside the danger zone even though they appeared to exhibit a long lag phase for most of the tested organisms.

Robinson and Mathews in 1990 conducted a similar study inoculating *E. coli*, *Salmonella muenchen* and *Staphylococcus aureus* onto Chinese barbecued ducks obtained from a Chinese outlet in Toronto.^{3,4} The study found that most bacterial counts fell steadily after the initial inoculation and by the end of 22 hours incubation at 30°C, the counts either

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dropped to zero or to levels lower than the initial inoculum (Figure 2).

As shown in Figures 1 and 2, a major discrepancy between the findings of the two studies is the bacterial counts at the end of the 22 hours incubation. A number of factors could have accounted for this difference:

1. The recipes used to prepare the products might vary substantially since the two studies were conducted 13 years apart in two different regions in the country;
2. The inoculates were poured onto the meat products in Stiles and Ng's study, whereas in Robinson and Mathews' study they were rubbed onto the duck surfaces using a sponge. This, according to Robinson, was necessary because the poured cultures rolled off the smooth and greasy duck surfaces in a manner similar to "*water rolling off a teflon surface*";³
3. All the tested products in Stiles and Ng's study were wrapped with aluminium foil for incubation whereas replicates 1 and 2 in Robinson and Mathews' study were covered only loosely with a sheet of aluminium foil, and replicate 3 was covered tightly with aluminium foil similar to that described in Stiles and Ng's study. Wrapping the tested products with foil could help maintain the moisture (i.e., higher water activity) and hence might render the products more favourable for pathogen growth. Since Chinese barbecued meats are conventionally displayed uncovered in the stores, the study findings of replicates 1 and 2 from Robinson and Mathews' study may be more representative of the actual growth rates.

Both studies noted that the tested products had either no or very low levels of contamination immediately after cooking. While the initial inoculum levels varied between the studies, both found that the counts either declined or grew very slowly during the first five hours of incubation.

In 1994, Chan et al. undertook an observational study including a Hazard Analysis Critical Control Point (HACCP) analysis of the complex preparation procedures, and were the first to identify a potential problem at the retail stage.⁵ The authors suggest that the conventional

Figure 1. E. coli Growth in BBQ Ducks, Stiles and Ng 1977

Figure 2. E. coli Growth in BBQ Ducks, Robinson and Mathews 1990

preparation procedures for barbecued ducks (dipping the ducks in a malt and vinegar mixture and air drying the skin) can render the *outer surfaces* less favourable for bacterial growth. The study also found that the ducks that were aseptically retrieved from the oven and placed whole into the display cabinet showed no or minimal signs of bacterial growth even after having been displayed at room temperature for five hours. Ducks that had undergone the normal retailing process (display, chopping and packaging) showed increases in E. coli and coliform levels. The probability of cross-contamination during the vending process was strengthened when the study authors observed a lack of handwashing among the food handlers and an absence of equipment sanitization.

Prompted by the findings of Chan et al., Sahota in 1996 carried out a series of environmental samples to determine the extent to which the conventional methods for cleaning equipment in Chinese barbecued meat outlets is effective in reducing microbial load.⁶ As it is impossible to immerse the large wooden cutting block into a sink, the conventional cleaning procedures involve scraping the grease from the wooden surface between orders by means of a cleaver, and then wiping off the remaining grease using a dish cloth. The study found high bacterial counts on both the cutting blocks and the cleavers throughout the day, and even prior to use in the morning. During operation, the bacterial counts *increased* after scraping and wiping with the dish cloth, which was also found to be

heavily loaded with bacteria. Sahota also noticed the lack of personal hygiene and equipment sanitation during the retailing process.

According to the Ontario Food Premises Regulation 562 (1993), large equipment should be sanitized with a 200 ppm chlorine solution. Since it will be impractical to require transporting a large butcher block to a sink for cleaning and sanitizing, the (former) Toronto Public Health Department tested the method of spreading a 200 ppm chlorine solution onto the block for 5-minute contact time in two retail premises. The method was capable of reducing microbial load only on the cleavers, but not on the wooden cutting blocks. It is hypothesized that the porous nature of the wood, and the grease from the meat products, might have reduced the disinfecting effect of chlorine.

A laboratory study has subsequently been conducted to determine what (if any) means of disinfecting is effective for the wooden cutting block.⁷ Two chlorine-based commercial sanitizers designed to penetrate and remove soil from food preparation equipment were tested for their ability to reduce microbial load (*E.coli* was used for this study) from a wooden cutting surface. A standard amount of fat extracted from Chinese barbecued pork was evenly spread onto the cutting surface to simulate typical conditions in these restaurants. Unfortunately, neither sanitizer was able to meet the criterion of a 3-log unit reduction in surface-adherent cells, a benchmark for determining sanitation effectiveness.⁸

Surveillance data

Despite the concerns about lack of temperature control and poor sanitation, Chinese-style barbecued meats have rarely been implicated in foodborne incidents in Canada. Between 1975 and 1993 (the only period for which records are available), about 7% of the 16,634 reported foodborne incidents in Canada were suspected to be associated with consumption of Chinese foods, but most of them were fried rice and egg rolls.^{9,10} Chinese barbecued meat was specifically implicated in only 14 incidents (less than 0.1%) over the 18 years. Although the number of foodborne

incidents associated with Chinese barbecued meat might have risen slightly in the latter half of the 1990s as consumption of this food continued to rise, the risk of contracting foodborne illnesses from Chinese barbecued meat is very small compared with other potentially hazardous foods.

