Full Length Research Paper

Effects of carbohydrate sources on the growth and body compositions of African catfish (Clarias gariepinus)

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Feeding trial was conducted to examine the protein sparing effects of carbohydrate in Clarias gariepinus, an attempt to reduce the feed cost. C. gariepinus fingerlings mean weights of 8.32 ±0.04 g were randomly allotted into a group of 15 fishes per tank in triplicate of 10 treatments. They were fed on nine experimental diets and a commercial catfish reference diet (CRD). The formulated diets have three levels of carbohydrate (5, 10 and 20%) of three carbohydrate sources (corn fibre, corn starch and glucose) and three levels of crude protein (30, 25 and 20%). The results of the trial showed significant differences (P<0.05) in all the carbohydrate sources fed to C. gariepinus at different levels of carbohydrate/protein ratios. However, of the three carbohydrate sources, corn fibre spared protein at 5% inclusion levels while other carbohydrate sources gave significantly same degree of performance.

Key words: Protein sparing, carbohydrate sources, Clarias gariepinus.

INTRODUCTION

Carbohydrate is a cheap source of dietary energy in domestic animals including fish (Shiau and Linn, 2001). Carbohydrates are important non-protein energy sources for fish and should be included in their diets at appropriate levels which maximize the use of dietary protein for growth. The amount of non-protein energy sources that can be incorporated in fish diets is not fully understood and as such no dietary requirement for dietary carbohydrate has been demonstrated in fish; however, certain fish species exhibit reduced growth rates when fed carbohydrate free diets (Wilson, 1994). Peragón et al. (1999) further reported that carbohydrates affect nutrient utilization in the muscle of Rainbow Trout (Oncorhynchus mykiss). Carbohydrate utilisation is much more variable and probably is related to natural feeding habits, and incorporation of this nutrient may add beneficial effects to the pelleting quality of the diet and to fish growth (Fagbenro et al., 2003; Wilson, 1994; NRC, 1993). Excessive dietary carbohydrate in fish diet may also lead to fat deposition by stimulating the activities of lipogenic enzymes (Likimani and Wilson, 1982). Thus, rainbow trout (Brauge et al., 1994), Tilapia zilli (El-sayed...
and Garling, 1988), and red drum, *sciaenops* (Serrano et al., 1992; Ellis and Reigh, 1991) have been reported to have poor utilization for carbohydrate than *Oreochromis niloticus* (Shimeno et al., 1993). It has been reported that carbohydrate deprivation reduces NADPH-production in fish liver but not in adipose tissue (Barroso et al., 2001). Information on nutritional studies in African catfish *Clarias gariepinus* seems limited and has been dealt mainly with dietary protein and energy requirements using semi purified diets (Degani et al., 1989; Uys 1989; Henken et al., 1986; Machiels and Henken, 1985). Until now, carbohydrate deprivation is still under investigation as reported by Sánchez-Muros et al., 1996, although *C. gariepinus* is reported to be omnivorous and might utilize carbohydrate well. The objective of this study is to determine the effect of feeding various sources of carbohydrate on growth and body compositions of African catfish, *C. gariepinus*.

**MATERIALS AND METHODS**

**Experimental system**

The study was conducted in a recycling water system of the Department of Water Resources, Aquaculture and Fisheries Technology of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna. Water quality parameters were monitored (Temperature- 24.5-25.60; pH-6.0-7.5; conductivity (μm/cm) × 10^-7.41-12.103.34; Dissolve oxygen (mg/L)-5.50-6.60 ± 3.00; Ammonia nitrogen (mg/L) -0.07-0.36 ± 0.05; Nitrate nitrogen (mg/L) - 0.39-6.07±250.00; Nitrite nitrogen (mg/L) - 0.02-0.24±0.25.

