

## Factors that Contribute to the Microbial Load in the Kitchen Environment

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### **SUMMARY**

*By the nature of the kitchen environment, surfaces are readily contaminated by environmental microbes through bioaerosols, human contact, and food residues. The high moisture, high temperature, re-use of items for multiple purposes, and hygiene lapses can render kitchen surfaces visually clean but susceptible to microbial survival and growth. Poor hygiene and hand washing practices in the kitchen can leave surfaces with higher than expected microbial loads. Improper cleaning and sanitization of food-contact surfaces before use have been commonly observed. Additionally, when the materials from which kitchen appliances and utensils are made begin to age, their propensity to be fomites is escalated. While there are several factors that have been recognized as contributors to the microbial load in the kitchen environment, it is necessary to identify and implement measures that will mitigate the risks of cross-contamination and foodborne illnesses.*

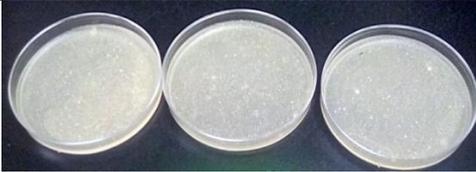
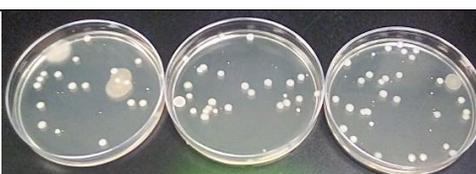
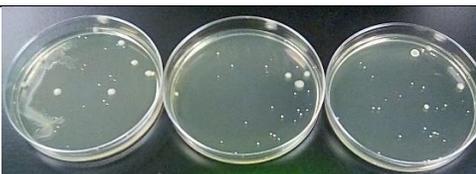
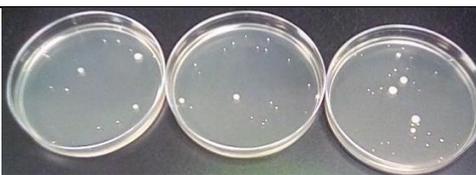
## Factors that Contribute to the Microbial Load in the Kitchen Environment

The kitchen environment includes utensils, flatware, appliances, and surfaces that have the potential to directly interact with food intended for consumption. While it is known that kitchen surfaces are not sterile, it is important to adopt measures that support hygienic practices in the kitchen. When there is failure to use proper handwashing practices, microbes can be transferred to surfaces in the kitchen. Hands actively contact processing containers, money, raw food, food packaging, cleaning substances, disinfectants, body parts, door handles, sink faucets, and human wastes in any facility. In a video study of 40 home kitchens, poor food handling and hygiene practices were observed. These include infrequent hand washing, poor hand-washing technique, lack of hand washing prior to food preparation, inadequate cleaning of kitchen surfaces, involvement of pets in the kitchen, touching of the face, mouth, nose, and/or hair during food preparation; and lack of separate hand and dish towels were the most common unhygienic practices observed (10).

Cleaning to reduce potential risks associated with the transfer of microbes from a surface, even a visually clean surface, to a ready-to-eat food, cannot be overemphasized. Cunningham *et al* (2011) quantified hygienic quality of surfaces in retail food service establishments. It was determined that surfaces with total aerobic plate count (TAPC) more than 125 CFU/50 cm<sup>2</sup> or those that were positive for enteric bacteria were classified as unclean (i.e., failed the microbial test), while surfaces with less than 125 CFU/50 cm<sup>2</sup> were classified as clean (i.e., passed the microbial test). The pass–fail threshold of 125 CFU/50 cm<sup>2</sup> for TAPC was based on work done by other researchers who determined that surfaces with greater than 2.5 CFU/cm<sup>2</sup> were not suitable for use in food preparation (4).

In an unpublished survey of a single office kitchen, surfaces with TAPC above the 2.5 CFU/cm<sup>2</sup> threshold included microwave buttons (5.5), dish drainer (9.1), sink sides (9.6), and sink base near the drain (>10). Areas with microbial populations that were close to the threshold included the utensil drawer handles (2.4), refrigerator water dispenser (2.4), and microwave turntable (2.3).

