Side view of the fish transport truck and trailer with four insulated seafood totes used during the study. Each tote was equipped with aerators, air vents, gas flow meters and gas diffusers.

PHYSIOLOGICAL RESPONSES OF ARCTIC CHAR (*Salvelinus alpinus*) DURING 5.5 HOUR LIVE TRANSPORT WITH ICE-SLURRY, AQUI-S^{TM}, OR CARBON DIOXIDE

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Top view of an insulated seafood tote used to transport live Arctic char (*Salvelinus alpinus*) during the study. Totes were equipped with aerators and filled with 850-900 L of 13 C spring water.

ABSTRACT

Arctic char (*Salvelinus alpinus*) is a relatively new, high-value cultured salmonid. Means of minimizing transport related stressors, which are known to affect end-product quality, have not yet been investigated in char. The objective of the following study was to investigate the potential for anesthetics or ice-slurry to minimize the stress responses of char during live transport. Four transport treatments were tested: control (water only), carbon dioxide (55.0 mg/L free carbon dioxide or CO_2), Aqui-S^{TM} (1 microliter/L), and ice-slurry (1:3 ice:water). All treatments were tested in triplicate using 1000-L insulated seafood totes filled with 850-900 L fresh spring water (dissolved O_2 > 80% saturation, temp 13.3 $\pm$ 0.2 C, pH 7.6 $\pm$ 0.1, and total alkalinity 250 $\pm$ 23 mg/L $CaCO_3$). Each tote was stocked with 50 Arctic char (average 1.2 Kg/fish) then subjected to transport conditions for 5.5 h. Blood samples were collected immediately before stocking, and at 1.0, 2.5, 4.0, and 5.5 h during transport for analyses of hematocrit, plasma glucose, lactate, and cortisol. Results indicate transport of char using anesthetics or ice-slurry did not alleviate transport-related stress responses; physiological responses were detected among all treatments during the 5.5-h study. Overall, use of anesthetics or ice-slurry provided no clear advantage at the concentrations used in this study for minimizing transport-related stress responses in char. In the case of CO_2 and ice-slurry, their use may result in a more severe stress response compared to fish transported in only water which may in turn reduce the end-product quality of the harvested fish. Alternative anesthetic doses or harvest techniques may yet show anesthetics to be beneficial during harvest of transport or fish and warrant further study.

INTRODUCTION

Little is known about the physiological responses of intensively grown Arctic char (*Salvelinus alpinus*) to aquacultural stressors, but preliminary studies in our laboratory have indicated char may be especially responsive to stressors such as sudden lighting changes, netting, handling, and live-transport. Aquacultural stressors, especially those perceived during harvest, have been shown to negatively affect the end-product quality of fish. Due to the potentially high sensitivity of char to stressors, it may be especially important to minimize the effects of transport or other harvest-related stressors so high product quality can be maintained. Anesthetics may provide one option to minimize the effects of transport stressors on fish. Currently, carbon dioxide (CO_2) is the only anesthetic approved by the US Food and Drug Administration (FDA) for use on food fish without a withdrawal period. A second potential anesthetic (Aqui-S^{TM}, New Zealand, Ltd.) that may not require a withdrawal period is currently under review by the FDA, but is not yet available to the commercial industry. Alternatively, ice and salt additives have been approved by the FDA to help alleviate fish stress responses during handling and transport. Use of anesthetics or additives at low, sub-lethal concentrations during live transport of char has not yet been investigated, but may help minimize stress responses, and in turn, maximize end-product quality.

OBJECTIVE

The objective of the current study was to determine if the physiological responses of char during 5.5-h live transport could be reduced with sub-lethal anesthesia (CO_2 or Aqui-S^{TM}) or ice exposure compared to transport in water alone.

METHODS

Arctic char were obtained from onsite stocks at the Freshwater Institute in Shepherdstown, WV, USA. Prior to the study, fish were maintained in a 3200-L circular fiberglass tank supplied with once-through aerated spring water. Fish were fed daily using commercial trout feed, but were fasted for 48 hours before the start of the study.

