Non-Antibiotic Disinfection in the Poultry Industry: A Case for Super Oxidized Water

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Abstract:

There is a need for the elimination of antibiotic growth promoters in the poultry industry due to the rapid development of antibiotic drug resistance and its spread to humans. At the same time, there is a high public health risk from raw poultry meat in terms of salmonella and campylobacter infection. This review attempts to summarise the data for the use of super-oxidised water (SOW) as a novel, safe, effective and inexpensive alternative to growth promoter antibiotics, disinfectants and sanitisers used in the poultry industry.

Background:

The 2010-2011 New Zealand Ministry of Primary Industries report on the sale of antibiotics found that around 25,000 kg of zinc bacitracin was used in feed for the poultry industry. This represented around an 8% decline on the 5-year average. Bacitracin is the largest antibiotic used by weight in New Zealand.[1]

Rates of resistance to bacitracin have been reported as high as 60% in *Enterobacter faecium* and *E. faecalis* in poultry.[2] By comparison, *E. faecalis* resistance to bacitracin in Belgium poultry was reported as 16% and 41% for *E. faecium*.[2] Zinc bacitracin was withdrawn from use in EU in 1999 as an antibiotic growth promoter.[3]

The third most used class of antibiotics by weight are the tetracyclines, at 6,000 kg, representing a 30% increase over five years. These antibiotics are being mainly used in pig and poultry feed and water.[1] Tetracycline, penicillin and amoxicillin have also been withdrawn from the EU as antibiotic growth promoters.[3] Direct animal to human transmission of antibiotic resistant bacteria was first reported with tetracycline-resistant *E coli*.[3]

A 2007 study found poultry workers were 32 times more likely to be gentamycin-resistant to *Escherichia coli* than the general public.[3] The same MRSA resistance genes have been found in *E. faecium* and *E. faecalis* isolated from humans and poultry in Denmark.[3]

Samples from gentamicin-resistant urinary tract infections (UTIs) and fecal *E. coli* isolates from humans and food animal sources in China showed that 84.1% of human samples and 75.5% of animal samples contained the *aaaC2* gene for gentamicin resistance.[3]

One of the most compelling studies to date is still Hummel's tracking of the spread of nourseothricin resistance, reported in 1986. In Germany, nourseothricin (a treptogramin antibiotic) was used solely for growth promotion in swine. Resistance to it was rarely found and was never plasmid mediated. Following 2 years of its use as a growth promoter, plasmid-borne antibiotic resistance appeared in *E. coli*, not only from the treated pigs (33%) but also in manure, river water, food, and the gut floras of farm employees (18%), their family members (17%), healthy outpatients (16%) and, importantly, in 1% of urinary tract infections. Ultimately, the resistance determinant was detected in *Salmonella* and *Shigella* strains isolated from human diarrhea cases.[3]

In the Netherlands, colonization of swine farmers with MRSA was found to be more than 760 times greater than that of patients admitted to Dutch hospitals.[3] Marshal *et al* concluded that a ban on growth promoter antibiotic use would help to minimise antibiotic resistance at a time when new classes of antibiotics are rare.[3] Contaminated fresh poultry meat is estimated to be responsible for around 30,000 cases of human *Campylobacter* infection each year in New Zealand.[6] About 30 of these cases lead to paralysis and, most infamously, the much admired co-leader of the Green Party, Ron Donald, died of Camplylobacter infection complications.

Super-Oxidized Water

Super-Oxidized water (SOW) contains a variety of highly oxidising species in very low stable concentrations (e.g. hypochlorous acid, ozone, superoxide, peroxide). These oxidative species first disrupt the bacterial cell wall, following which the solution ruptures the cell through osmolarity as it is very hypotonic at 13 mOsmol/L. The mode of cell kill is actually physicochemical rather than cytotoxic and thus, not prone to resistance.[4] This is compared to a 0.5% bleach solution with an osmolarity of ~200 mOsmol/L. [4]

SOW for Egg Decontamination

In a 2009 study published in *Poultry Science,* a total of 2,160 breeder flock eggs were randomly split into a control group and a group to be sprayed with SOW.[10] Hatched chickens were grown out to day 39. The results showed that the SOW group chickens had significantly less contamination compared to the control group. Spraying SOW on eggshell surfaces resulted in the complete elimination of *E. coli, Listeria monocytogenes, Salmonella enterica* serovar *Typhimurium*, and *Staphylococcus aureus*. Spraying hatching eggs with SOW did not negatively affect embryonic development or survival, nor broiler growth, and yet total aerobic bacteria counts were significantly lower on eggs that were sprayed with SOW compared with eggs left untreated. This result may have contributed to the reduction in broiler mortality during the first 2 weeks of production, by reducing the bacteria present in the young broilers.

SOW as Broiler Drinking Water Additive

In a 2014 study, two broiler farms were studied during 3 rearing periods. Houses and equipment were identical on each farm.[11] "The use of [SOW] as a supplementary measure can be considered to permanently achieve a better drinking water quality and had no negative effects on bird health and performance. Furthermore, the use of [SOW] contributes to current European Union requirements regarding the reduction of using antibiotic substances."[11]

A 3-week experiment published in the *International Journal of Food Microbiology* in 2002 used 144 Ross 308 broilers, aged 21 days.[15] SOW treatment had no negative effects on average weight gain, feed conversion rate or other routine measures of poultry meat quality. In a second study where broilers were watered with 3% SOW in their drinking water and slaughtered at day 34 the chicken meat quality was normal as measured by pH and colour.[14]

Campylobacter Biofilms in Watering Systems

Environmental disinfection of *Campylobacter* and other pathogens is often complicated by their rapid re-emergence after disinfection despite good hygiene measures in place. This is principally because the bacteria form chemical resistant biofilms particularly in hard to reach areas from where they can rapidly reinfect.[8] Bacteria growing in biofilms can become up to 1000-fold more resistant to antibiotics and biocides as compared to their planktonic counterparts. SOW has shown excellent biocidal activity against *Pseudomonas aeruginosa*, *MRSA* and *C. albicans* biofilms.[9]

Decontamination of *Campylobacter* on Chicken Meat

During slaughtering, chicken carcasses are often contaminated with faecal matter.[13] In a study published in 2013, chicken pieces with and without skin were sprayed with 5% SOW prior to packaging and storage at 4^{o}C. After 10 days of storage, SOW decreased the level of logarithmic CFU/mL by 0.78-1.48 for meat with skin and by 0.8-1.05 for meat with no skin. SOW was shown to be superior to chlorinated water for inactivating *Campylobacter* during poultry washing.[15]

Summary:

SOW is proven to be a superior option to antibiotics and standard disinfectants at all stages of poultry production, including egg decontamination, growth promoter, antibiofilm, decontamination of hen houses, slaughterhouses and raw meat. SOW exerts its powerful antimicrobial effect principally by osmotic shock and is therefore not prone to resistance. It is safe to breath, inexpensive and leaves but a few micrograms of plain salt as a residue. SOW is an attractive alternative to our reliance on antibiotics in the poultry industry and therefore in our public health efforts to prevent the advance of antibiotic resistance in humans.

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