**Experimental diets**

The experimental design was complete randomized design (CRD). Nine experimental diets and one commercial reference diet [(CRD - Coppens Catfish feed from Netherland)] were used for the feeding trial. The experimental diets were formulated using equational method of two unknowns. Nine experimental diets of three levels of protein (30, 25 and 20% CP) were formulated with three sources of carbohydrate; complex, moderately complex and simple sugar (corn fibre, corn starch and glucose-D) at 5, 10 and 20% inclusion levels. The formulation and its proximate analysis is shown in Table 1.

**Experimental fish**

150 fingerlings of African catfish, *C. gariepinus* of mean weight 8.32±0.04 g were obtained from the hatchery unit of the Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna. The fishes were acclimatized for one week and fed on commercial catfish diet (crude protein 45%). At the commencement of the feeding trial, a group 15 fishes were randomly selected, weighed and assigned to 50 L cylindrical tank. The treatments were randomly assigned to a triplicate group of the tanks. The duration of the experiment was 8 weeks. Before the commencement of the feeding trial, 7 fishes from the acclimated lots were randomly sacrificed for determination of initial whole body composition. The fishes were bulked weighed fortnightly and at the end of the experiment, all fishes were weighed and counted individually. 5 fishes from each tank were collected for determination of final whole body composition. The fishes were fed twice daily between the hours 10.00 and 16.00 to apparent satiation.

**Experimental analyses and growth parameters**

Proximate analysis for moisture, crude protein, crude lipid and ash of carcass, feed ingredients and experimental diets were determined according to the methods of Association of Official Analytical Chemists (AOAC, 2000). The growth parameters were computed stated as follows:

\[
\text{Mean weight gain} = \frac{W_f - W_i}{T_f - T_i} \\
\text{Specific Growth Rate (SGR)} = \frac{\log W_f - \log W_i}{T_f - T_i} \times 100 \\
\text{Protein efficiency ratio (PER)} = \frac{\text{Mean weight gain per protein fed}}{\text{Protein intake}} \\
\text{Apparent net protein utilization (ANPU %)} = \frac{(P_2 - P_1)}{\text{Total protein consumed}} \times 100
\]

Where, *W*₂ and *W*₁ represent final and initial weight, and *T*₂ and *T*₁ represent final and initial time.

**Statistical analysis**

The experimental design was factorial and the data was subjected to one way analysis of variance to test their significant levels at 5% probability. The mean were separated using Turkey’s method. The regression coefficients were analyzed using Minitab Release 14 while the graphs were drawn using the Microsoft excel window 2007.

**RESULTS**

Table 2 showed the results of growth parameters for various carbohydrate sources fed *C. gariepinus*. The growth performance of *C. gariepinus* fed corn fibre at three levels of carbohydrate (C) and protein (P) (C/P) ratios indicated no significant differences (P<0.05) between treatment 10:25 and 20:20 C/P ratios both of were significantly lower (P<0.05) than 5 : 30 in mean weight gain (MWG) and specific growth rate (SGR). There were no significant differences (P>0.05) in the feed conversion ratios (FCR) for all the treatments. There were significant differences (P<0.05) in the protein
Table 1. Formulation and composition of the experimental diets and proximate analysis.

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</thead>
<tbody>
<tr>
<td>Fishmeal</td>
<td>27.92</td>
<td>33.31</td>
<td>36.39</td>
<td>20.97</td>
<td>26.93</td>
<td>30.33</td>
<td>14.03</td>
<td>20.70</td>
<td>24.26</td>
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<tr>
<td>Corn fibre</td>
<td>67.09</td>
<td>0.00</td>
<td>0.00</td>
<td>74.03</td>
<td>0.00</td>
<td>0.00</td>
<td>80.97</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
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<tr>
<td>Corn Starch</td>
<td>0.00</td>
<td>61.69</td>
<td>0.00</td>
<td>0.00</td>
<td>68.08</td>
<td>0.00</td>
<td>0.00</td>
<td>74.46</td>
<td>0.00</td>
<td></td>
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<tr>
<td>Glucose</td>
<td>0.00</td>
<td>0.00</td>
<td>58.61</td>
<td>0.00</td>
<td>0.00</td>
<td>64.67</td>
<td>0.00</td>
<td>0.00</td>
<td>70.74</td>
<td></td>
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<tr>
<td>V/M premix</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
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<tr>
<td>Total</td>
<td>100.01</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.01</td>
<td>100.00</td>
<td>100.16</td>
<td>100.00</td>
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</table>

Table 2. Mean growth parameters of *Clarias gariepinus* fed various Carbohydrates : Protein ratios for 8 weeks.

