Effects of Sodium Bicarbonate on Anaesthesia of Common Carp (Cyprinus carpio L., 1758) Juveniles

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Received 21 March 2008
Accepted 03 December 2008

Abstract

In current study, anaesthetic effects of sodium bicarbonate (NaHCO₃) in 6 concentrations were determined in common carp (Cyprinus carpio) juveniles (7.70±0.4 g and 8.38±0.8 cm) kept in two different pH levels and at 23°C water temperature. Its effective concentrations were 1000 and 600 mg L⁻¹ in pH 6.5 and 7.7, respectively. While stage of anaesthesia and recovery time increased, induction time decreased; opercular rate firstly increased but than slowly decreased with increasing the concentration of anaesthetic in both pH. No mortality was observed in the study. Applications of NaHCO₃ in high pH levels, seems to be suitable on anaesthesia of common carp.

Keywords: Cyprinus carpio, sodium bicarbonate, induction time, recovery time, opercular rate, pH, water temperature

Introduction

Sodium bicarbonate (NaHCO₃) known as baking soda, is white in color, dissolved in water easily and gives carbon dioxide when dissolved in water. Carbon dioxide gas is listed for anaesthetic purposes in cold, cool and warm water fishes and has been used primarily to sedate fish during transport or to allow handling of large numbers of fish (Bowser, 2001). It was firstly described as a fish anaesthetic by Fish (1942). It is safe for human and there is no banning or restrictions in its using (Summerfeld and Smith, 1990; Çetinkaya and Şahin, 2005). It might also be only partly effective at immobilizing fish, slow acting, and lethal after repeated exposures (Marking and Meyer, 1985). Carbon dioxide gas is soluble in water. The gas is bubbled in the water. It is introduced into the water either directly through an air stone or indirectly by addition of sodium bicarbonate as a source of carbon dioxide. When NaHCO₃ is dissolved in water, it slowly releases carbon dioxide gas (Prince et al., 1995; Bowser, 2001).

While this is somewhat effective in immobilizing fish, deep anaesthesia is difficult to achieve (Prince et al., 1995). The authors reported that anaesthesia stage 4 of 5 informed by Keene et al. (1998) could be achieved in adult sockeye salmon Oncorhynchus nerka within about 6 minutes; however, it was noted that the procedure should be tested to determine appropriate concentrations on nonsalmonids.

Booke et al. (1978) studied the effects of NaHCO₃ on common carp juveniles at only low temperature (10°C). They are acclimated the fish to low water temperature in the laboratory during 10 days before treatment for this application.

Materials and Methods

Common carp (7.70±0.4 g and 8.38±0.8 cm) was obtained from Fisheries Department, Regional Directorate of State Hydraulic Works (Adana). The experiment was carried out in glass aquaria (5 L) in laboratory of Fisheries Faculty of University of Çukurova. All of the fish were starved for 24 h prior to experiment (Weyl et al., 1996).

Experiment was performed out at 23°C water temperature and in triplicate. Common carp generally prefers slightly acidic or alkali ambience and its optimal pH range is 6.5-9.0 (Tekelioglu, 2000; FAO, 2008). For this reason, two water resources having different pH level were used in this experiment; one of them was tap water (natural pH level 7.7) used in the laboratory and the other was adjusted (to 6.5 pH) by adding hydrochloric acid (HCl) (37%), 12 normality (Merck) to this water. Sodium bicarbonate (NaHCO₃) (extra pure, Merck) in 6 concentrations (0 (control), 200, 400, 600, 800, 1000 mg L⁻¹ for 6.5 pH,
and 0 (control), 400, 600, 1000, 1400, 2000 mg L\(^{-1}\) for 7.7 pH was added into each aquarium and water was mixed. The concentrations were established by taking into consideration of the results obtained from previous studies (Booke et al., 1978; Prince et al., 1995). Because NaHCO\(_3\) alters pH, pH level of the water in each aquarium was measured, when fish was stocked. Measurements of pH and temperature of the water was carried out by pH meter (Toledo mark).

After adding the anaesthetic agent, five fish was stocked into the each aquarium. When fish reached anaesthesia, induction time, anaesthesia stage, opercular rate and mortality of the fish were noted. It is generally accepted that there are five stages of anaesthesia in fish (Coyle et al., 2004): however, in aquaculture applications, stages were informed in different number and feature in previous studies. In this study, fish was observed for four different anaesthesia stages shown below and modified from anaesthesia stages identified by Abbas et al. (2006):

1. Tranquility period (slow swimming and slight increase in opercular rate),
2. Excitation period (unrest voluntary swimming, still possible increase in opercular rate high reaction to external stimuli),
3. Light anaesthesia level (turning to one side, still reaction to external stimuli, high opercular rate loss of co-ordination excrement discharge)
4. Deep anaesthesia (lying on one side without movement, opercular movement very high (up to 200 min\(^{-1}\)) in some of the fish and very low (9-17 min L\(^{-1}\)) in others increase in excrement discharge high reaction to external stimuli in fish with a high opercular rate, and no reactions to external stimuli in those with a slow opercular rate).

After the anaesthesia, fish was removed from anaesthetic added water and transferred to clean water aquarium. Recovery time was recorded and fish was maintained there for 48h in order to observe possible mortality.

