Puerarin: From the Roots of Kudzu, an Invasive Plant, to the Front Lines in Modulating Stress within Farmed Salmonids

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Puerarin: From the Roots of Kudzu (Pueraria lobata) to the Front Lines of Stress Modulation in Farmed Salmon

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INTRODUCTION

In aquaculture, husbandry practices comprise of crowding thousands of fish where they are stressed. In addition, they are often handled with nets for grading, transportation and vaccination. The cumulative effects of all the stressors in farming practices leads to reduced growth and immunocompetency. To prevent any disease outbreaks, use of antibiotics or other synthetic chemicals are not preferred due to their harmful effects on non-target species. Therefore, current research initiatives have focused on developing naturally derived nutraceuticals which could be supplemented to commercial fish-feed to improve the health of farmed fish.

OBJECTIVE

An 8-week long study was developed to determine the effects of supplementing puerarin, the most biologically active ingredient from the roots of kudzu (Pueraria lobata), with commercial fish-feed on Chinook salmon (Oncorhynchus tshawytscha) exposed to both acute and chronic stress through handling.

MATERIALS AND METHODS

Chinook salmon fingerlings were acquired from Bodine State Fish Hatchery, IN, and allowed to acclimatize to laboratory conditions for 1 month. The fish were sorted into 8 designated tanks: 2 control-feed unstressed (CFU), 2 control-feed stressed (CFS), 2 kudzu/puerarin-feed unstressed (K FU), and 2 kudzu/puerarin-feed stressed (KFS). Stress was initially induced by randomly distributing fish into the 8 designated tanks at 0 hours (D0). Prior to the distribution, sampled fish were euthanized with a lethal dose of MS-222 to represent control fish unstressed (CFU) at 0 hours (D0). All the fish were tested for condition factor (K), plasma cortisol, plasma glucose, hematocrit, plasma protein, spleen-somatic indices (SSI), and macrophage respiratory burst.

After 5 hours following the transfer, the fish were fed to satiation with their respective feeds; following which, the stressed groups were chased with nets for 5 minutes. At 24 hours (D1), fish from each group were sampled to determine the effects of puerarin-supplementation on acute stress. For chronic stress, the chasing protocol was performed everyday throughout the study and samplings were done at 2-week, 5-week, and 8-week marks of the study.

RESULTS

Plasma cortisol levels gradually decreased along the length of the study illustrating the effectiveness of the stress induced in the experiment. Puerarin lowered plasma cortisol levels in stressed fish. Puerarin supplementation lowered hematocrit and plasma protein levels which are indicative of secondary stress. Hematocrit levels are indicative of increased risk of cardiac disease while elevated plasma protein levels are indicative of stress in vertebrates. Elevated hematocrit and plasma proteins lead to a reduction in blood plasma volume, which results in greater energy expenditure for pumping blood which could be used for mounting an effective immune response. Improved blood circulation with puerarin has also been observed in other animal models.

Under duress, fish spleens shrink in size due to release of immune cells. The spleen produces antibodies and helps generate immunological memory. However, through increased blood circulation, puerarin supplementation produced higher SSIs within puerarin fed stressed fish than control-feed groups (both stressed and unstressed fish) at weeks 2, 5, and 8. In addition, puerarin fed fish had improved macrophage respiratory burst activity at weeks 2 and 5. Furthermore, puerarin endowed all these beneficial properties to the health of the fish without impacting the growth of the fish.

DISCUSSION

Plasma cortisol levels are generally considered to be indicative of primary stress, and prolonged exposure to cortisol leads to a compromised immune response (tertiary stress). Cortisol levels gradually decreased along the length of the study illustrating the effectiveness of the stress induced in the experiment. Puerarin lowered plasma cortisol levels in stressed fish. Puerarin supplementation lowered hematocrit and plasma protein levels which are indicative of secondary stress. Hematocrit levels are indicative of increased risk of cardiac disease while elevated plasma protein levels are indicative of stress in vertebrates. Elevated hematocrit and plasma proteins lead to a reduction in blood plasma volume, which results in greater energy expenditure for pumping blood which could be used for mounting an effective immune response. Improved blood circulation with puerarin has also been observed in other animal models.

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CONCLUSIONS

In conclusion, we were successful in creating a study which generated stressful conditions, under which puerarin, concurring with prior studies on other animals, was able to improve overall well-being of the fish through enhanced greater systemic circulation while attenuating plasma cortisol and glucose levels, SSIs, and improving respiratory burst activity. We consider this study informative in illustrating the possibilities with supplementing puerarin in aquaculture feed to improve circulation within fish.