Scientific Comparative Analysis: Bio-G-Active vs. Chlorine as an Antimicrobial Agent

Introduction

Bio-G-Active, developed by **BGA-Dictum GmbH**, is an advanced, biologically-derived antimicrobial agent specifically designed for the decontamination of poultry carcasses. It targets the reduction of microbial load on meat surfaces, including dangerous pathogens such as *Salmonella* and *Escherichia coli* (E. coli). While chlorine has been widely used as a disinfectant in poultry processing, it has notable drawbacks regarding microbial efficacy, the sensory properties of treated meat, and health and environmental concerns.

This report provides a detailed scientific analysis of the proven advantages of Bio-G-Active over chlorine, emphasizing superior antimicrobial effectiveness, sensory improvements, and lower health and environmental risks. Additionally, the biological processes and mechanisms of Bio-G-Active will be explained, illustrating why it is a safe and effective solution for modern food processing. A deeper understanding of the problematic aspects of chlorine will also be integrated, highlighting Bio-G-Active's advantages.

Microbial Efficacy of Bio-G-Active vs. Chlorine

Microbial efficacy is the central aspect when choosing a decontamination agent for poultry processing. Bio-G-Active surpasses chlorine in nearly all relevant areas of microbial reduction. This is due to Bio-G-Active's mechanism, which lowers the pH on the meat surface, creating conditions that drastically impair microbial survival.

- **Reduction of Total Bacterial Count (TBC):**
  Bio-G-Active demonstrated a reduction in total bacterial count of up to three log cycles within a few hours of application. In comparison, chlorine achieved a reduction of only about one to one and a half log cycles. These differences stem from the fundamental chemical properties of chlorine and Bio-G-Active. While chlorine acts only on the surface, Bio-G-Active penetrates deeper into microscopic crevices of the skin, leading to more effective decontamination.
- **Effect on Enterobacteriaceae and *Staphylococcus aureus*:**
  Bio-G-Active has been shown to significantly reduce the concentration of Enterobacteriaceae on poultry carcasses more effectively than chlorine. Studies demonstrated that E. coli and similar bacteria were notably reduced after the first application of Bio-G-Active, which is particularly relevant as these bacteria serve as indicators of fecal contamination and hygiene standards in poultry production, Staphylococcus aureus, another important pathogen in food production, also showed

significant reductions after treatment with Bio-G-Active, while chlorine was less effective under similar conditions.

- **Effectiveness Against *Salmonella* spp.:**
  Controlling *Salmonella* is a critical factor for food safety in the poultry industry. Bio-G-Active demonstrated superior efficacy against *Salmonella* in multiple studies. While chlorine can reduce the number of *Salmonella* colonies, Bio-G-Active significantly reduced the number of *Salmonella*-positive samples. In some cases, no *Salmonella* was detectable after treatment with Bio-G-Active, indicating its strong bactericidal properties.
  The bactericidal effect of Bio-G-Active is achieved by lowering the pH and directly attacking bacterial cell membranes. Chlorine, which can be partially inactivated by organic matter on the meat surfaces, showed weaker performance in comparative tests. Chlorine reacts with organic compounds, forming partially inactive or less effective byproducts.

Problems with Chlorine in Spin Chillers: pH and Efficacy Issues

One of the significant challenges associated with the use of chlorine in poultry processing, especially in **spin chillers**, is its interaction with the pH of the water. Spin chillers are systems designed to cool down poultry carcasses rapidly while also washing off contaminants. However, the effectiveness of chlorine as a disinfectant in this setting can be severely compromised due to changes in pH.