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</thead>
<tbody>
<tr>
<td>Initial Body Wt. (g)</td>
<td>1.72±0.08</td>
<td>1.80±0.11</td>
<td>1.87±0.33</td>
<td>1.72±0.06</td>
<td>1.72±0.21</td>
<td>1.72±0.30</td>
<td>1.68±0.16</td>
<td>1.63±0.05</td>
<td>1.59±0.06</td>
<td>1.68±0.17</td>
<td>0.18</td>
</tr>
<tr>
<td>Final Body Wt. (g)</td>
<td>3.17±1.75</td>
<td>2.02±0.11</td>
<td>2.14±0.37</td>
<td>2.25±0.52</td>
<td>2.61±0.56</td>
<td>2.04±0.16</td>
<td>1.89±0.29</td>
<td>2.00±0.09</td>
<td>1.83±0.35</td>
<td>6.55±1.34</td>
<td>0.76</td>
</tr>
<tr>
<td>Weight gain (g)</td>
<td>1.46±1.74</td>
<td>0.37±0.31</td>
<td>0.27±0.10</td>
<td>0.54±0.51</td>
<td>0.90±0.58</td>
<td>0.32±0.31</td>
<td>0.21±0.31</td>
<td>0.18±0.05</td>
<td>0.30±0.39</td>
<td>4.87±1.18</td>
<td>0.74</td>
</tr>
<tr>
<td>SGR(%)</td>
<td>1.09±0.90</td>
<td>0.21±0.48</td>
<td>0.24±0.08</td>
<td>0.48±0.40</td>
<td>0.79±0.40</td>
<td>0.31±0.33</td>
<td>0.21±0.14</td>
<td>0.16±0.04</td>
<td>0.32±0.38</td>
<td>2.42±0.21</td>
<td>0.41</td>
</tr>
<tr>
<td>FCR</td>
<td>3.06±2.32</td>
<td>3.29±1.89</td>
<td>3.24±2.55</td>
<td>4.02±3.22</td>
<td>2.67±1.26</td>
<td>4.45±1.70</td>
<td>4.32±0.00</td>
<td>4.95±0.00</td>
<td>2.59±0.00</td>
<td>0.41±0.09</td>
<td>1.99</td>
</tr>
<tr>
<td>PER</td>
<td>2.86±3.40</td>
<td>0.91±0.76</td>
<td>0.73±0.28</td>
<td>0.92±0.88</td>
<td>1.87±1.21</td>
<td>2.94±2.74</td>
<td>0.30±0.39</td>
<td>0.38±0.10</td>
<td>0.81±1.04</td>
<td>5.19±1.25</td>
<td>1.57</td>
</tr>
<tr>
<td>ANPU(%)</td>
<td>43.43±0.01</td>
<td>75.91±0.01</td>
<td>91.49±0.01</td>
<td>1.60±0.01</td>
<td>66.26±0.01</td>
<td>59.19±0.01</td>
<td>13.03±0.01</td>
<td>39.51±0.01</td>
<td>95.53±0.01</td>
<td>30.88±0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>53.34±2.03</td>
<td>60.00±6.67</td>
<td>62.22±7.70</td>
<td>68.89±36.71</td>
<td>46.67±24.04</td>
<td>71.11±0.10</td>
<td>40.00±0.00</td>
<td>44.44±15.39</td>
<td>40.00±24.04</td>
<td>75.59±16.78</td>
<td>19.40</td>
</tr>
</tbody>
</table>

Mean data on the same row carrying letters with different superscripts are significantly different (P<0.05) from each other.