DISCUSSION

While most of the studies thus far are small-scale investigations incapable of offering conclusive evidence, several consistent findings did emerge:

- 1) The conventional cooking procedures for Chinese barbecued ducks, and probably for barbecued pork, produce internal temperatures high enough to destroy all vegetative pathogens resulting in absence or very low levels of microbial load on the products immediately after cooking (note: not precluding possible undercooking due to human or equipment error in individual outlets);
- 2) When challenged with a number of common foodborne organisms in laboratory settings, the outer surface of the freshly cooked Chinese barbecued ducks appeared to be able to delay pathogen growth during the initial 5 hours of storage at 30°C;
- 3) The retail process (cutting, handling, and packaging) could represent a high potential for cross-contamination due to lack of proper handwashing and equipment sanitation.

The conventional trade practices of Chinese-style barbecued meats also provide some additional safeguards against food poisoning. The products are usually cooked in the main kitchen and then promptly transported to a separate retail area, often located in the front of the premises, where no or only limited cooking takes place (e.g., boiling noodles and pre-formed dumplings). This separation from the main kitchen area is vital in avoiding cross-contamination between cooked and raw meat. In addition, most outlets tend to make only a small batch at a time to ensure their products are sold quickly. This is especially important for barbecued ducks because prolonged storage will cause the skin to lose its crispness and shine, becoming less desirable to customers.

An unexpected characteristic of these products is their ability to inhibit bacterial growth during the first five hours after cooking. This protective factor against the risk of foodborne illness is, however, subject to several conditions. For example, the outer layer of barbecued ducks is protective only when the cooked surface is intact. Once it is cut and the skin is broken, the meat underneath may be subject to pathogen growth as is any other potentially hazardous food, and cross-contamination can easily happen during cutting of the meat. Unfortunately, for convenience reasons, most customers, when purchasing barbecued meats for take-out, prefer to have them chopped into bite-size pieces at the store. Since the food is kept at room temperature at point-of-purchase, consumers may have the wrong impression that refrigeration is not necessary. The hazard can thus be further increased when the meats are stored unrefrigerated in a car or in home for several hours prior to consumption (i.e., allowing opportunity for bacterial incubation), and this is of particular concern during the summer months. In addition, although most outlets follow the traditional methods of preparing Chinese-style barbecued meats, the exact recipes pertaining to steps such as skin coating and drying time before cooking may vary slightly from outlet to outlet, and from region to region. It is not known to what extent these variations may affect the protective outer layer.

While it would be useful to gain better understanding of the nature and risk factors of this food, developing a sound food safety policy remains difficult for public health officials. Many factors need to be considered, including risk management and assessment, burden of illness, legal liability, enforceability of any food safety requirements, and last but not least, cultural sensitivity. The problem in equipment sanitizing presents an additional challenge to public health officials as studies have suggested that even adhering to the regulatory requirement (i.e., 200 ppm chlorine solution) may not necessarily result in a safe food contact surface.

From the risk management perspective, the evidence thus far suggests that it would be more cost-effective to focus the limited

inspection resources on reducing risk of cross-contamination during the retail stage than on enforcing the debatable temperature control requirements for the cooked meats on display. While further studies are needed in this area, an interim policy may be to allow room temperature display of the whole Chinese-style barbecued ducks and barbecued pork for no more than five hours providing the following conditions are met:

- 1) The meats are prepared according to the conventional method including steps such as marinating the meats with vinegar and malt, and air drying of the duck skin prior to cooking;
- 2) All the critical control points identified by HACCP audits are properly executed (except allowing for up to five hours of room temperature display);
- 3) Basic standards in equipment sanitizing and personal hygiene are incorporated into daily operation and practised consistently; and
- 4) Food samples are regularly taken, and bacterial counts do not exceed the safe limits.

More important is to develop a comprehensive food safety program to address the following aspects:

- 1) Food handler education – food handlers need to understand the potential risks of the products and precautionary measures such as thorough cooking, adequate handwashing and equipment sanitation;
- 2) Public health staff training – Environmental Health Officers (Public Health Inspectors) must be knowledgeable about the potential risk and nature of this food so that they can assist the food handlers to incorporate the proper critical control measures into daily operation;
- 3) Public awareness – consumers need to be informed of the risk potential of this food and the safeguard measures (e.g., refrigeration prior to consumption); strategies such as placing a multi-language warning label on take-out boxes should be considered by public health departments;⁵

4) Partnership with the Chinese food industry – public health officials need to work with the industry to develop a practical retailing routine that also meets current food safety standards (e.g., equipment cleaning and sanitizing procedures);

5) Research – further studies are required to systematically assess the risk of Chinese barbecued meat products and other non-barbecued products (e.g., soy sauce chicken, steamed chicken) that are conventionally displayed at room temperature, as well as in the area of equipment sanitation.

The issues with Chinese-style barbecued meats represent only the tip of the iceberg of new food safety challenges being faced by public health officials today. As immigration continues, and the food industry becomes increasingly globalized, public health officials frequently encounter food ingredients and preparation methods that are unfamiliar in North America. Many of these foods have not gone through any risk assessment process in their countries of origin and thus very little food safety information is available. It is the officials' responsibility to respect the different food cultures and at the same time to ensure that the basic safety standards are in place even though this often requires extra effort in research and inspection resources.

CONCLUSION

A consistent and risk-based food safety policy for Chinese-style barbecued meats is long overdue in North America. Studies have repeatedly shown that certain barbecued meats possess a long lag phase (5 hours) before pathogen growth, but this protective characteristic will vanish once the surface is cut open. Poor retail practices (lack of proper handwashing and equipment sanitation) may represent a much higher risk for foodborne illness than previously thought. Development of a food safety policy should seek input from the Chinese food industry to ensure the requirements are practical and can be incorporated into daily operation. Further

research is needed to fully assess the risk of different types of Chinese meat products that are displayed at room temperature, and it is hoped that this review article will serve as a catalyst for further studies in this area.

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