THE GROWTH OF JUVENILE «JAQUAR GUAPOTE»
(Cichlasoma managuense) FED DIETS WITH DIFFERENT CARBOHYDRATE LEVELS

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ABSTRACT

The experiment was conducted in a 16.45 L aquarium recirculation system. The objective was to evaluate the growth of jaquar guapote (Cichlasoma managuense) when fed isocaloric diets with increasing carbohydrate levels from 11 to 36 percent. Relative metabolic growth rate and feed conversion were similar with diets containing 11.5%, 18.8%, and 26.5% carbohydrate (P>0.05). The highest protein efficiency ratio (PER) and apparent net protein utilization (NPU) values were found with the 18.8% carbohydrate diet. Growth performance, feed utilization parameters, and the survival were the lowest with fish fed the highest carbohydrate level (35.6%). Fish body protein increased and body fat decreased with increasing dietary carbohydrate levels. The body ash showed a trend similar to the body protein. It is concluded that juveniles C. managuense can grow well when fed 40% protein diets containing up to 26.5% carbohydrate.

RESUMEN

Se evaluó el crecimiento de juveniles del guapote (Cichlasoma managuense) alimentados con dietas isocalóricas conteniendo niveles de carbohidrato del 11 al 36 por ciento. El experimento se realizó en un sistema de recirculación de 16 acuarios de 45 litros cada uno. La fase de crecimiento relativa metabólica y la conversión alimentaria fueron similares con los peces consumiendo la dieta con 11.5%, 18.8% y 26.5% de carbohidrato (P>0.05). La tasa de eficiencia de la proteína y la utilización meta aparente de la proteína más alta se obtuvieron con la dieta contentiendo 18.8% de carbohidrato. Los valores más bajos de crecimiento, alimentación del alimento y sobrevivencia se presentaron en los peces alimentados con la dieta con el mayor contenido de carbohidrato. El contenido de proteína corporal se incrementó y el de grasa corporal disminuyó al incrementarse el nivel de carbohidrato en la dieta. La ceniza corporal mostró una tendencia similar a la proteína corporal. Se concluyó que los juveniles de C. managuense crecieron bien con dietas conteniendo 40% de proteína y un máximo de 26.5% de carbohidrato.

INTRODUCTION

In fed formulations, carbohydrates (CHO) is cheaper as energy source than protein or lipid, and it can be used to exert a protein sparing action in fish diets (AUSTRENG et al. 1977). For carnivorous coldwater (rainbow trout, _Berojo_ 1979; EDWARDS et al. 1977; KAUSHIK et al. 1989a) and _Kim_ and _KAUSHIK_ 1992; Siberian sturgeon, _KAUSHIK_ et al. 1989b) and warmwater species (channel catfish, _Garling_ and _WILSON_ 1977; European catfish, _DEGANI_ and _VIOLA_ 1987) alike, good growth was obtained administering up to 25-35% CHO by weight in the diet. By
Cichlasoma monocline (local name: guapote tipica) is a Central American freshwater fish highly valued for its good taste and meat texture. The carminivorous guapote exhibits positive culture traits like easy year-round reproduction and low rearing mortality, acceptance of formulated diets and resistance to handling stress and diseases (Gunther and Boza 1991).

Previous research on nutritional requirements of juvenile C. monocline showed that the best growth was obtained with 35-40% protein diets with 10-12 mg protein per kcal digestible energy (Ulloa and Verdejo 1994). The objective of the study was to detect the effect on growth and feed utilization of juvenile C. monocline fed different dietary CHO levels in isonitrogenous 40% protein diets. Diets were formulated using practical ingredients.

**Table 1. Composition of the experimental diets used in the feeding trial**

<table>
<thead>
<tr>
<th>Feedstuffs</th>
<th>1 (35.6%)</th>
<th>2 (26.5%)</th>
<th>3 (18.8%)</th>
<th>4 (11.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>25.00</td>
<td>25.00</td>
<td>25.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Blood meal</td>
<td>20.00</td>
<td>12.29</td>
<td>10.96</td>
<td>10.69</td>
</tr>
<tr>
<td>Sknake meal</td>
<td>0.67</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>5.70</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Corn meal</td>
<td>1.21</td>
<td>9.62</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wheat meal</td>
<td>45.32</td>
<td>23.55</td>
<td>22.17</td>
<td>11.14</td>
</tr>
<tr>
<td>Bone meal</td>
<td>-</td>
<td>2.05</td>
<td>14.34</td>
<td>23.80</td>
</tr>
<tr>
<td>Cod liver oil</td>
<td>-</td>
<td>-</td>
<td>0.05</td>
<td>1.87</td>
</tr>
<tr>
<td>Commercial salt</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Antibiotic A</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Note:**
- Add 32 as diet filler.
- 100,000 IU vitamin A; 10,000 IU vitamin D; 0.1 mg copper; 1.0 g sodium; 1.0 g phosphorus; 1.2 g potassium; 0.9 g chlorine.