- **pH Dependence of Chlorine Efficacy:**
  Chlorine's antimicrobial efficacy is highly dependent on the pH level of the water in which it is used. Chlorine is most effective at a slightly acidic pH (around 6-7). In this range, the predominant disinfecting agent is **hypochlorous acid (HOCl)**, which is much more effective at killing bacteria than its counterpart, the hypochlorite ion (OCl^-).
  However, in a spin chiller environment, the pH tends to **rise over time** due to the introduction of organic material (such as blood, fat, and proteins from poultry), which can interact with and neutralize the chlorine, leading to an increased pH level. As the pH rises above 7.5, the proportion of hypochlorous acid decreases, and the less effective hypochlorite ion becomes dominant. This shift drastically reduces the antimicrobial efficacy of chlorine.
- **Limitations in Maintaining Consistent Efficacy:**
  The need to maintain a low, stable pH level in spin chillers to ensure chlorine's efficacy presents logistical challenges. Operators must constantly monitor and adjust the pH, often requiring the addition of acidic compounds to keep it within the optimal range. This is not only costly but also increases the complexity of the process.
  Despite these efforts, fluctuations in pH levels are common, especially when processing large batches of poultry. As a result, the effectiveness of chlorine as a disinfectant can vary significantly throughout the process, leading to inconsistent decontamination.
- **Bio-G-Active's Advantage in pH Management:**
  Unlike chlorine, Bio-G-Active **remains effective across a broader pH range**. Its

formulation, which includes organic acids, naturally lowers the pH of the spin chiller water, ensuring a more acidic environment that is hostile to microbial survival. This eliminates the need for constant pH adjustment, providing a more **consistent and reliable antimicrobial effect** throughout the cooling process.
Furthermore, Bio-G-Active's stability means that it does not react with organic matter to produce less effective byproducts, as chlorine does. This ensures that its efficacy remains high even as organic loads increase, offering a consistent level of decontamination without the need for continuous intervention.

Mechanisms of Microbial Efficacy

Bio-G-Active works through a biologically enhanced process that supports the natural breakdown of the microflora on meat surfaces. The mode of action can be divided into four phases:

- **Phase 1 – pH Reduction:** Bio-G-Active's ingredients, including organic acids like lactic acid, significantly lower the pH on meat surfaces. A lower pH inhibits bacterial growth since most pathogenic microorganisms thrive in neutral or slightly alkaline environments. This pH reduction hinders cell proliferation and makes cells more susceptible to destruction. Additionally, Bio-G-Active actively influences the natural microflora on meat surfaces. Its prebiotic carbohydrates, particularly monosaccharides, promote the growth of probiotic or non-pathogenic microorganisms, which dominate the environment through metabolic activity, displacing pathogenic bacteria. This stabilizes the microbiological quality of poultry and sustainably extends its shelf life.
- **Phase 2 – Bactericidal Action:** Bio-G-Active penetrates the cell membranes of microorganisms, disrupting their structure and ultimately leading to cell death. This effect is enhanced by the synergistic combination of lactic acid, phosphates, and ascorbic acid. Chlorine, by contrast, acts primarily on outer cell layers and is inactivated by organic matter on meat surfaces, limiting its effectiveness. Bio-G-Active amplifies the pH reduction effect through organic acids that disrupt the ionic balance of cells, causing osmotic stress. This combined effect destabilizes the cell structure of pathogenic microorganisms, stopping their metabolism and achieving significant reductions in pathogens like Salmonella and Campylobacter even with short contact times.
- **Phase 3 – Antioxidative Effects:** In addition to antimicrobial action, Bio-G-Active offers antioxidative properties crucial for the sensory and physical quality of poultry. Ascorbic acid prevents myoglobin oxidation, stabilizing meat color and ensuring a fresh, appealing appearance. Additionally, antioxidative ingredients reduce the oxidative degradation of lipids and proteins, preserving texture, tenderness, and taste. This mechanism not only extends shelf life but also prevents unwanted odors or flavors caused by oxidative stress. Compared to chlorine, Bio-G-Active excels in this area as chlorine neither inhibits nor improves oxidative processes and may even negatively impact sensory qualities.
- **Phase 4 – Complete Biological Degradability:** All components of Bio-G-Active are biologically degradable, leaving no residues. This contrasts with chlorine, which reacts with organic matter to form toxic by-products like organochlorine compounds, suspected of being harmful to health. The complete degradability of Bio-G-Active ensures safe application and eliminates concerns about potential toxic residues in the final product.

