DIETARY CARBOHYDRATE REQUIREMENT OF HETEROBRANCHUS LONGIFILIS

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ABSTRACT
The dietary carbohydrate requirement of Heterobranchus longifilis was evaluated in two separate experiments. In the first experiment, varying levels of carbohydrate ranging from 28.24% to 56.72% were fed to the fish of mean weight 2.83 ± 0.02g. Results revealed that the polynomial regression curve for the mean weight gain and the carbohydrate levels did not present a point where Y-max is equal to X-max and so the requirement was not obtained. The second experiment was therefore, conducted with lower levels of carbohydrate ranging from 17.00% to 20.86% and fed to fish with mean weight 0.49 ± 0.02g. Based on growth and feed efficiency data the carbohydrate requirement was determined to be 19.5%.

INTRODUCTION
The role of carbohydrates in fish nutrition is vital (Buhler and Halver, 1961; Pieper and Pfeiffer, 1980; Anderson et al., 1984). Studies on the utilization of carbohydrates showed that common carp (Ogino et al., 1976; Shimeno et al., 1977, 1981; Sen et al., 1978; Takeuchi et al., 1979; Furuchi and Yone, 1980), channel catfish (Garling and Wilson, 1976, 1977, Likimani & Wilson, 1982), and sea bream (Furuchi and Yone, 1971, 1980) prefer higher levels than yellow tail (Furuchi and Yone 1971; Furukawa 1976) and Salmonids (Philips and Brockway, 1956; Buhler and Halver 1961, Austreng et al., 1977; Edwards et al., 1977, Atkinson and Hilton, 1981) Omnivorous and herbivorous species of fish like common carp and Oreochromis niloticus utilize dietary carbohydrate than carnivorous species such as pike or salmonids (Philips et al., 1948, Ufodike and Matty 1983, Anderson et al., 1984).

Growth of channel catfish fingerlings were reduced when they were fed isocaloric, iso-nitrogenous semi-purified diets containing no dextrin as compared with fish fed diets containing dextrin (Garling & Wilson, 1977; Likimani and Wilson, 1982). According to NRC (1983) carbohydrates serve as the least expensive source of dietary energy and it helps the pelleting quality of practical fish diets. It spares the use of protein for energy production when it is adequately supplied. Protein therefore, will be utilized for growth. Carbohydrates may serve as precursors for various metabolic intermediates necessary for growth (NRC. 1983). From the foregoing the need to know the carbohydrate requirement of H. longifilis as an important component of the diet to facilitate good growth cannot be overemphasized. The dearth in the research on catfishes in this area needs to be addressed in order to have an overall knowledge of the nutrient requirement of this fish.

This study was carried out in order to determine the carbohydrate requirement of H. longifilis

Materials and Methods
Two independent feeding trials were carried out to determine the carbohydrate requirement of H. longifilis fingerlings. The second experiment was a follow-up of the first experiment. In the first experiment seven diets were formulated 28.24%, 36.5%, 38.45%,
45 16%, 48 13%, 53.45% and 58.72% carbohydrate and 45 36% protein using guinea corn, groundnut cake, fish meal and soybean (Table I). These feed were fed to H. longifilis of 2.83 ± 0.02g stocked 15 fingerlings/trough. The troughs are 25cm in depth and 55cm in diameter consisting of a flow-through system, which supplies water 15 hours daily through a 2mm diameter hose. The water level was maintained at 26.4 litres. The water is renewed daily by sprinkling through holes in the hose into the trough to aid aeration. Each treatment was fed twice daily in triplicate at 5% body weight for 56 days. The ration at each feeding time (7.00, 17.00hrs) was half the daily ration. The second experiment was conducted with six diets containing the following levels of carbohydrates I (17.00), II (17.14%), III (17.69%), IV (18.13%), V (20.29%) and VI (20.86%). The protein level was the same as the first experiment (Table II). H. longifilis of 0.49 ± 0.02g were stocked at the same rate as experiment one.

The feed and carcass composition were analyzed according to AOAC (1990). Sampling was done biweekly by bulk weighing the fish in each trough. Rations were adjusted after sampling. Weight gain and feed efficiency results were subjected to one-way analysis of variance -ANOVA, multiple range test and second order polynomial regression using solid curves.