TABLE 1. Swab survey of an office kitchen

| Surface                               | Swab study agar plates  | Total aerobic plate count (CFU/cm <sup>2</sup> ) |
|---------------------------------------|---|--|
| Base of kitchen sink (close to drain) |    | >10  |
| Sides of kitchen sink                 |    | 9.6  |
| Dish drainer                          |    | 9.1  |
| Microwave buttons                     |    | 5.5  |
| Drawer handles                        |   | 2.4  |
| Refrigerator water dispenser          |  | 2.4  |
| Microwave turntable                   |  | 2.3  |
| Cupboard handles                      |  | 2.0  |

*Unpublished*

Microbial survey of office coffee preparation areas and coffee cups found that high bacterial populations in the sink area, on counters, and on dishcloths or sponges. The detection of coliforms and *E. coli* in these areas indicate unsanitary conditions. Bacterial types identified in the cups included the coliforms *Citrobacter freundii*, *Enterobacter agglomerans*, *Enterobacter cloacae*, *Klebsiella oxytoca*, and *Klebsiella pneumoniae*. Opportunistic pathogens such as *Pseudomonas aeruginosa*, *Pseudomonas cepacia*, and *Serratia liquefaciens* were also identified (13). Kitchen items such as towels or mittens may harbor and spread microbes to utensils and flatware. Handling flatware and utensils with soiled towels allow transfer microbes to food-contact surfaces (5). Table 2 shows that cleaning tools such as sponges harbor large numbers of bacteria and are therefore a potential source of spreading microorganisms throughout food preparation areas during use (8).

**Table 2. Geometric average of bacteria in tested sponges after 28 days**

| Type of sponge             | Geometric average per sponge (CFU/sponge) |           |                |
|----------------------------|---|-----------|----------------|
|                            | Heterotrophic plate Count (HPC)           | Coliforms | <i>E. coli</i> |
| Cellulose                  | 238,000                                   | 1,220     | 45.8           |
| Antimicrobial Cellulose    | 479,000                                   | 1,120     | 56.5           |
| Polyurethane               | 129,000                                   | 590       | 0.27           |
| Antimicrobial Polyurethane | 45,700                                    | 552       | 0.23           |

Source: Gerba *et al* (2017)

Studies have shown that high bacterial populations in kitchen sponges, hand towels, and dishcloths is a common occurrence. Eighty-two kitchen towels were collected from households in five cities in the United States (Chicago, Tucson, New Orleans, Orlando) and Canada (Toronto). The numbers of heterotrophic bacteria, coliform bacteria, and *E. coli* in each towel were determined. All kitchen towels for the 5 cities had at least  $1 \times 10^3$  CFU/towel, and some had HPC greater than  $1 \times 10^9$  CFU/towel. The overall average was  $3.16 \times 10^8$  CFU/towel. Coliform bacteria were detected in almost all towels (89.0%) and *E. coli* in 25.6%. Coliform values above  $1 \times 10^6$  MPN were observed in two cities. Factors that affected bacterial

population in kitchen towels include age of towel, frequency of washing, and frequency of use (7).

Food-contact surfaces are routinely subjected to biofouling due to a complex of various factors, such as types of food being handled, processes to which they are being subjected, and the environment in which the food is being processed (air, people, surface, material). These factors impact the composition of the organic soil in the kitchen, the nature of microbes as well as the microbial load that land, survive, and potentially grow on food-contact surfaces. Microbes and organic soil mixture may be derived from a single soiling event, from several events separated by inadequate cleaning and sanitization processes, or, in rare instances, via biofilm formation.

Soiled food-contact surfaces may contain residues of fats, proteins, carbohydrates and/or assorted microorganisms. An inadequately cleaned food contact surface contains food residues, and many foods leave residues of protein that can nourish microorganisms. Food-contact surfaces often have residues that persist after washing and may provide nourishment that allow contaminants to propagate. Residues provide nutrients for contaminating microbes to utilize and multiply (2, 4).

Bioaerosols are created from multiple sources such as high-power washes and respiratory/nasal droplets settle and foul surfaces in the kitchen. Exposure to microorganisms on surfaces may take place either directly by contact with contaminated objects or indirectly via aerosols. Airborne microbes have been determined to be capable of survival on food and food-contact surfaces for at least a short time (9, 16).

The kitchen environment contains equipment and utensils constructed from different surface materials with varied propensities to be vehicles for microbial attachment and survival. Silva *et al* (2008) evaluated the adhesion and viability of *Listeria* on eight food-contact surface materials commonly used in kitchens was conducted: stainless steel 304, marble, granite, glass, polypropylene from a bowl and from a cutting board, and two kinds of silestone. The results indicated that there is a complex relationship between nature of surface materials and microbial surface properties in the attachment of microorganisms to abiotic surfaces. All *L.*

*monocytogenes* strains attached to all surfaces, although to different extents. *L. monocytogenes* adhered most tightly to granite and marble, followed by stainless steel 304, glass, silestones, and finally polypropylene surfaces.