Summary of Bio-G-Active's Mechanisms of Action

Bio-G-Active's mechanisms of action are based on a unique combination of four phases that ensure both the microbiological safety and sensory quality of poultry:

1. **pH Reduction:** Organic acids, particularly lactic acid, significantly lower the pH on meat surfaces, inhibiting pathogenic microorganisms and making them more susceptible to destruction.
2. **Bactericidal Action:** Bio-G-Active destabilizes the cell membranes of pathogenic microorganisms through synergistic effects of lactic acid, phosphates, and ascorbic acid, achieving sustainable reductions in pathogens like Salmonella and Campylobacter.
3. **Antioxidative Effects:** Ascorbic acid and other antioxidative ingredients inhibit oxidative processes, stabilizing meat color and preserving texture, taste, and freshness.
4. **Complete Biological Degradation:** After the active antimicrobial and antioxidative phases, Bio-G-Active breaks down completely into harmless by-products like water and CO_2, leaving no residues and ensuring sustainability.

Compared to chlorine, Bio-G-Active offers clear advantages: It penetrates deeper, remains effective in the presence of organic matter, and does not negatively affect meat color or taste. Moreover, Bio-G-Active is fully biodegradable and leaves no residues on meat surfaces, making it an innovative and sustainable solution for poultry processing.

Comparison Table: Bio-G-Active vs. Chlor vs. Trisodium Phosphate

Parameter	Bio-G-Active	Chlor	Trisodium Phosphate
pH Reduction	Effective and stable	Moderate	High but short-lived
Antimicrobial Action	Penetrates deeply	Superficial	Strong, but leaves residues
Antioxidative Effect	Yes, prevents oxidation	None	Minimal
Residue-Free	Yes	No, leaves by-products	No
Environmental Impact	Biodegradable	Toxic by-products	Limited biodegradability

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Scientifically Proven Advantages of Bio-G-Active

Bio-G-Active offers a range of scientifically proven advantages over chlorine:

1. **Significantly Higher Microbial Efficacy:**
   Bio-G-Active reduces microbial load, especially dangerous pathogens such as *Salmonella* and *E. coli*, far more effectively than chlorine. It provides more efficient and consistent decontamination of poultry carcasses.
2. **No Harmful Residues:**
   While chlorine can leave residues that are potentially harmful, Bio-G-Active leaves none. It is fully biodegradable, making it a safer choice for the food industry.
3. **Enhanced Sensory Properties:**
   Bio-G-Active improves the texture, taste, and color of treated meat, increasing consumer acceptance. These sensory benefits make the product more attractive to consumers and enhance marketability.
4. **Environmentally Friendly and Health-Conscious:**
   Bio-G-Active is fully biodegradable and does not produce harmful byproducts, making it an eco-friendly alternative to chlorine. This reduces disposal costs and minimizes environmental impact.
5. **Consistent Efficacy in Spin Chillers:**
   Bio-G-Active does not suffer from the pH-related efficacy issues that affect chlorine. Its formulation naturally maintains an acidic environment, ensuring stable performance even under varying organic loads. This allows for consistently high antimicrobial action throughout the cooling process, without the need for constant pH adjustments.
6. **Safe to Use and Handle:**
   Chlorine can pose health risks to personnel during use, especially due to the formation of toxic fumes. Bio-G-Active, on the other hand, is safe to handle, produces no harmful fumes, and does not pose such risks to the health of workers in food processing facilities. This makes it a more user-friendly and safer alternative for industrial applications.
7. **Protection of Stainless Steel Machinery:**
   A further significant advantage of Bio-G-Active is that, unlike chlorine, it **does not corrode stainless steel surfaces**. Chlorine solutions can cause **corrosion and material degradation** in stainless steel components with prolonged use, necessitating costly maintenance and early replacement of equipment. Bio-G-Active is non-corrosive, ensuring long-term protection of processing machinery. This reduces operational costs and significantly extends the lifespan of equipment, making it both an economically and technically advantageous solution.

By combining these factors, Bio-G-Active stands out as a superior choice for the decontamination of poultry carcasses. It offers significant benefits in terms of food safety, sensory quality, environmental protection, and operational efficiency. The issues associated with chlorine, particularly its declining efficacy in spin chillers due to pH fluctuations and its potential to corrode machinery, highlight the need for safer, more effective alternatives like Bio-G-Active.

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