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Simulation of improper food hygiene practices: A quantitative assessment of *Vibrio parahaemolyticus* distribution

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ABSTRACT

Kitchen mishandling practices contribute to a large number of foodborne illnesses. In this study, the transfer and cross-contamination potential of *Vibrio parahaemolyticus* from bloody clams to ready-to-eat food (lettuce) was assessed. Three scenarios were investigated: 1) direct cross-contamination, the transfer of *V. parahaemolyticus* from bloody clams to non-food contact surfaces (hands and kitchen utensils) to lettuce (via slicing), was evaluated; 2) perfunctory decontamination, the efficacy of two superficial cleaning treatments: a) rinsing in a pail of water, and b) wiping with a kitchen towel, were determined; and 3) secondary cross-contamination, the microbial transfer from cleaning residuals (wash water or stained kitchen towel) to lettuce was assessed. The mean of percent transfer rates through direct contact was 3.6%, and an average of 3.5% of total *V. parahaemolyticus* was recovered from sliced lettuce. The attempted treatments reduced the transferred population by 99.0% (rinsing) and 94.5% (wiping), and the relative amount of *V. parahaemolyticus* on sliced lettuce was reduced to 0.008%. *V. parahaemolyticus* exposure via secondary cross-contamination was marginal. The relative amount of *V. parahaemolyticus* recovered from washed lettuce was 0.07%, and the transfers from stained kitchen towel to lettuce were insubstantial. Our study highlights that *V. parahaemolyticus* was readily spread in the kitchen, potentially through sharing of non-food contact surfaces. Results from this study can be used to better understand and potentially raising the awareness of proper handling practices to avert the spread of foodborne pathogens.

1. Introduction

Foodborne pathogens are microorganisms that cause illness in human, either infectious or toxin-producing in nature, often transmitted through raw or undercooked foods. Alternatively, these pathogens may also be introduced on ready-to-eat (RTE) foods as a result of improper food-handling practices, such as cross-contaminations, which may take place either directly by contact with the contaminated objects or indirectly through other foods (Kusumaningrum et al., 2003). For instance, a restaurant outbreak investigation revealed that cross-contamination from raw chicken to chopped cilantro and cutting board used for cooked chicken led to an outbreak of *Salmonella* infections among restaurant customers (Patel et al., 2010).

A high proportion of food poisoning incidents are caused by food prepared at home. An estimate of 40 to 60%, and up to 87% cases of foodborne incidents were due to improper food-handling at home (Cogan et al., 2002; Duff et al., 2003; van Asselt et al., 2008). Studies conducted in the U.S, United Kingdom and Australia showed a significant numbers of consumers did not exercise safe or hygienic kitchen practices at home (see Redmond and Griffith, 2003). A recent study by Moreb et al. (2017), likewise, revealed that the Irish residents had a critically low level of knowledge in food handling.

Survey studies have shown that unsafe kitchen practices are common among consumers. Anderson et al. (2004) highlighted that

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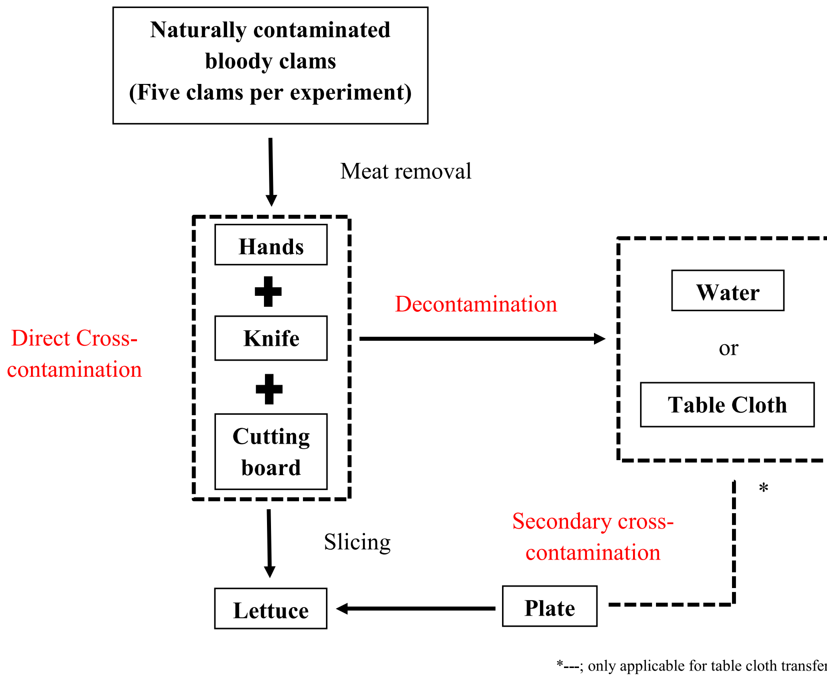