Kitchen surfaces are often used for multiple tasks. Kitchen work surfaces, particularly utensils and chopping boards, are generally used for a variety of tasks during food preparation. Based on a survey reported by Moore *et al* (2007), 30 to 71% of consumers reported using the same chopping board or area of work surface to prepare raw meats and other foods. Real-time microbiological analysis suggested that if contaminated surfaces are not adequately cleaned, there is an 81% chance that subsequently prepared food will be significantly contaminated. These results are supported by Ak *et al* 1994) in a study aimed at evaluating decontamination of plastic and wooden cutting boards. Bacterial contaminants: *Escherichia coli* (two nonpathogenic strains plus serotype O157:H7), *Listeria innocua*, *L. monocytogenes*, or *Salmonella typhimurium*, applied to the block surface in nutrient broth or chicken juice, were recovered by soaking the surface in nutrient broth or pressing the block onto nutrient agar, within minutes or ~12 h later. The results indicated that fewer bacteria were generally recovered from wooden blocks than from plastic blocks. Clean wood blocks rapidly absorbed all the inoculum, after which the bacteria could not be recovered within 3 to 10 min. If the board surface was coated with chicken fat, some bacteria might be recovered even after 12 h at room temperature and high humidity. Cleaning with hot water and detergent generally removed these bacteria, regardless of bacterial species, wood species, and whether the wood was new or used (1).

Inability to effectively wash, rinse and sanitize kitchen surfaces may lead to the buildup of biofilms through food. Studies regarding the rigor required to remove biofilms from smooth surfaces highlight the need for materials of optimal quality in multiuse equipment ([www.fda.gov](http://www.fda.gov)). Surfaces may be marked with scratches or crevices due to wear and tear, as well as polishing with abrasive powders or substances. These crevices or channels may serve to entrap food residues and microorganisms (18).

Biofilm formation has been documented on a wide variety of surfaces of which the material and microtopography of surfaces can influence biofilm structure and density. There is evidence that the density of biofilm formation varies with substratum. When compared in a study by Corcoran *et al* (2013), biofilm growth on tile is denser than on the other substrata that were evaluated (glass, steel, and concrete). Transfer of bacteria from tile to food after exposure time of up to 28 h was shown and it was suggested that differences in surface properties such as polarity and/or surface roughness of substratum are important in microbial attachment or biofilm density. Biofilm formation is also affected by types of food products. Biofilm formation is greater in meat and poultry broths than in produce broths. Raw materials such as meat and dairy products provide rich substrates for bacterial adhesion, colonization, and biofilm formation on food-contact surfaces (11).

Poorly executed or inadequate cleaning and sanitizing regimes can induce stress responses making microbes more prone to adhering to solid surfaces. Cleaning and sanitizing of kitchen surfaces are used to eliminate and control the presence of microbes in foods. When cleaning and sanitizing regimes are poorly executed or inadequate, microorganisms may remain on surfaces in an injured state. Sub-lethal treatments can result in unique adaptive responses by bacteria whereby the organism becomes more resilient (17). For example, starvation stress is often accompanied by an increase in cell number, a decrease in cell size, and an increase in adhesiveness to solid surfaces where they benefit from an enhanced nutrient status.

Microbial contamination of processed and ready-to-eat (RTE) foods can occur as they encounter raw contaminated vegetables through cutting boards and slicing, cutting, handling or packaging utensils. When there is failure in handwashing and daily sanitation of cutting utensils and other surfaces, the possibility of contamination of processed and RTE foods increases (12).

When flatware is stored wet, they are likely to become contaminated. The residual moisture on wet-nested food-contact surfaces prevents desiccation of contaminating microbes and facilitates their survival and growth ([www.webmd.com](http://www.webmd.com)). Moisture is retained on surfaces and in pockets when dishes are stacked after removal from the wet, warm dishwasher, or in cases where dishes are hand washed and insufficiently dried before storage. Among the important

factors in bacterial transfer from one surface to another are moisture, contact time and pressure which can result in higher transfer between surfaces (15).

Kitchen surfaces are readily contaminated by environmental microbes from bioaerosols, human contact, and food residues. The high moisture, high temperature environment coupled with re-use of items for multiple purposes and hygiene lapses can render kitchen surfaces visually clean but susceptible to microbial survival and growth. These conditions, exacerbated by poor hygiene and hand washing practices in the kitchen, can leave surfaces with higher than expected microbial loads. Improper cleaning and sanitization of food-contact surfaces before use have been commonly observed. Additionally, when the materials from which kitchen appliances and utensils are made begin to age, their propensity to be fomites is escalated. Attention to hygienic practices, cleaning, and sanitization are the critical measures necessary to mitigate risks of cross-contamination and outbreaks of foodborne illnesses.

