**Date: 1/17/16**

**Group name:** The Disciples

**Research question:** Is silver antibacterial?

**Control condition:** Stainless steel flatware

**Experimental condition:** Silver flatware

**Synopsis of investigation:** It has long been tradition that flatware be made from silver, and it is common belief that the material became so popular because of anti-bacterial properties. Since modern technology has brought about new materials that are more affordable to manufacture, household silverware has been replaced by stainless steel flatware and other alternatives. As news headlines alarm of increasing cases of growing bacterial resistance, is it possible that returning to silver utensils could add another barrier to bacterial contamination? By exposing silver and stainless steel flatware to common germs on hands, it is our hypothesis that the silver utensil swabs will produce fewer bacterial colonies.

**1) Bacterial count hypothesis:** Silver flatware will have **fewer** bacterial colonies than stainless steel flatware.

**2) Motility hypothesis:** Bacteria from the silver flatware will be **less** motile than bacteria from the stainless steel flatware.

**3) Gram Stain hypothesis:** Bacteria from the silver flatware will be **equally as** gram negative as bacteria from the stainless steel flatware.

**4) Antibiotic resistance hypothesis:**

**a) Ampicillin sensitivity:** Bacteria from the silver flatware will be **more** ampicillin sensitive than bacteria from the stainless steel flatware.

**b) Kanamycin sensitivity:** Bacteria from the silver flatware will be **more** kanamycin sensitive than bacteria from the stainless steel flatware.

**c) Gentamicin sensitivity:** Bacteria from the silver flatware will be **more** gentamicin sensitive than bacteria from the stainless steel flatware.

**Rationale**:

Previous study about silver material suggest silver has antibiotic activity against bacteria that the Ag+ ions could damage the bacteria’s cell wall and led to condensation of DNA in center of cells. (Garduque, 2010) In fact, it is well known that Ag ions and Ag-based compounds are highly toxic to microorganisms, showing strong biocidal effects on as many as 12 species of bacteria. (Zhao, 1998) In those species, there are both Gram-negative (Escherichia coli and P. aeruginosa) and Gram-positive (S. aureus) bacteria (Jorge, 2017), so the level of gram-negative on silver flatware should remain same as on stainless steel flatware. Since E. coli is one of the main bacteria silver ions targeted, and it is a kind of motile bacteria via flagella, (Mittal, 2003) the decrease of the number of E. coli may led to the decrease of the motility on silver flatware than on stainless steel flatware. There is evidence showing that, over 50% of Staphylococcus aureus isolates from 83% of the world's regions are resistant to methicillin (MRSA), whereas the isolation of Escherichia coli resistant to both third-generation cephalosporins and fluoroquinolones is common. (CDC, 2013) Thus, the decrease of the number of E. coli and S. aureus on silver might also make the ampicillin, Kanamycin and Gentamicin more effective. Antibiotic-resistant bacteria are often resistant to multiple antibiotic classes (Boucher, 2010) so the smaller number of these kinds of antibiotic-resistant bacteria on silver flatware would make the overall sensitivity to antibiotics like ampicillin, Kanamycin and Gentamicin increase.

**Impact:**

The CDC estimates that each year roughly 1 in 6 Americans (or 48 million people) gets sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases. Previous research suggests silver may be harmful to E. Coli, and “the CDC estimates that 265,000 STEC infections occur each year in the United States. E. coli O157:H7 causes over 36% of these infections” (CNN, 2016). There is severe concern that “bacterial biofilm formation in foodservice facilities is a continuous cross-contamination risk through survival and persistence despite disinfectant treatments,”(Lim, 2017) and the proof of anti-bacterial utensils could provide an extra measure of protection against harmful bacteria in food service industries. The above stated health concerns are especially relevant in light of a recent report that 900 food establishments found that “out of compliance percentages remained high for issues relating to...(2) poor employee personal hygiene; and (3) contaminated equipment. Of the data collected, improper cleaning and sanitizing of food contact surfaces was the item most commonly observed to be out of compliance”(Lee 2007). Antibacterial utensils would provide an immediate impact on negligence in food service, since behavioral changes will be more difficult and lengthy to correct.

Additionally, while silver is more expensive than stainless steel, it is a naturally occurring element that does not need to be artificially produced. The production of stainless steel, however, uses energy. If incentive was created for businesses to use silver utensils, less energy would be consumed. “According to PE International (2009), the amount of CO2 emitted during the production of stainless at the steel plant varies between 0.28 and 0.49 tons / ton of stainless”; additionally, “ISSF calculates that the amount of CO2 emissions connected to the electricity required to produce stainless steel at the stainless steel plant were 0.54 tons / ton of stainless steel from the data collection in 2013” (ISSF). Reason to change consumer behavior could help reduce human carbon emission.

Previous studies on the effects of silver on bacteria have largely examined the impact of ionized silver in alternate states, complexes, or solutions. While this information can inform how we may hypothesize the outcome of our own experiment, the data on elemental silver is very scarce. By testing solid elemental silver, these findings will help to diversify the available research.

**Materials:** 16 silver forks, 16 stainless steel forks, cotton swabs, petri dishes

**Experimental Protocol:**

Step One: 16 pieces each of stainless steel and silver forks will be sanitized under the same conditions in a dishwasher—to ensure maximum sanitation prior to entrance to the experiment to minimize sources of error.

Step Two: The test subjects are blindfolded.

Step Three: Beginning with the stainless-steel control, each fork will be passed to each student in the class after lunch break to hold for 10 seconds to expose it to a variety of bacteria--in the hopes of replicating common pathogens in food service areas.To ensure a more even dissemination of bacteria across both the control and variable flatware, the forks will alternate stainless-steel / silverware throughout the rotation.

Step Four: After exposure, each object will be swabbed in 2cm intervals on the length of the handle and placed in a petri dish according to lab procedure, labeled with where on the handle each sample was taken.

Step Five: Bacteria will then be grown, gram-stained, and tested for mobility in accordance with standard lab procedure as provided to the students by the lab supervisor (Dr. Will).

*How many pieces of silverware will you need for your conditions?*

Under the standard of needing ~240 cm2 of surface area to swab per variable, the experiment would need approximately 16 pieces of flatware per material with an approximate standard handle length of 15 cm.

*How should the colonies for further characterization be chosen?*

The colonies should be chosen to be visually most similar to the other colonies to best observe the general trend of material properties.

*There will be many colonies to choose from (hopefully), so you need to write a protocol instructing us which one to isolate.*

Colonies should be isolated to provide a diversity in handle area from which it was collected. This will help account for variability in contact with bacteria, as well as provide information about motility across the surface area.

*How could this step change our results and conclusions?*

As examined in class, with so few samples to analyze the samples that are chosen for analysis can sway our trend because outliers have more sway in final analysis.

**References:** List references here – this does not count in the 2-page minimum.

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