Full Length Research Paper

Protein sparing effects of carbohydrate in 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 (cornfibre, cornstarch 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 starch and glucose spared protein for growth while corn fibre did not.

Key words: *Clarias gariepinus*, protein sparing, carbohydrate sources.

INTRODUCTION

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). 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 (Wilson, 1994; National Research Council, 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). Information on nutritional studies in African catfish *Clarias gariepinus* seems limited and have 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 utilization has not been studied, although, *C. gariepinus* is reported to be omnivorous and might utilize carbohydrate well.

The objective of this study is to determine the protein sparing effects of carbohydrate in African catfish *C. gariepinus*.

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Ts were formulated using equational method of monitored (Temperature
ingerlings of African catfish, Coppens Catfish feed from
Nine experimental diets and one commercial diet (CRD). Experimental diets
The experimental design was complete randomized design
Water quality parameters were monitored (Temperature
The study was conducted in a recycling water system of
Experimental diets
Feedstuff
Proximate value
Crude protein
Crude fat
Ash
NFE
Moisture
Total
Diet 1
Diet 2
Diet 3
Diet 4
Diet 5
Diet 6
Diet 7
Diet 8
Diet 9
Diet 10

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 (μ/cm) X10^{2} 74.12 - 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 table of formulation and its proximate analysis is shown in Table 1.

Table 1. Formulation and composition of the experimental diets and proximate analysis.

<table>
<thead>
<tr>
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<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>
<td></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>80.97</td>
<td>0.00</td>
<td>0.00</td>
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<td></td>
</tr>
<tr>
<td>Corn Starch</td>
<td>0.00</td>
<td>61.69</td>
<td>0.00</td>
<td>68.08</td>
<td>0.00</td>
<td>74.46</td>
<td>0.00</td>
<td>74.46</td>
<td>0.00</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>64.67</td>
<td>0.00</td>
<td>0.00</td>
<td>70.74</td>
<td>0.00</td>
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</tr>
<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>
<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>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
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</tr>
</tbody>
</table>

The table of formulation and proximate analysis is shown in Table 1.

Experimental fish
150 fingerlings of African catfish, *Clarias 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 fish were acclimatized for one week and fed on commercial catfish diet (crude protein 45%). At the commencement of the feeding trial, a group of 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 of 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. Final values for each group represent the arithmetic mean of the triplicates. Feed intake was monitored to measure average feed intake and their effects on growth. The growth and
nutrient utilization parameters measured include weight gain, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), apparent net protein utilization (ANPU). The growth parameters were computed as stated as follows:

Mean weight gain = Mean final weight – mean initial weight.

Specific growth rate (SGR) = \[ \frac{\log W_2 - \log W_1}{T_2 - T_1} \times 100 \]

Where, \( W_2 \) and \( W_1 \) represent – final and initial weight, \( T_2 \) and \( T_1 \) represent – final and initial time.

Feed conversion ratio = Feed fed on dry matter/fish live weight gain.

Protein efficiency ratio (PER) = Mean weight gain per protein fed.

Protein intake (g) = Feed intake \times \text{crude protein of feed}.

Apparent net protein utilization (ANPU %) = (P2 - P1) / Total protein consumed (g) \times 100.

Where, P1 is the protein in fish carcass (g) at the beginning of the study and P2 is the protein in fish carcass (g) at the end of the study.

**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 carbo-hydrate (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 which 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 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 cornstarch based diets did not exhibit significant differences (P>0.05) for all the 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 treatment 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...
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</th>
<th>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>66.33±0.01</td>
<td>53.37±0.01</td>
<td>67.15±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>
<td>5.26±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>
<td>7.02±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>
<td>4.88±0.01</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>
<td>1.99±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>16.08±0.01</td>
<td>27.47±0.01</td>
<td>13.68±0.01</td>
</tr>
</tbody>
</table>

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

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 cornstarch based diets exhibited insignificant 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 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 which was lowest for 10:25 C/P ratio. There were significant differences (P<0.05) in the PER and ANPU values for all the treatments which were highest for 20:20 and 10:25 C/P ratios, respectively. The survival percentage was significant (P<0.05) for all the treatments but was lowest for 15:25 C/P ratio. The glucose based diets indicated 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 difference (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 cornstarch based diets exhibited significant differences (P<0.05) in the body protein for all the treatments which was highest 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 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 Figures 1 and 3 indicated a growth curve with apparently similar trend while, the corn starch appeared to have a better protein sparing toward the end of the feeding trial at 10:25 C/P ratio (Figure 2). The regression coefficient in Figure 4a showed positive relationship between weight gain and the glucose levels (x = 0.154 + 0.0052y; r² = 0.40; P<0.05) and negative relationship with protein levels in Figure 4b (x = 0.443 – 0.088y; r² = 0.54, P<0.05). The cornstarch showed a negative relationship in its weight gain and the inclusion levels of corn.
Figure 1. Growth response of *Clarias gariepinus* fed different Cornfibre/Protein ratios for 8 Weeks.

Figure 2. Growth response of *Clarias gariepinus* fed different cornstarch/protein ratios for 8 weeks.

Figure 3. Growth response of *Clarias gariepinus* fed different glucose/protein ratios for 8 weeks.

Figure 4a. Regression of *Clarias gariepinus* fed with different levels of glucose/protein based diets for 8 weeks.

starch (*x* = 0.800 - 0.0178y; *r*² = 0.26, *P* < 0.05 Figure 5a) and a positive relationship with protein levels (*x* = 0.052 + 0.0216y; *r*² = 0.16, *P* < 0.05 Figure 5b) while in Figure 6a, the corn fibre based diets indicated a negative relationship between the weight gain and the corn fibre levels (*x* = 1.54 - 0.088y; *r*² = 0.66, *P* < 0.05) and positive relationship with protein levels (2.37 + 0.124y; *r*² = 0.82, *P* < 0.05 Figure 6b).

**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). This performance did not translate into protein sparing. 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. Similarly, 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 often can be substantial, and reportedly range from 15 to 35%. This is in agreement with the finding in this study; however, the ability of *C. gariepinus* to handle complex carbohydrate is very limited.
as observed in the growth response of various ratios of corn fibre based diets.

The negative relationship between the weight gain and corn starch inclusion level and negative correlation between the mean weight gain and feed conversion ratio confirmed further the limited ability of *C. gariepinus* to utilize carbohydrate of a complex nature. This is in agreement with the reports of Jacquelyn (2000) and Smith (2009) who said that the most readily available carbohydrate for growth was the simple sugars and starch. Dietary carbohydrate levels beyond a certain point have been reported to depress feed efficiency and growth, and even cause eventual mortality (Hilton and Atkinson, 1982; Kaushik et al., 1989). Therefore, in this study, glucose and corn starch were found to spare protein as energy source for growth at 20 and 15% inclusion levels, respectively.

**Conclusion**

The results obtained indicated protein sparing by moderately complex carbohydrate and simple sugar. This has further established the ability of *C. gariepinus* to utilize carbohydrate in its diets sparing expensive protein for growth.

**ACKNOWLEDGMENTS**

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**REFERENCES**


