Benefits and Risks of Use of Chlorine-Containing Disinfectants

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LEARN TO ADJUST YOUR RESPIRATOR
CORRECT and QUICK
Don't breathe while doing it, and this won't happen to you.
Disinfectants

• Oxidants and chemically reactive
• Vary in their oxidation capability and other chemical activity
• Ideal disinfectant
  – high broad-spectrum activity against microbes
  – low by-product formation potential
Relative characteristics of oxidants/disinfectants

<table>
<thead>
<tr>
<th>Oxidant</th>
<th>Disinfecting efficiency</th>
<th>Oxidizing efficiency</th>
<th>Halogenation capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Chlorine dioxide</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Monochloramine</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Ozone</td>
<td>High</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>Low</td>
<td>Moderate</td>
<td>None</td>
</tr>
<tr>
<td>Bromine</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Iodine</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Rice & Gomez-Taylor (1986)
Chlorine-based disinfectants

• Acidified sodium chlorite
  – sodium chlorite and a food-grade acid

• \textit{N-Chloramines}
  – ammonia or organic amines and chlorine

• Chloramine-T
  – chlorination of benzene sulfonamide or p-toluene sulfonamide

• Chlorine dioxide
  – gas produced in various reactions
Chlorine-based disinfectants

• Hypochlorite-related compounds
  – chlorine gas
  – sodium hypochlorite
  – calcium hypochlorite
  – hypochlorous acid
  – hypochlorite ion

\[
\text{Cl}_2 + \text{H}_2\text{O} \leftrightarrow \text{HCl} + \text{HOCl} \\
\text{HOCl} + \text{H}_2\text{O} \leftrightarrow \text{H}^+ + \text{OCl}^- 
\]
Uses in the food industry

• Poultry processing
  – carcass washers
  – equipment wash water
  – immersion chiller water and pre-chiller water

• Hypochlorite-related compounds

• Range of other compounds

• Effective
  – prevent cross contamination
  – control on carcasses
Uses in the food industry

• Red meat processing
  – carcass spray
  – primary cut spray
• Primarily hypochlorite-related compounds
• Lower use than other industries
• Some doubt about efficacy
• Other compounds as useful or better
Uses in the food industry

• Fisheries product processing
  – post-harvest rinsing
  – pre-processing washing
  – immersion
  – ice

• Primarily hypochlorite related compounds at end-point

• Appear relatively effective but data sparse
Uses in the food industry

• Fresh fruit and vegetable processing
  – spray at harvest
  – post harvest spray and soaking/washing
• Mainly hypochlorite-based compounds
• Effective in reducing cross-contamination in wash water
• Little effect on product at levels used
Uses in the food industry

• Food contact surfaces
  – wide range of chlorine-based compounds
  – hypochlorite, chlorine dioxide, chloramine-T

• Process generally effective if preparation is correct

• Several alternatives that are effective

• Not clear how much residue is transferred to foods
By-product formation

• Reactions with organic matter in solutions or proteins and fats

• Potential formation of compounds of concern
  – mostly chlorite, chlorate and chloride ions
  – nitrosamines suggested
  – chloroganics and oxidized organics
  – trihalomethanes (THMs)
  – haloacetic acids (HAAs)
By-product formation

McClellan, 2000
Chemical risk-assessment

• Toxicological studies examined in relation to potential compounds of concern
• Suggested link between compounds and bladder cancer
• Some suggested link to bowel cancer but results of studies inconclusive
• Exposure in drinking water when at high levels
Chemical risk-assessment

• Only product treated at levels equivalent to those of concern was in poultry processing
• No data on levels on food, effect of storage or cooking (exposure)
• Lack of data was a problem but high risk scenarios were not identified
Microbiological risk-assessment

• Data at laboratory scale is abundant but not so at pilot scale or industrial scale
• Most compounds are active against pathogens in the laboratory but it is not clear this is the case in the industry
• Data indicates that cross contamination is controlled by the application of many of the compounds
Microbiological risk-assessment

• Difficult to translate pathogen data to public health outcomes
• Potential use of models to achieve this
• Lack of a standardized approach to studying effect of disinfectants
  – biofilms
  – attached
  – planktonic
Unintended consequences

• Potential of generating unintended consequences
• Antimicrobial resistance
• Changing of microbial populations (normal flora) to allow the growth of pathogens
• Effect on the nutrient content of foods
• Effect on sensory characteristics
Risk-benefit of chlorine disinfection

- Lack of exposure assessment data for chemical assessment
- Some information for hypochlorite but not most other compounds
- Lack of toxicological data
- High risk not identified even with a degree of conservatism and uncertainty
Risk-benefit of chlorine disinfection

• Lack of data on microbiological risk
• Some data on control of pathogens in washing and preventing cross-contamination
• Some data on effectiveness on *Campylobacter* in poultry processing (extends to public health outcomes)
Risk-benefit of chlorine disinfection

• Potential scenarios
  – no health concern identified; no benefits identified
  – no health concern identified; benefits identified
  – health concern identified; no benefits identified
  – health concern identified; benefits identified

• Range of recommendations
Recommendations

• Hygiene critical and should not be used to mask this
• More research on effect on food and in seawater
• Level of residues formed
• Standardized microbial protocols
Research opportunities

• Identified knowledge gaps need to be filled
• Many of these require industry / academic / research institute interactions
• Data must be published
• Trust and openness required
Document available at