Assessment of different stunning methods and recovery of farmed Atlantic salmon (Salmo salar): isoeugenol, nitrogen and three levels of carbon dioxide

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Abstract

Isoeugenol (17 mg L⁻¹), nitrogen, and three levels of carbon dioxide (low: 70–80, medium: 180–250 and high: > 400 mg CO₂ L⁻¹) were tested as stunning agents for Atlantic salmon (Salmo salar) fasted for six days. All methods were tested under optimised conditions (starting with rested fish, and stunning and recovery under good water quality conditions). The fish were assessed in relation to behaviour and stress in terms of blood chemistry and muscle biochemistry. Only isoeugenol fulfilled all of our set criteria related to fish welfare and stress as it: (i) minimised aversive reactions upon exposure and ability to render the fish unconscious; (ii) showed no recovery during a period of 10 min post stunning; and (iii) achieved minimal muscle activity (good muscle quality). The fish treated with nitrogen showed the strongest aversive reactions, produced the most stressed fish, and fish that did not appear to be sedated. Nitrogen stunning cannot therefore be recommended. None of the levels of carbon dioxide fulfilled all criteria. When exposed to high and medium levels, fish exhibited aversive reactions and became considerably stressed. At the low level, changes in behaviour and stress were modest, but in such cases the fish were not sufficiently immobilised to facilitate easy handling in a possible pre-stunning context. No level of carbon dioxide rendered the fish unconscious. Even under optimised stunning conditions, the use of carbon dioxide cannot be recommended in connection with slaughter of Atlantic salmon.

Keywords: animal welfare, recovery, rested harvest, salmon, stress, stunning

Introduction

Fish welfare during harvesting and slaughter has received increasing attention during the last decade (Wall 2001). Particular focus has been placed upon stunning and killing methods, despite the fact that welfare may also be seriously compromised during the preceding steps in a slaughter line. A slaughter method can be considered to be humane if insensitivity (unconsciousness) is introduced instantaneously without fear or pain (EFSA 2009). Carbon dioxide narcosis has been identified as a potential cause of poor welfare since the fish exhibit clear aversion reactions and fail to be rendered unconscious by the treatment (Robb & Kestin 2002). Consequently, the fish might experience distress or pain during subsequent processing steps, namely bleeding and gutting. In Norway, the use of carbon dioxide for stunning of fish will be banned and alternative methods of stunning, such as electrical or percussion, are currently being introduced. However, other methods (see later) might be conceivable in the future, either as stunning agents, or in connection with pre-slaughter procedures.

This study evaluates the effect of using gases (carbon dioxide and nitrogen) and an anaesthetic (isoeugenol, administered in liquid form) on Atlantic salmon (Salmo salar) welfare and stress during exposure and recovery. The novel points addressed here were the evaluation of all stunning methods on equal terms, ie under optimal conditions with good water quality and without confounding factors, such as crowding stress, pumping or other factors affecting homeostasis of fish before stunning in the industry (Erikson 2008). Moreover, the study was designed to be valid in an industrial context where adequate stunning, and preferably with no subsequent recovery, were considered key factors. For good welfare, the fish should not recover after stunning, remaining unconscious until they eventually die due to loss of blood during exsanguination. Robb et al (2000) showed that fish that were not stunned prior to bleeding lost visual-evoked responses (VERs) 2.5 to 7.5 min after exsanguination, whereas fish subjected to carbon dioxide narcosis and exsanguination lost their VERs after 5 and 9 min. This is cause for concern since it takes at least 6 min to lose sensibility under carbon dioxide narcosis (Kestin et al 2002). Therefore, to avoid possible pain sensation during bleeding, we set a criterion of no recovery within 10 min post stunning in the present study. The rationale behind selecting the various stunning methods differed to some extent, and they were as follows.