Results

In the first experiment, diet I (28.24) showed the best growth performance while diet VI (53.45) was the poorest (Table III and Fig. 1). The polynomial regression curve of mean weight gain and percentage carbohydrate fed did not present a maximum point, X-max but presented a curve which was the right half of a hyperbola graph (Fig 2). This result revealed that the requirement of H. longifilis for carbohydrates is lower than the least level of carbohydrate in this experiment.

The second experiment showed no significant (P > 0.05) variation in the food conversion ratio (FCR), specific growth rate (SGR), mean initial weight (MIW) and mean final weight (MFW) of H. longifilis fed varying diets. There was significant variation (P < 0.05) in protein efficiency ratio (PER) and apparent net protein utilization (ANPU). The fish fed diet I had the best biological parameters, FCR 1.60, SGR 3.53 and PER 0.083. Conversely, diet IV showed the poorest parameters FCR 3.55, SGR 2.32 and PER 0.025 (Table IV). In utilizing correlation coefficient matrices to analyze the relationship between growth parameters of H. longifilis fed 17.00 to 20.86% Carbohydrate, the mean final weight correlated positively with specific growth rate and significant at 0.05, while the food conversion ratio correlated negatively with percentage survival and significant at 0.05.

The carcass crude protein content of H. longifilis fed diet II was highest (14.15%), while the lowest (11.46%) was with diet V. The lipid content was highest (11.00%) with diet I and lowest (7.10%) with diet IV. There was significant variation (P < 0.05) in the crude protein, lipid, ash and moisture content of carcass of fish fed the varying diets (Table V).

In subjecting the mean weight gain and level of diets to polynomial regression analysis using second order solid curve, the Y-max/X-max on the curve was found to be 19.5% (fig 3) as calculated using the equation of the curve a+b+bx+bx² = c. From the equation of the curve, the following calculation confirms the requirement obtained from the mean weight gain of H. longifilis fed the diets:

\[
Y = 5.56 + 0.78x - 0.02x^2
\]

\[
dy = 0.78x - 0.02x \]

\[
dx = 0.78 - 0.04x
\]

\[
0.04x = 0.78
\]

\[
x = 0.78 / 0.04
\]

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$x = 19.50$

Note that in mathematics the calculated value in a polynomial regression is accepted as more accurate than the extrapolated in the graph.

**Discussion**

The mean final weight and mean weight gain showed that there was a trend of increase from diet I to III and a sharp fall with diet IV and an increase with diet V and VI. As observed from the polynomial regression curve and calculation using the equation $a + bx + bx^2 = C$ (Zeitoun et al., 1976) the carbohydrate requirement for *H. longifilis* is 19.5%. The nutrient utilization parameters derived from feeding *H. longifilis* with varying levels of carbohydrates showed that there was no significant variation ($P > 0.05$). The best FCR, SGR and PER values were recorded for fish fed diet I. The mean final weight correlated positively with specific growth rate, which is a normal relationship in a nutritional study of this nature indicating the favorable response of the fish being reared to the feed provided. Food conversion ratio correlated negatively with percentage survival. Survival in any nutritional study is not restricted to the nature of the feed supplied but an interaction of this with water quality parameters and so this observed relationship may have resulted from the latter reason.

Diet III contained a dietary fibre of 16.42%, which is slightly higher than 5 – 10% dietary inclusion recommended by Cowey and Sargent (1979) and Davies (1985) for fish. The fact that *H. longifilis* can cope with this level shows that the factors suggested below in previous studies as being responsible for restrictive absorption of carbohydrate are not of any effect in this case: lack of appropriate digestive enzymes (Stickney & Shumway, 1974), restricted access of digestive enzymes to the carbohydrates due to their physical and or chemical properties (Spannhoff & Platikow, 1983) and negative physiological effect which is caused by saturation of intestinal absorption sites by glucose thus restricting amino acid assimilation and hence utilization and growth (Alvarado and Robinson, 1979).

