The Potential Role of Antimicrobial Copper in Food Processing Applications

Introduction

Copper is a broad-spectrum antimicrobial agent effective against a range of pathogens threatening public health today, whether they are foodborne, airborne, waterborne or transmitted by touch. Recent science shows that copper has an intrinsic ability to rapidly inactivate dangerous foodborne pathogens (including *E. coli* O157:H7, *Campylobacter jejuni*, *Listeria monocytogenes* and *Salmonella enteritidis)* at both refrigerated and room temperature. Copper and copper alloys could therefore help to reduce the incidence of cross-contamination in food processing facilities.

Reducing Contamination on Touch Surfaces and HVAC Components

Extensive laboratory research at centres around the world has demonstrated copper's ability to kill pathogens that cause healthcare associated infections such as meticillin-resistant *Staphylococcus aureus (*MRSA), vancomycin-resistant enterococci (VRE) and *Clostridium difficile.* Clinical trials in the UK, US and Chile have confirmed copper's antimicrobial efficacy in significantly reducing microbial contamination in hospitals. These trials demonstrated that the copper surfaces, subjected to typical hospital activities and standard cleaning protocols, were as effective in reducing microbial contamination as a terminal clean, i.e. the sanitation of the bed and area around it with a detergent/germicidal agent after the patient is discharged or transferred.

Recently, adoption of this additional defence against infection and the spread of disease has begun, with healthcare architects specifying antimicrobial copper touch surfaces in hospitals and clinics in the UK, Ireland, Germany and Japan.

Field trials are currently under way to evaluate copper's efficacy in reducing contamination in heating, ventilation and air conditioning (HVAC) systems, in buildings and buses, on the basis of laboratory findings that airborne pathogens such as *Aspergillus niger* and Influenza A (H1N1) cannot survive on copper.

For food processing applications, laboratory studies have confirmed copper's efficacy against a range of foodborne pathogens, including salmonella, campylobacter, *E. coli* O157 and *Listeria monocytogenes.* These are the four organisms responsible for the majority of foodborne illness in the UK, according to the Food Standards Agency.

Next Steps

What's needed now is a practical assessment of copper's performance under typical end use conditions for food processing applications – contact with various foodstuffs and application of relevant hygiene practices and cleaning agents – to evaluate the potential for improving surface hygiene and therefore reducing the risk of cross-contamination. Copper touch surfaces (door handles, taps, hand rails etc), HVAC components (cooling coils, heat exchanger fins and drip pans) and food processing surfaces could, together, make a significant contribution to improved hygiene in food processing, supplementing the existing stringent practices.

Key References

Antimicrobial Activity of Copper Surfaces Against Suspensions of *Salmonella enterica* and *Campylobacter jejuni.*

Gustavo Faúndez, Miriam Troncoso, Paola Navarrete and Guillermo Figueroa. BMC Microbiology 2004, 4:19.

Salmonella enterica and *Campylobacter jejuni* are amongst the more prevalent bacterial pathogens that cause foodborne diseases, commonly contaminating poultry and poultry products. This study aimed to evaluate the antibacterial activity of metallic copper surfaces on these important enteropathogens, and to determine the potential acquisition of copper by food exposed to this metal.

The antibacterial activity of copper surfaces was evaluated using overlying suspensions of 10^6 CFU/ml of *S. enterica* and *C. jejuni* and enumerating bacterial counts after 0, 2, 4 and 8 hours at 10°C and 25°C. Stainless steel and a synthetic polymer were used as control surfaces. The results showed that, when these enteropathogens were kept in contact with copper, a significant antibacterial activity was noted whereas, when the same load of pathogen suspensions was tested over the control surfaces, it was found that the bacterial counts remained unchanged or even increased with time.

The potential acquisition of copper by food exposed to this surface was also evaluated. Meat exposed for one hour to a copper surface adsorbed residual copper in a time-dependent manner.

These results show that metallic copper surfaces have an antibacterial activity against *S. enterica* and *C. jejuni* and suggest its potential application as an inhibitory agent in the various stages of food processing operations.

Use of Copper Cast Alloys To Control Escherichia coli O157 Cross-Contamination during Food Processing.

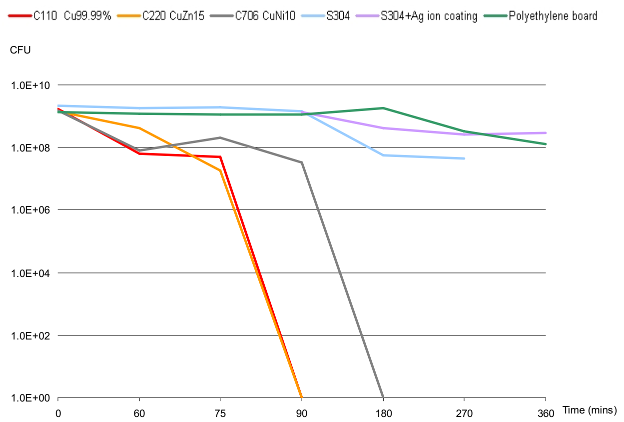
Noyce J O, Michels H T and Keevil C W, Applied and Environmental Microbiology 72:4239-44 (2006).