Efficiency ratios (PER) of treatments 15:25 and 20:20 C/P ratios which were significantly higher (P<0.05) than 5:30 C/P ratio. There were significant differences (P<0.05) in the apparent net protein utilization (ANPU) for all the treatments which was highest for diet 20:20 C/P ratio. The survival percentages also indicated significant differences (P<0.05) between diets 15:25 and 20:20 both of which were significantly higher (P<0.05) than 5:30 C/P ratio. The corn starch based diets did not exhibit significant differences (P>0.05) for all the
Table 3. Body composition of *Clarias gariepinus* fed different carbohydrate sources to different protein ratio.

<table>
<thead>
<tr>
<th>Proximate analysis (%)</th>
<th>Initial</th>
<th>Corn fibre</th>
<th>Corn starch</th>
<th>Glucose-D</th>
<th>CRD SD±</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>52.95±0.01</td>
<td>63.55±0.00</td>
<td>66.78±0.01</td>
<td>63.33±0.01</td>
<td>67.19±0.01</td>
</tr>
<tr>
<td>Crude fat</td>
<td>5.39±0.01</td>
<td>9.52±0.01</td>
<td>3.78±0.02</td>
<td>4.45±0.01</td>
<td>5.72±0.01</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>1.23±0.01</td>
<td>6.20±0.01</td>
<td>7.17±0.04</td>
<td>6.12±0.01</td>
<td>5.71±0.01</td>
</tr>
<tr>
<td>Ash</td>
<td>5.60±0.06</td>
<td>10.13±0.01</td>
<td>5.31±0.01</td>
<td>3.91±0.01</td>
<td>6.63±0.06</td>
</tr>
<tr>
<td>NFE</td>
<td>8.66±0.01</td>
<td>0.36±0.01</td>
<td>2.01±0.01</td>
<td>3.11±0.01</td>
<td>1.10±0.01</td>
</tr>
<tr>
<td>Moisture</td>
<td>26.15±0.01</td>
<td>10.25±0.01</td>
<td>14.91±0.01</td>
<td>16.09±0.01</td>
<td>27.47±0.01</td>
</tr>
</tbody>
</table>

Mean data on the same row carrying letter(s) with different superscripts are significantly different (P<0.05).

treatments, however, diet 20:20 C/P ratio gave the lowest mean weight gain (MWG). There were significant differences (P<0.05) in the SGR for all the treatments which was highest in 10:25 C/P ratio. The FCR values also indicated significant differences (P<0.05) for all the treatments but diet 10:25 gave the lowest FCR value. There were significant differences (P<0.05) in the PER values for all the treatments which was highest for 20:20 C/P ratio. However, the ANPU values also showed significant differences (P<0.05) for all the treatments but diet containing 10:25 C/P ratio gave the highest value.

The corn starch based diets exhibited significant differences (P<0.05) in the body protein for all the treatments but was lowest for 15:25 C/P ratio. The glucose based diets indicated insignificant differences (P>0.05) for all the treatments in the MWG and SGR values. There were significant differences (P<0.05) in the FCR for all the treatments but was lowest for 20:20 C/P ratio. The PER values indicated no significant differences (P>0.05) between diets 5:30 and 10:25 both of which were significantly lower (P<0.05) than 20:20 C/P ratio. The ANPU values were significant for all the treatments but highest for 20:20. The survival percentages indicated no significant differences (P>0.05) between diets 5:25 and 20:20 but were significantly high (P<0.05) for 10:25.

Table 3 showed the results of the nutrient utilization. There were no significant differences (P>0.05) between diets 15:25 and 20:20 in the body protein and significantly higher (P<0.05) than 5:30. The body fat showed significant differences (P<0.05) for all the treatments which was highest for 5:30 C/P ratio. The body ash indicated significant differences (P<0.05) for all the treatments but was lowest for 20:20 C/P ratio. There were significant differences (P<0.05) in the moisture content but lowest for 10:30 C/P ratio.