According to NRC. (1973) gross energy in uncooked cornstarch is about approximately 40% digestible by rainbow trout but 60% digestible by channel catfish. Cruz (1975) further stated that cooking or extrusion processing of fish feeds increases the digestibility of starch for channel catfish by 5 to 10%. Guinea cornstarch, which was utilized in this study, is more digestible and less fibrous and so this would have contributed a great deal to the utilization of the feed provided. Luquet and Moreau (1990) showed that *Clarias* catfish efficiently utilizes non-protein energy from carbohydrate and hence improve protein retention. Furthermore, Jantrarotai et al., (1992) reported that catfish could well utilize up to 49% carbohydrate in diets without any detrimental effects. When the dietary carbohydrate level was further increased to 54% however, reduction in growth was observed.

The increasing level of carcass lipid up to diet III could be as a result of its content in the feed. Although the lipid content is the same in diet I & IV, *H. longifilis* utilized it better in diet I. The utilization of a higher level of lipid in the experiment corroborates NRC (1983), observation that catfishes require more lipids than tilapia.
REFERENCES
carboxylic acids and monosaccharides at the intestinal brush border membrane. Journal of
physiology 295: 457 – 475.
Atkinson, J. L. and L. W. Hilton (1981). Response of Rainbow trout to increased dietary
diets II. Influence of carbohydrate levels on chemical composition and feed utilization of
Buhler, D. R. and J. E. Halver (1961). Nutrition of salmonid fishes IX carbohydrate requirement of
Cruz, E. M. (1975). Determination of nutrient digestibility in various classes of natural purified
feed materials for channel catfish. PhD dissertation Auburn University.
Davies (1985). The role of dietary fibre in fish nutrition. In: Recent Advances in Aquaculture
diets I. Growth of fish of different families fed diets containing different proportions of
Furuchi, M. and Y. Yone (1971). Studies on nutrition of red sea bream IV. Nutritive value of
dietary carbohydrate. Report of Fisheries Research Laboratory, Kyushu University. 1
75 – 81.
efficiency, the chemical composition of liver and dorsal muscle, and the absorption of
Conference on Aquaculture Nutrition, K. S. Price, W. N. Shaw and K. S. Danbert, eds
and body composition of fingerling channel catfish. Progressive Fish-Culturist 39: 43 – 47
growth and performance of hybrid walking catfish. National Inland Fisheries Institute
National Research Council (1973) Nutrient requirements of trout, salmon and catfish. Nutrient
National Academy Press, Washington, D.C. p. 102


Table I: Ingredients and percentage proximate composition of feed fed to *H. longifilis* containing varying levels of carbohydrates in Experiment I.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Diet I</th>
<th>Diet II</th>
<th>Diet III</th>
<th>Diet IV</th>
<th>Diet V</th>
<th>Diet VI</th>
<th>Diet VII</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28.24</td>
<td>36.50</td>
<td>38.45</td>
<td>45.16</td>
<td>48.13</td>
<td>53.45</td>
<td>58.72</td>
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<tr>
<td>Soybean</td>
<td>18.81</td>
<td>16.20</td>
<td>13.60</td>
<td>10.99</td>
<td>8.38</td>
<td>5.77</td>
<td>3.16</td>
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<tr>
<td>Groundnut Cake</td>
<td>18.81</td>
<td>16.20</td>
<td>13.60</td>
<td>10.99</td>
<td>8.38</td>
<td>5.77</td>
<td>3.16</td>
</tr>
<tr>
<td>Fish meal</td>
<td>18.81</td>
<td>30.46</td>
<td>13.60</td>
<td>10.99</td>
<td>8.38</td>
<td>5.77</td>
<td>54.49</td>
</tr>
<tr>
<td>Guinea corn</td>
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<td>2.00</td>
<td>35.27</td>
<td>40.08</td>
<td>44.88</td>
<td>49.69</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>18.92</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>34.03</td>
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<td>Premix</td>
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<td>21.94</td>
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<td>2.00</td>
<td>2.00</td>
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<tr>
<td>Binder</td>
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<td></td>
<td></td>
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<tr>
<td>Proximate</td>
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<td>6.15</td>
<td>7.28</td>
<td>7.03</td>
<td>7.55</td>
<td>6.25</td>
<td>3.73</td>
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<tr>
<td>Composition of feed (%) as fed</td>
<td>45.36</td>
<td>45.36</td>
<td>45.36</td>
<td>45.36</td>
<td>45.36</td>
<td>45.36</td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>16.65</td>
<td>15.50</td>
<td>45.36</td>
<td>7.03</td>
<td>7.55</td>
<td>6.25</td>
<td>3.73</td>
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<tr>
<td>Protein</td>
<td>2.90</td>
<td>1.90</td>
<td>14.25</td>
<td>45.36</td>
<td>45.36</td>
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<tr>
<td>Lipid</td>
<td>25.34</td>
<td>34.69</td>
<td>2.80</td>
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<td>12.05</td>
<td>14.00</td>
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<td>Crude fibre</td>
<td>4.58</td>
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<td>1.50</td>
<td>2.40</td>
<td>1.90</td>
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<td>NFE</td>
<td>5.84</td>
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<td>45.73</td>
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<tr>
<td>Acid Insoluble ash</td>
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<td></td>
<td>5.91</td>
<td>5.07</td>
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Table II: Ingredients and percentage proximate composition of feed fed to *H. Longifilis* containing varying levels of carbohydrates in Experiment II.