**Results**

Anaesthetic effects of NaHCO\(_3\) in different concentrations and pH values at 23°C on common carp were shown in Table 1.

After stocking into the treatment aquaria, fish began to swim towards to aquarium walls and became hyperactive in first one or two minutes in each group. Then, fish gathered in together and began to enter the anaesthesia. An increase in the concentration of NaHCO\(_3\) increased pH level of the water, slightly (Table 1).

In pH 6.5, fish reached from 1 to 3 of the anaesthesia stage; however, only half of the fish entered the 3\(^{rd}\) stage of anaesthesia in the highest concentration. Only the 3\(^{rd}\) stage of anaesthesia could be seen in all concentrations except first concentration of pH 7.7.

Induction time decreased with increasing of the concentration of NaHCO\(_3\) in both pH treatments; to average 7 in pH 6.5 but to average 4 in pH 7.7. Recovery time increased with an increase in the concentration in both water resources. Opercular rate firstly increased and then slowly decreased with increasing the concentration of anaesthetic in both pH levels (Table 1).

No mortality was recorded in any concentration of NaHCO\(_3\) during the application and post recovery period.

**Discussion**

It is suggested that pH-controlled carbon dioxide release from the sodium bicarbonate caused the anesthetic response (Booke et al., 1978). Thus, pH level of the water after addition of NaHCO\(_3\) generally was adjusted with HCl (Booke et al., 1978) and sulphuric acid (H\(_2\)SO\(_4\)) (Hseu et al., 1995) and glacial acetic acid (CH\(_3\)COOH) (Quinlan, 1997). In this study, HCl was used.

The result that the fish become hyperactive in one or two minutes is similar with the result informed for brook trout (Salvelinus fontinalis) by Quinlan (1997).

Booke et al. (1978) implied that NaHCO\(_3\) at combination 642 mg L\(^{-1}\), pH 6.5 (10°C) on common carp was the most effective for causing the fish to cease locomotion and slow opercular rate, but to retain reflex response to pressure on the caudal fin.

In the present study (23°C), the best results were seen in the concentrations of 1,000 mg L\(^{-1}\) and 600 mg L\(^{-1}\) for the water resources which pH levels were 6.5 and 7.7, respectively before adding NaHCO\(_3\). Concentration of NaHCO\(_3\) to reach the stage of anaesthesia 3 in pH 6.5 was higher (1000 mg L\(^{-1}\)) than results of species (rainbow trout (Oncorhynchus mykiss), brook trout (Salvelinus fontinalis) and common carp (Cyprinus carpio)) in study of Booke et al. (1978).

With increasing of the water temperature, solubility of NaHCO\(_3\) increases (Anonymous, 2006a). However, any increment in temperature slightly decreases solubility and CO\(_2\) level of water (Cirik and Cirik, 1991; Wedemeyer, 1996; Göksu, 2003). So, more NaHCO\(_3\) (1000 mg L\(^{-1}\)) was used to anaesthetize common carp in this study than that of Booke et al. (1978).

In contrast to Booke et al. (1978), stages of anaesthesia were higher in the same concentrations of pH 7.7 than those in pH 6.5 in this study. This can indicate that high pH level of the water is more suitable to anaesthetize the fish with NaHCO\(_3\) in this temperature. Already, NaHCO\(_3\) dissolved more in high pH level; additionally NaHCO\(_3\) increases the water pH level (Anonymous, 2006b) as seen in Table 1 of this study.
Induction time, recovery times and opercular rate of the fish can vary depending on concentration of anaesthetic (Booke et al., 1978; Hseu, 1995; Yanar and Kumlu, 2001). In NaHCO₃ application, induction time for common carp changed between 4-12 min; recovery time was 15 min for 3rd stage of anaesthesia (Booke et al., 1978). Induction times for this stage in all concentrations of present study were in harmonious with the result of the authors but recovery times were shorter.

Consequently, this study highlighted that high concentration of NaHCO₃ is needed in order to anaesthetize common carp juveniles at higher temperatures including optimal water temperature for growth. Additionally, NaHCO₃ applications at high pH level can be a good alternative to other anaesthetics.

**References**


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**Table 1. Anaesthetic effects of NaHCO₃ (mg L⁻¹) at 23°C in different pH levels on common carp**

<table>
<thead>
<tr>
<th>pH Level of the Water Before Adding NaHCO₃</th>
<th>Concentrations of Anaesthetic (mg/L)</th>
<th>pH Level of the Water After Adding NaHCO₃</th>
<th>Stage of anaesthesia</th>
<th>Induction time (min)</th>
<th>Recovery time (min)</th>
<th>Opercular rate (per/min)</th>
</tr>
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<tbody>
<tr>
<td>0 (Control)</td>
<td>200</td>
<td>7.00</td>
<td>1</td>
<td>9</td>
<td>1-2</td>
<td>78±3.6</td>
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<td>7.11</td>
<td>1</td>
<td>8</td>
<td>1-2</td>
<td>125±6.5</td>
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<td>600</td>
<td>7.25</td>
<td>2</td>
<td>7.5</td>
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<td>111±4.2</td>
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<td>800</td>
<td>7.38</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>102±6.0</td>
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<td>1000</td>
<td>7.47</td>
<td>2-3</td>
<td>7</td>
<td>10</td>
<td>105±4.3</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>78±3.1</td>
</tr>
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<td>8.27</td>
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