## References

1. Ak, N.O., Cliver, D.O., Kaspar, C.W. 1994. Decontamination of Plastic and Wooden Cutting Boards for Kitchen Use. *J Food Prot.* 57 (1): 23-30.
2. Anderson, M.E., Huff, H.E., Marshall, R.T., Naumann H.D. 1986. A Simple Qualitative Method for Detecting Cleanliness of Food-contact surfaces. *J Food Prot.* 49 (5):342-346.
3. Corcoran, M., Morris, D.N., DeLappe, N., O'Connor, J., Lalor, P., Dockery, P., Cormican, M. 2013. Salmonella enterica Biofilm Formation and Density in the Centers for Disease Control and Prevention's Biofilm Reactor Model Is Related to Serovar and Substratum *J Food Prot.* 76 (4): 662–667.
4. Cunningham, A.E., Rajagopal, R., Lauer, J., Allwood, P. 2011. Assessment of Hygienic Quality of Surfaces in Retail Food Service Establishments Based on Microbial Counts and Real-Time Detection of ATP. *J of Food Prot.* 74 (4): 686–690.
5. Enriquez, C. E., V. E. Enriquez, and C. P. Gerba. 1997. Reduction of contamination in the household kitchen environment through the use of self-disinfecting sponges. *Dairy, Food Environ Sanit.* 17:550–554
6. <https://www.fda.gov/downloads/food/guidanceregulation/retailfoodprotection/foodcode/ucm374510.pdf>
7. Gerba, C.P., Tamimi, A. H., Maxwell, S., Sifuentes, L.Y., Hoffman, D.R., Koenig. 2014. Bacterial Occurrence in Kitchen Hand Towels. 2014. *Food Protection Trends.* 34 (5): 312-317.
8. Gerba, C.P., Sifuentes, L.Y., Tamimi, A.H. 2017. A Comparison of Urethane and Cellulose Sponges as Cleaning Tools in Household Kitchens. *Food Protection Trends* 37 (3): 170–175.
9. Ingham, S.C., Wadhera, R. K., Chun-Him, C., Devita, M.D. 2006. Survival of *Streptococcus pyogenes* on Foods and Food-contact surfaces. *J Food Prot.* 69 (5): 1159–1163.
10. Jay, L. S., Comar, D., and Govenlock, L.D. 1999. A Video Study of Australian Domestic Food-Handling Practices. *J Food Prot.* 62 (11): 1285-1296.
11. Kim, S-H., and Wei, C. 2009. Molecular Characterization of Biofilm Formation and Attachment of *Salmonella enterica* Serovar Typhimurium DT104 on Food-contact surfaces. *J Food Prot.* 72 (9): 1841–1847.
12. Kotzekidou. P. 2016. Factors Influencing Microbial Safety of Ready-To-Eat Foods. *In: Kotzekidou P., editor. Food Hygiene and Toxicology in Ready-to-Eat Foods. Academic Press.* p33-47.
13. Meer, R.R., Gerba, C.P., Enriquez. C.E. 1997. A microbial Survey of Office Coffee Cups and Effectiveness of an Office Cup Washer for reduction of bacteria. *Dairy, Food Environ Sanit.* 17 (6):352-355.
14. Moore, G., Blair, I.S., McDowell, D.A. (2007). Recovery and Transfer of *Salmonella* Typhimurium from Four Different Domestic Food-contact surfaces. 2007. *J of Food Prot.* 70(10): 2273–2280.
15. Purohit, Chaitali. 2009. Bacterial transfer from mouth to different utensils and from utensils to food. All Theses. Paper 623.  
[http://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=1623&context=all\\_theses](http://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=1623&context=all_theses)

16. Silva, S., Teixeira, P., Oliveira R., Azeredo, J. 2008. Adhesion to and Viability of *Listeria monocytogenes* on Food-contact surfaces. *J of Food Prot.* 71 (7): 1379–1385.
17. Smoot, L.M., and Pierson, M.D. 1998. Effect of Environmental Stress on the Ability of *Listeria monocytogenes* Scott A to Attach to Food-contact surfaces. *J Food Prot.* 61 (10): 1293-1298.
18. Taku, A., Gulati, B.R., Allwood, P.B., Palazzi, K., Hedberg, C.W., Goyal, S.M. (2002). Concentration and Detection of Caliciviruses from Food-contact surfaces. *J Food Prot.* 65(6): 999–1004.
19. <http://www.webmd.com/a-to-z-guides/news/20010817/air-dry-your-dishes#1>