<table>
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<th>Ingredients</th>
<th>Diet I</th>
<th>Diet II</th>
<th>Diet III</th>
<th>Diet IV</th>
<th>Diet V</th>
<th>Diet VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soyabean</td>
<td>17.00</td>
<td>17.14</td>
<td>17.69</td>
<td>18.13</td>
<td>20.29</td>
<td>20.86</td>
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<td>Groundnut cake</td>
<td>28.73</td>
<td>28.92</td>
<td>28.82</td>
<td>28.63</td>
<td>28.53</td>
<td>28.44</td>
</tr>
<tr>
<td>Fish meal</td>
<td>28.73</td>
<td>28.92</td>
<td>28.82</td>
<td>28.63</td>
<td>28.53</td>
<td>28.44</td>
</tr>
<tr>
<td>Guinea corn</td>
<td>0.08</td>
<td>1.45</td>
<td>4.18</td>
<td>5.54</td>
<td>6.91</td>
<td></td>
</tr>
<tr>
<td>Premix</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Binder</td>
<td>9.01</td>
<td>11.17</td>
<td>10.09</td>
<td>7.93</td>
<td>6.86</td>
<td>5.78</td>
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</table>

Dietary carbohydrate levels (%)

<table>
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<tr>
<th>Ingredients</th>
<th>Diet I</th>
<th>Diet II</th>
<th>Diet III</th>
<th>Diet IV</th>
<th>Diet V</th>
<th>Diet VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>4.52</td>
<td>4.32</td>
<td>4.26</td>
<td>4.73</td>
<td>3.65</td>
<td>3.67</td>
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<tr>
<td>Protein</td>
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<td>45.36</td>
<td>45.36</td>
<td>45.36</td>
<td>45.36</td>
<td>45.36</td>
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<tr>
<td>Lipid</td>
<td>27.92</td>
<td>26.32</td>
<td>26.32</td>
<td>27.92</td>
<td>25.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Ash</td>
<td>5.60</td>
<td>6.86</td>
<td>6.41</td>
<td>6.16</td>
<td>5.70</td>
<td>5.11</td>
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<tr>
<td>Crude fibre</td>
<td>16.42</td>
<td>16.09</td>
<td>17.32</td>
<td>16.98</td>
<td>17.32</td>
<td>17.92</td>
</tr>
<tr>
<td>NFE</td>
<td>0.58</td>
<td>1.05</td>
<td>0.33</td>
<td>1.15</td>
<td>2.97</td>
<td>2.94</td>
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</table>

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Table III: Growth of *H. longifilis* fed varying levels of carbohydrates in a mini-flow through system in Experiment I.