Fig. 1. Schematic diagram of the experimental design to assess the cross-contamination, decontamination and secondary cross-contamination of *V. parahaemolyticus* from bloody clams to lettuce.

nearly all their respondents cross-contaminate ready-to-eat (RTE) foods with raw meat, poultry, seafood, egg and unwashed vegetables. Redmond and Griffith (2003) reported that 81% of consumers shared the same utensils and cutting boards for the preparation of raw and ready-to-eat foods. In addition, 25% of the respondents (total 1620) from Klontz et al. (1995)'s survey were found to reuse the cutting board without cleaning, after cutting raw meat or chicken. Li-Cohen and Bruhn (2002) on the other hand, noted that 5% of their respondents would dry wipe, and 24% of them would wash the cutting board with water alone, after cutting meat, prior to RTE foods. Despite the awareness of importance of proper hygiene handlings, Biranjia-Hurdoyal and Latouche (2016) reported that half of their respondents did not put the knowledge into practice. These findings suggest that a notable number of handlers are unaware or indifferent of the risk of cross-contamination.

Studies have confirmed that improper kitchen conducts facilitate the spread of pathogens in the kitchen (Luber et al., 2006 & Ravishankar et al., 2010). Furthermore, it has been shown that cross-contamination to be of greater importance than the risk associated with undercooked foods (Luber, 2009). Microbial cross-contamination via contaminated raw foods especially by raw meat and chicken in the kitchen are catching more attention by scientists in recent years; some examples are, *Campylobacter* (see Guyard-Nicodème et al., 2013), *Salmonella* (see Gkana et al., 2016), *Listeria* (see Jiang et al., 2017). However, studies focusing on other food matrixes, such as vegetables and seafood, are rather scarce (Chai et al., 2008 & Kim et al., 2012). And, to date, only Kim et al. (2012) evaluated the transfer of *V. parahaemolyticus* from grated fish fillet, with several interesting findings.

Based on Foodborne Disease Active Surveillance Food (FoodNet) data and Morbidity and Mortality Weekly Report (MMWR) published by Centers for Disease Control and Prevention (CDC), *V. parahaemolyticus* was estimated to contribute about 34,664 episodes of foodborne illness annually in the United States (Huang et al., 2016). In addition, presence of *V. parahaemolyticus* in bloody clams has been documented, and presents a risk to consumers in Malaysia (Malcolm et al. 2015 & 2016). The current study was undertaken to assess the transmission of *V. parahaemolyticus* from naturally contaminated bloody clam samples to lettuce (RTE) by simulating the probable mishandling practices in domestic kitchens.

2. Materials and methods

2.1. Sampling collection

A total of 46 bloody clams (*Anadara granosa*) samples (46 simulations – five clams each) were randomly purchased from various wet markets and hypermarkets located in Selangor, Malaysia within a period of five months. During collection, all the samples were transferred to sterile plastic bags for transportation on ice and were analyzed immediately on their arrival at the laboratory.

2.2. Experimental design

The experiment was designed based on general mishandling practices by the local consumers in Malaysia. Three scenarios were assessed: 1) direct cross-contamination, 2) perfunctory decontamination, and 3) secondary cross-contamination (indirect). The model framework described in Fig. 1. summarizes the simulation design of this study.

Direct cross-contamination was designed to simulate the transfer of *V. parahaemolyticus* from bloody clams to non-food contact surfaces (hands and kitchen utensils) to lettuce (via slicing). In addition, the efficacy of two superficial cleaning treatments on hands and kitchen utensils were evaluated: 1) rinsing in a pail of water, and 2) wiping with a kitchen towel, respectively, prior slicing the lettuce. Secondary cross-contamination mimicked the indirect transfer of bacteria from wash water or stained kitchen towel to lettuce.

Simulations were conducted until at least four data sets were collected. For each scenario, the data were obtained from two phases: 1) non-food contact surfaces only, and 2) complete process of transfer to lettuce. Each experiment started with the performing person washing her hands with soap thoroughly and followed by subsequent spray with 70% ethanol to be left air-dried. Likewise, the kitchen utensils used were autoclaved before each experiment.