The corn starch based diets exhibited significant differences (P<0.05) in the MWG for all the treatments which was lowest for 15:25 C/P ratio. Similarly, the body fat indicated significant differences (P<0.05) for all treatments but was lowest for 20:20 C/P ratio. The body ash also expressed significant differences (P<0.05) for all the treatments, however, diet 10:25 gave the lowest body ash. There was also significant differences (P<0.05) in the body moisture contents which was lowest for diet 20:20 C/P ratio.

The glucose based diets indicated significant differences (P<0.05) in the MWG for treatments 5:35 and 10:25 C/P ratios both of which were significantly higher (P<0.05) than 20:20 C/P ratio. There were significant differences (P<0.05) for all the treatments in the SGR values which was highest with 10:25 C/P ratio. The FCR values also were significant (P<0.05) for all the treatments, however, diet 10:25 gave the lowest body ash. There was also significant differences (P<0.05) in the body moisture contents which was lowest for diet 20:20 C/P ratio.

The glucose based diets indicated significant differences (P<0.05) in the body protein for all the treatments but was highest for 20:20. The body fat also showed significant differences (P<0.05) for all treatments but was lowest for 5:30 C/P ratio. Similarly, there were significant differences (P<0.05) in the body ash and body moisture which are lowest for 10:25 and 20:20 C/P ratios respectively.

However, the growth responses for corn fibre and glucose shown in Figure 1 indicated a growth curve with apparently similar trend while, the corn fibre appeared to have a better protein sparing toward the end of the feeding trial at 5:30 C/P.
Figure 1. Clarias gariepius fed various sources of carbohydrate at varying levels of inclusion for 56 days.

\[
\text{weight gain (g) vs Level} = 1.33 + 0.0512 \quad r^2 = 40.1 \quad (p<0.05)
\]

Figure 2. Regression of Clarias gariepinus fed varying inclusion levels of corn starch, corn fibre and glucose for 8 weeks.
ratio. The regression co-efficient in Figure 2 showed positive relationships between weight gain and the glucose levels and negative relationship with protein levels. The corn starch also showed a negative relationship in its weight gain and the inclusion levels of corn starch and a positive relationship with protein levels in the corn fibre based diets indicated a negative relationship between the weight gain and the corn fibre levels and positive relationship with protein levels.

**DISCUSSION**

The results on growth performance indicated utilization of carbohydrate irrespective of sources by *C. gariepinus* which was an expression of carbohydrate sparing effects of protein. Examining the carbohydrate sources at the three levels of carbohydrate/protein ratios, the corn fibre based diets was well utilized for growth at the lowest inclusion level of carbohydrate and highest crude protein inclusion level (C5:30P). However, this performance may not be seen as true protein sparing since protein was still at its maximum level of inclusion. On the contrary, the corn starch based diets at a higher inclusion level (15:25), performed better than other carbohydrate sources. While at the highest level of ratio (20:20), glucose exhibited same level of growth with other ratios. The similar in trend of growth for the glucose based diets signified that *C. gariepinus* can tolerate up to 20% glucose level in its diet without adverse effects. Utilization of up to 20% glucose level is an indication of protein sparing effects of glucose in *C. gariepinus* as evident in the regression equation that was positive which was corroborated with strong positive correlation between the mean weight gain, specific growth rate and protein efficiency ratio. This is contrary to the report of Machiels and Van Dam (1987) who reported that *C. gariepinus* has a low ability to metabolize glucose. The corn fibre did not spare protein at all while corn starch spared protein at 15:25 C/P ratio. Moreover, Balogun and Ologhobo (1989), Heinsbroek et al. (1990), and Fagbenro et al. (1993) reported that carbohydrate levels in *C. gariepinus* diets can be utilized for growth. The authors have not declared any conflict of interests.

**Conflict of Interests**

The authors have not declared any conflict of interests.

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