<table>
<thead>
<tr>
<th>DIET</th>
<th>MIW</th>
<th>MFW</th>
<th>MWG</th>
<th>SGR</th>
<th>FCR</th>
<th>PER</th>
<th>ANPU</th>
<th>PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2.83±0.02</td>
<td>6.48±0.14</td>
<td>3.64±0.15</td>
<td>1.42±0.04</td>
<td>3.54±0.16</td>
<td>0.084±0.004</td>
<td>10.86±0.10</td>
<td>77.78±2.22</td>
</tr>
<tr>
<td>II</td>
<td>2.84±0.01</td>
<td>6.35±0.53</td>
<td>3.25±0.46</td>
<td>1.43±0.08</td>
<td>3.92±0.44</td>
<td>0.10±0.01</td>
<td>6.08±0.02</td>
<td>86.67±8.01</td>
</tr>
<tr>
<td></td>
<td>(36 59)</td>
<td>(38 59)</td>
<td>(40 59)</td>
<td>(42 59)</td>
<td>(44 59)</td>
<td>(46 59)</td>
<td>(48 59)</td>
<td>(50 59)</td>
</tr>
<tr>
<td>III</td>
<td>2.82±0.01</td>
<td>5.19±0.65</td>
<td>2.37±0.65</td>
<td>1.08±0.14</td>
<td>5.78±2.7</td>
<td>0.073±0.004</td>
<td>8.04±0.04</td>
<td>97.78±3.9</td>
</tr>
<tr>
<td></td>
<td>(38 45)</td>
<td>(40 45)</td>
<td>(42 45)</td>
<td>(44 45)</td>
<td>(46 45)</td>
<td>(48 45)</td>
<td>(50 45)</td>
<td>(52 45)</td>
</tr>
<tr>
<td>IV</td>
<td>2.84±0.01</td>
<td>4.74±0.98</td>
<td>1.90±0.97</td>
<td>0.92±0.05</td>
<td>8.44±3.16</td>
<td>0.062±0.001</td>
<td>2.66±0.01</td>
<td>88.89±3.9</td>
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<tr>
<td></td>
<td>(45 16)</td>
<td>(47 16)</td>
<td>(49 16)</td>
<td>(51 16)</td>
<td>(53 16)</td>
<td>(55 16)</td>
<td>(57 16)</td>
<td>(59 16)</td>
</tr>
<tr>
<td>V</td>
<td>2.85±0.02</td>
<td>4.81±0.23</td>
<td>1.96±0.24</td>
<td>0.93±0.24</td>
<td>6.84±3.01</td>
<td>0.075±0.001</td>
<td>7.88±0.01</td>
<td>93.33±5.88</td>
</tr>
<tr>
<td></td>
<td>(48 13)</td>
<td>(50 13)</td>
<td>(52 13)</td>
<td>(54 13)</td>
<td>(56 13)</td>
<td>(58 13)</td>
<td>(60 13)</td>
<td>(62 13)</td>
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<tr>
<td>VI</td>
<td>2.84±0.01</td>
<td>4.11±0.048</td>
<td>1.27±0.48</td>
<td>0.68±0.03</td>
<td>56.67±67.29</td>
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<td>86.67±4.45</td>
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<tr>
<td></td>
<td>(53 45)</td>
<td>(55 45)</td>
<td>(57 45)</td>
<td>(59 45)</td>
<td>(61 45)</td>
<td>(63 45)</td>
<td>(65 45)</td>
<td>(67 45)</td>
</tr>
<tr>
<td>VII</td>
<td>2.84±0.03</td>
<td>4.61±0.26</td>
<td>1.77±0.24</td>
<td>0.83±0.07</td>
<td>9.10±3.93</td>
<td>0.087±0.01</td>
<td>14.7±0.30</td>
<td>91.11±3.85</td>
</tr>
<tr>
<td></td>
<td>(58 72)</td>
<td>(60 72)</td>
<td>(62 72)</td>
<td>(64 72)</td>
<td>(66 72)</td>
<td>(68 72)</td>
<td>(70 72)</td>
<td>(72 72)</td>
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Figures in the same column with the same superscript are not significantly different.

MIW - Mean Initial Weight = Mo
MFW - Mean Final Weight = Mt
MWG - Mean Weight Gain = Mt - Mo
SGR - Specific Growth Rate = 100 x In Wt - In Wo / time
FCR - Food Conversion Ratio = Feed given / Wt - Wo
PER - Protein Efficiency Ratio = Weight gain / protein fed
ANPU - Apparent Net Protein Utilization = 100 x Carcass protein gain / protein fed
PS - Percentage Survival