The experimental design for the study was as follows:

- Four transport treatments
  - water only (control)
  - CO_2 anesthesia (55.0 mg/L free CO_2)
  - Aqui-S^{TM} (1 microliter/L)
  - ice-slurry (1:3 ice to water)
- Totes each stocked with 50 Arctic char (average 1.2 Kg per fish)
- 3 replicate totes per treatment
- Transport lasted 5.5 hours
- Blood samples collected from 5 fish per tote per sample time
- Blood samples collected immediately before stocking, then at 1.0, 2.5, 4.0, and 5.5 h during transport
- Blood analyzed for
  - hematocrit
  - cortisol, plasma glucose, and lactate
- Statistical analyses included repeated measures and Fisher's LSD tests, with an alpha-level of 0.05

Additional conditions during the study included:

- Totes were filled with 850 to 900 L of fresh spring water
  - dissolved O_2 > 80% saturation
  - temp 13.3 $\pm$ 0.2 C (ice-slurry temp < 3 C)
  - pH 7.6 $\pm$ 0.1
  - total alkalinity 250 $\pm$ 23 mg/L as $CaCO_3$
- All totes (1000-L capacity) equipped with aerators and supplemental oxygen diffusers
- Sampled fish were also analyzed for product quality attributes (results not shown)

RESULTS

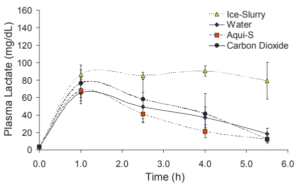
Physiological stress responses were detected within all treatment groups during the 5.5-h transport study.

Hematocrit: the overall hematocrit response for all treatments immediately before transport was 30.6%, then increased to between 37.0 and 49.5% during transport depending on sample time. At 5.5 h, hematocrit of all treatment groups had decreased below 40%, except for the CO_2 treatment which remained significantly elevated at 49.5%.

Plasma cortisol: the average concentration among all treatments immediately before transport was < 25 ng/mL, then increased to between 85 and 239 ng/mL during transport. Carbon dioxide treatment resulted in the highest cortisol concentrations of all treatments tested (239 ng/mL at 2.5 h). Ice-slurry also showed significantly higher cortisol concentrations at 2.5 h during transport (175 ng/mL), compared to the control and Aqui-S^{TM} treatments (103 and 98 ng/mL, respectively). Cortisol concentrations in all treatment groups remained significantly elevated (> 85 ng/mL) through 5.5 h, compared to the 0-h fish.

Plasma glucose: the average plasma glucose concentration among all treatments immediately before transport was 79.5 mg/dL. Plasma glucose concentrations then increased within all treatments to between 88.2 and 102.5 mg/dL by 5.5 h.

Plasma lactate: concentrations among all treatments increased from < 4 mg/dL at 0 h to > 65 mg/dL at 1.0 h. All treatment groups then showed a gradual decline back to 0-h levels, except for the ice-slurry treatment, which remained elevated through 5.5 h.



CONCLUSIONS

Results show use of anesthetics or ice-slurry during transport did not reduce transport-related stress responses in char. The Aqui-S^{TM} exposed fish showed no significant differences compared to the control group, and thus showed no advantage to warrant its use at the dose used in this study. However, higher doses of Aqui-S^{TM} may yet prove beneficial during transport. Use of CO_2 resulted in significantly higher hematocrit and cortisol responses during transport, compared to the control group, indicating use of CO_2 may make the stress response worse or more severe when used during transport. Ice-slurry treatment also resulted in significantly elevated stress responses (cortisol and lactate) compared to the control group. Thus, ice-slurry is not recommended for use during transport of live char. Overall, use of anesthetics or ice-slurry provided no clear advantage for minimizing transport-related stress responses in char. However, physical damage to the fish was not measured during the present study, but could be reduced even when the physiological stress responses are not reduced through the use of anesthetics. Alternative anesthetic doses or harvest techniques may also show anesthetics to be beneficial during harvest or transport of fish and warrant further study.

ACKNOWLEDGMENTS

This study was conducted as part of the Aquaculture Food and Marketing Development Project at West Virginia University and was funded by the USDA Cooperative State Research, Education and Extension Service. Additional support was provided by the West Virginia Cooperative Fish and Wildlife Research Unit (USGS, BRD) and the Division of Forestry at West Virginia University. The Conservation Fund's Freshwater Institute provided the fish and facilities to conduct this study.