Neutral Lipid Accumulation in Algae by Oxidative Stress Due to Poultry Wastewater Antimicrobials

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Microalgae-derived biofuels are a promising source of alternative fuel. Unlike other feedstocks, algae are able to grow rapidly in diverse environments without consuming agricultural resources. Unfortunately, high production costs mean that algal biofuels are not yet commercially viable. Options to assist in lowering the production cost and increasing the environmental benefit of algal biofuels include finding ways to increase the production of lipids by the algae and experimenting with different growth mediums, such as wastewater. Here we investigate the effectiveness of an algal-bacterial treatment system on poultry processing wastewater containing the antimicrobial agents peracetic acid (PAA) and cetylpyridinium chloride (CPC). We hypothesize that the interactions between algae and the poultry processing antimicrobial CPC will result in increased lipid productivity within the algae by inducing oxidative stress, thus opening the door to an integrated wastewater processing and biofuel production system.

All experiments were carried out in lab-scale hybrid tube photo-bioreactors. Algae were cultivated over the course of five days with samples taken each day to monitor growth and adjust pH. The first experiment studied the effect of various concentrations of CPC on algal growth and composition. Analysis of algal growth over the course of cultivation revealed that CPC somewhat inhibited algal growth but not to a significant degree (Figure 1A). Lipid content analysis indicated that CPC somewhat hindered lipid production but that this observation was not significantly different from the control. Starch production was also slightly, but not significantly, inhibited.

We also tested simulated poultry processing wastewater (sppw) with four different treatments: only CPC, only algae, CPC with algae, and a control. Analysis of the algal biomass indicated that the presence of CPC increased the production of starch (+0.5%) and decreased the production of lipid (-1%), though neither effect appears to be significant. We also investigated the impact of CPC and the presence of algae on nitrification in the wastewater, a crucial step in the treatment process. Using ion and anion chromatography, we found that there were high concentrations of ammonia (Figure 1B) and nitrite (Figure 1C) in the sppw+CPC treatment which indicates that CPC suppressed their oxidation. Analysis of the treatment of sppw + CPC and sppw +CPC + algae reveals that algae promote the oxidation of ammonia and nitrite (Figure 1D), thus significantly mitigating the negative effects of CPC, which result in low nutrient removal in the sppw.

The initial hypothesis that CPC would induce oxidative stress in algae, thus increasing the lipid and starch production was proven mostly incorrect. Though the algae may have experienced some stress, the production of lipid was slightly reduced while the effect of CPC on algae's production of starch varied among experiments. However, neither change in lipid or starch production appears to be significant. The mitigating effect of algae on the negative impact of CPC on oxidation of ammonia and nitrite was promising for the viability of algae cultivation on poultry processing wastewater. Further work will be required to fully assess the feasibility of growing algae as a bioenergy product using wastewater as the growth medium.

Statement of Research Advisor

This research is significant because the use of algae in the treatment of poultry processing wastewater is promising. It can allow algae to assist nitrifying bacteria in overcoming the negative effects of antimicrobial agents used in poultry processing plants. This is a critical treatment function. Moreover, this work was aimed at understanding if the algae that results from this treatment process is viable for biofuel production. While the antimicrobial agent CPC seemed to have no benefit for lipid production, this is still an important finding and suggests that other ways to valorize the algal biomass may be worth exploring.

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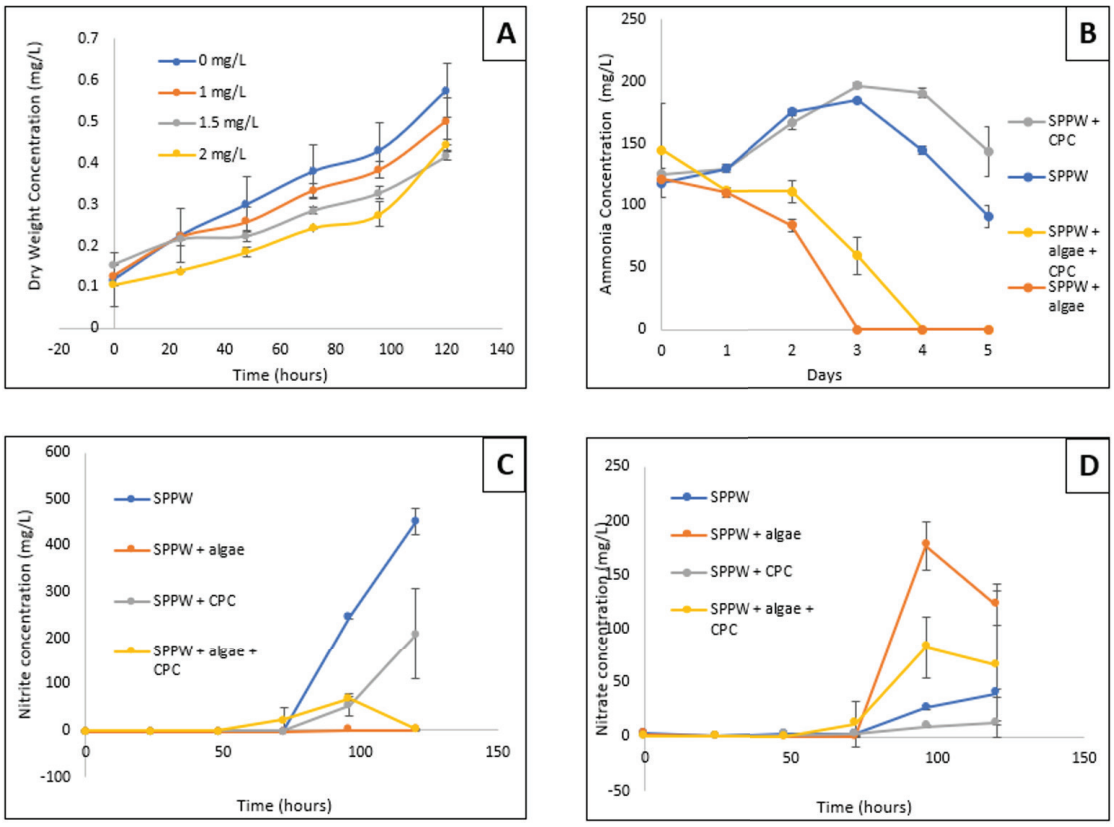

Figure 1. Effects of CPC on algal biomass and simulated poultry processing wastewater over time. (A) Dry weight concentration of algae for different concentrations of CPC. Concentrations of ammonia (B), nitrite (C), nitrate (D) for different treatments over time.