The most notable method of infection from *E. coli* O157 is through contaminated food products, usually minced beef. The objective of this study was to evaluate seven cast copper alloys (61 to 95% Cu) for their ability to reduce the viability of *E. coli* O157, mixed with or without minced beef juice, and to compare these results to those for stainless steel.

Without beef extract, three alloys completely killed the inoculum during the 6 h exposure at 22°C. At 4°C, only the high-copper alloys (>85%) significantly reduced the numbers of O157. With beef juice, only one alloy (95% Cu) completely killed the inoculum at 22°C. For stainless steel, however, no significant reduction in cell numbers occurred. Reducing the inoculum to 10^3 CFU resulted in a complete kill for all seven cast copper alloys in 20 min or less at 22°C.

These results clearly demonstrate the antimicrobial properties of cast copper alloys with regard to *E. coli* O157, and consequently these alloys have the potential to aid in food safety.

E. Coli viability on various surfaces at 20°C



Pathogens that cause foodborne illness, such as *E. coli*, are quickly eliminated from copper and copper alloy (e.g. brass, bronze) surfaces but survive for prolonged periods on plastic and stainless steel surfaces.

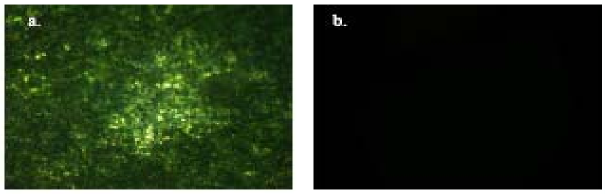
Survival of *Listeria monocytogenes* Scott A on Metal Surfaces: Implications for Cross-contamination.

Wilks S A, Michels H T, Keevil C W, Int J Food Microbiol Sep 1;111(2):93-8. Epub 2006 Jul 28.

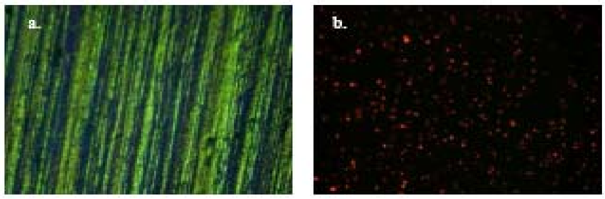
Listeria monocytogenes is an important re-emerging pathogen which is commonly found in the environment. Many outbreaks have been associated with the contamination of food produce, often linked to cross-contamination from surfaces or equipment used to prepare foodstuffs. In this study, a number of copper-base metal alloys were used to assess the survival times of *L. monocytogenes* on different materials, in comparison with stainless steel, at room temperature. High concentrations (10^7) of bacteria were placed on metal coupons cut from each alloy. After defined incubation times, coupons were placed in tubes containing phosphate buffered saline and vortexed to remove the cells. Aliquots were then plated onto tryptone blood agar plates and the number of colony forming units counted. The high concentration of bacteria was used to represent a 'worst-case' scenario.

The results indicate that survival is greatly reduced on a copper-base alloy compared to stainless steel. Viable cells could be detected on stainless steel after 24 h incubation at room temperature. On copper, brass, aluminium bronze and silicon bronze, no viable bacteria could be detected after 60 min incubation, indicating a 5-log reduction (the detection limit of the procedure was 100 bacteria).

The results suggest that careful choice of surface material could reduce the potential risk of cross-contamination in industrial, commercial and domestic environments.

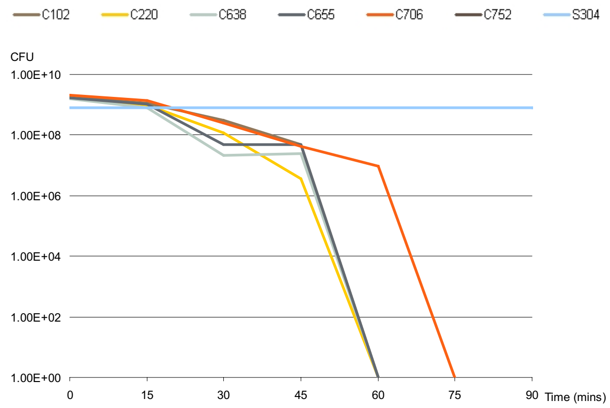


a) EDIC microscopy image of bacteria on copper after 90 minutes incubation
b) EF microscopy image of bacteria stained with CTC, after 90 minutes incubation. No bacteria were visible. This confirms that no bacteria survived on the copper.



a) EDIC microscopy image of bacteria on stainless steel after overnight incubation
b) EF microscopy image of bacteria stained with CTC, after overnight incubation. Respiring (hence surviving and viable) bacteria were stained bright red.

L. monocytogenes viability on copper alloy surfaces at 20°C



Number of bacteria surviving after various incubation times on different metal alloys at room temperature.

Further Information

Further scientific references and articles can be found at www.copperinfo.co.uk/antimicrobial, where you will also find more information on the science and applications of antimicrobial copper.

To register for email updates, join the Antimicrobial Copper Interest Group by contacting: bryony.samuel@copperdev.co.uk.

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