Modeling Microbial Cross-contamination in Quick Service Restaurants by Means of Experimental Simulations With *Bacillus* Spores

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Conclusions

According to our results, handling of a portion of raw minced meat contaminated at **4.10^4 cfu** leads to the presence of **24 cfu** on both hands, **3 cfu** on **ready-to-eat product (RTE) manipulated with unwashed hands**, **1 cfu** on **RTE manipulated with wiped hands** and absence on **RTE manipulated with washed hands**. Although these numbers seem insignificant, situations where raw meat is heavily contaminated or situations where handling of food is done by an infected person (with poor hygiene habits) will actually pose a considerable risk. This study focused only on the hands as route of cross contamination but it is important to keep in mind that surfaces and equipments may also contribute greatly to cross contamination. This study provides adequate quantitative data for QMRAs.

Objectives

Cross contamination has been frequently mentioned as being in the origin of a wide range of food borne outbreaks (2, 7, 9). Handling of food is one of the ways through which cross contamination may occur (1, 4, 6, 7, 10). For many different reasons, quick service restaurants are particularly at risk. Due to its importance, cross contamination via the hands should be taken into consideration when carrying out a quantitative risk assessment. The main goal of this study was to determine the transfer rates (Tr) of bacteria to and via the hands, the reduction rates (Rr) of two hand sanitizing procedures and to apply the results to a QMRA model.

Methods

Bacterial strains and growth conditions: *Bacillus thuringensis israelensis* strain 4Q7 (Univ. Catholique de Louvain), rifampicin resistant was used for this study. Spore suspensions were obtained from cultures grown on PCA plate, at 30°C for 7 days (3). Hamburger patties were inoculated with spore suspensions (10ml.kg^{-1} at 5,2.10^7 - 4,2.10^8 spores.ml^{-1}). After inoculation, the patties were reshaped to their original form and were then kept overnight at 4°C.

***Cross contamination experiments*:** A simulation of the working methods observed in a fast food kitchen was carried out and the original ingredients were used. Different transfer rates were measured: raw meat to hands; contaminated hands to foodstuff; and raw meat to hands protected by latex gloves. Reduction rates attained by two sanitizing procedures were also determined: hand-wiping (with paper) and standardized hand-washing. All the samples collected were plated onto PCA+ Rifampicin and incubated at 30°C for 24h.

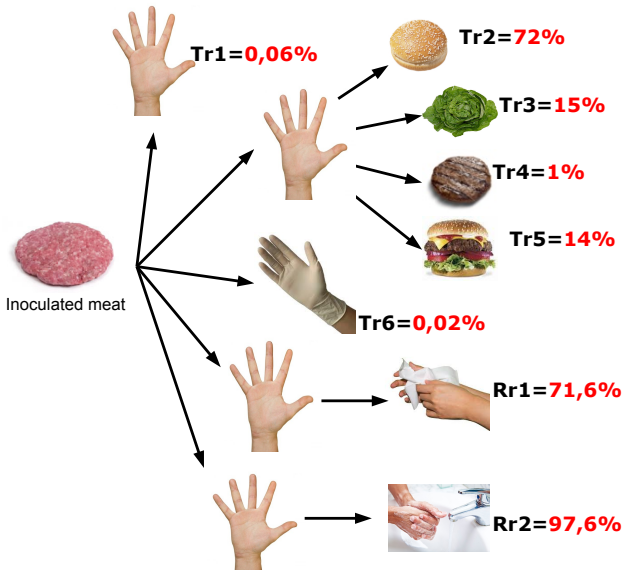

Figure 1 - Graphical representation of the procedures tested and the corresponding calculated transfer (Tr) and reduction (Rr) rates.

Results

Since the meat was deep inoculated, the number of bacteria that could be found on the patty's surface that was truly "touched" was estimated. For that purpose, the formulae proposed by Uyttendaele *et al.* were followed (8). Also, according to the results presented by Miraglia *et al.* (5), the swab recovery rate was established to be 11%. **Each bacterial count is the geometric average of 12 repetitions, each of them made in double** (Table 1). Aside from the experimental assays, a mathematical model was constructed in order to describe the production methods observed in the kitchen's restaurants (Figure 2). The experimental measurements were integrated in the model allowing for a quantitative estimation of the contamination linked to cross contamination via the hands (with and without a sanitizing procedure being applied by the restaurant employees) (Table 2).

		Destination				
		CFU/hands	CFU/bun	CFU/salad	CFU/patty	CFU/hamburger
Origin	CFU/patty (manipulated fraction)	5,2.10^6	3,0.10^3±1,4.10^3			
	CFU hands	3,0.10^3±1,4.10^3		2,2.10^3±1,4.10^3	4,6.10^2±3,5.10^2	4,0.10^1±5,4.10^2	2,9.10^2±9,9.10^2

		CFU/gloves	CFU/hands after cleaning	CFU/hands after washing
Origin	CFU/patty (manipulated fraction)	8,5.10^7	2,0.10^4±9,5.10^3	
	CFU hands	1,4.10^8	1,6.10^4±1,8.10^4	1,3.10^3±14.10^3

Table 1 - Bacterial counts. For the results obtained from 12 repetitions, only the geometric average and standard deviation are presented.

$$C_{manip} = C_{bun} + C_{salad} + C_{patty}$$

$$C_{manip} = \left[(C_0 \times Tr1) \times Tr2\right] + \left[(C_0 - C_{bun}) \times Tr3\right] + \left[(C_{bun} - C_{salade}) \times Tr4\right]$$

Figure 2 - Mathematical equation created to model the cross contamination via the hands that may take place in the restaurant's kitchen. C_{manip}: bacterial concentration of a food product after a manipulation stage; C_{bun}: bacterial concentration on the bun after its manipulation ;C_{salad}: bacterial concentration on the salad after its manipulation; C_{patty}: bacterial concentration on the cooked patty after its manipulation; C_0: bacterial contamination of the food product before the manipulation stage.

[0;1]

Table 2 - Inputs added to the cross contamination model (Figure 2) in order to include the possibility of a sanitizing procedure (ex: Rr2) being applied during the manipulation stage.

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