**Materials and Methods**

Diet preparation and analysis

Formulation and proximate compositions of the experimental diets are listed in tables 1 and 2, respectively. The diets were formulated to contain four different levels of carbohydrates (16, 20, 24, and 26%). Diets were kept approximately isonitrogenous by adding cod liver oil when needed. However, differences in fat composition produced slight imbalance in the energy content. Bone meal was used as a diet filler to adjust dietary carbohydrate levels. In diet 1, bone meal (20%) had to be included in place of tankage to keep the protein content in the diet (40%). Wheat and corn meal were used as main carbohydrate sources in the formulation of the diets. The four diets were analysed for moisture protein, lipid, fibre and ash by standard AOAC methods (AOAC 1980). The carbohydrate content was determined as Total Urine Carbohydrates by the Anthrone method of CLP/G (USborne and Vogt 1986). Dietary amino acids and essential fatty acid contents followed the requirements for channel catfish (ARC 1983) and for warm-water carnivorous fish (TACON 1990).
<table>
<thead>
<tr>
<th>Proximate analysis</th>
<th>1 (35.6%)</th>
<th>2 (36.5%)</th>
<th>3 (18.8%)</th>
<th>4 (11.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>5.61</td>
<td>5.97</td>
<td>5.15</td>
<td>5.59</td>
</tr>
<tr>
<td>Lipids</td>
<td>9.25</td>
<td>11.77</td>
<td>12.12</td>
<td>14.39</td>
</tr>
<tr>
<td>Fibre</td>
<td>2.13</td>
<td>1.97</td>
<td>1.99</td>
<td>1.78</td>
</tr>
<tr>
<td>Ash</td>
<td>7.13</td>
<td>15.13</td>
<td>22.28</td>
<td>26.06</td>
</tr>
<tr>
<td>Protein</td>
<td>40.68</td>
<td>39.55</td>
<td>39.78</td>
<td>40.72</td>
</tr>
<tr>
<td>Carbohydrate (^1)</td>
<td>35.56</td>
<td>26.54</td>
<td>18.75</td>
<td>11.52</td>
</tr>
<tr>
<td>Digestible energy (^2)</td>
<td>3.06</td>
<td>3.00</td>
<td>2.85</td>
<td>2.88</td>
</tr>
</tbody>
</table>

\(^1\) Total utilisable carbohydrate determined according to the methods of Clapp (OSBORNE Y VICTOR \(1965\)).

\(^2\) Calculated according to the mean digestible energy coefficients for Atlantic salmon (NRC \(1977\)).

To obtain the pellets, all dry ingredients were thoroughly mixed before adding the lipids and afterwards for another 15 minutes. Subsequently, water was added gradually until a desirable paste-like consistence was reached. The paste was forced through a 2-mesh screen using a manually operatedotecat grinder. The spaghetti-like feed was then dried during 16 hours at 50°C. Then, the feed could be easily crumbled lengthwise by hand to pellet size.

**Experimental procedure**

Fish were reared in a recirculating unit consisting of 16 aquaria (30 x 50 x 30 cm), a bio-filter and a sedimentation tank. Water quality was checked in the common outflow of the aquaria. Water temperature and dissolved oxygen were measured (twice daily: 8:00 and 17:00 h). The pH, nitrite and ammonium levels were measured every four days. By adjusting the water flow, nitrite and total ammonia levels were maintained below 0.40 and 0.20 ppm, respectively. The photoperiod was constantly kept at 13 hours light per day.

Fish with a live weight of 0.5-1.0 g were taken from a laboratory population and acclimated to experimental conditions for 10 days. At the beginning of the experiment each aquarium was stocked with 70 fish. Treatments consisting of four isonitrogenous diets with varying CHO levels (Table 2), were assigned randomly in quadruplicate over the aquaria.

A metabolic ration of 15 g/kg of bodyweight/day was used, which was adjusted for body weight at 10-day intervals. The daily ration was given to the fish in three equal portions at 10:00, 14:00 and 17:00 hours. Unconsumed feed and faeces were skimmed from the aquarium bottom daily at 8:00 hours. The experiment lasted 50 days. Twenty fish from the laboratory population were taken for body composition analysis before the start of the experiment. At the end of the feeding trial, 20 fish from each treatment group were also analysed according to AOAC methods (AOAC \(1980\)).

**Data analysis**

The following growth parameters were calculated:

- The relative metabolic growth rate (RmGR): 
  \[
  \text{RmGR} = \frac{W_f - W_i}{t} \times 10^{5} \text{ kg/m}^2 \text{d}^{-1}
  \]
  where: 
  - \(W_f\): final body weight
  - \(W_i\): initial body weight
  - \(t\): feeding period (days)

- The protein efficiency ratio (PER): 
  \[
  \text{PER} = \frac{(W_f - W_i)}{(N_f - N_i)} \times 10^{4} \text{ CP}
  \]
  where: 
  - \(W_f\): final body weight
  - \(W_i\): initial body weight
  - \(N_f\): final nitrogen content
  - \(N_i\): initial nitrogen content
  - \(CP\): crude protein content

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The apparent net protein utilization (NPU) = \frac{W_f - BP_f - W_b - BP_b}{TF + CP} \times 100\%.

Where W = average individual fish weight; t = number of days; BP = g/100 g fish protein; TF = percentage of total protein in the diet; CP = percentage of crude protein in the diet; W_f = fish weight at the beginning of the experiment; W_b = fish weight at the end of the experiment.

Data analysis was done over the total experimental period by one-way ANOVA using the software package STATGRAPHICS 2.6. Treatment means were compared by least significant difference test (LSD).

RESULTS

The water quality parameters measured (pH, NO₂⁻, NO₃⁻, NH₃, temperature and dissolved oxygen) remained within the range for fish culture during the experimental period (BOYD, 1958).

Results of the ANOVA of all parameters measured or calculated are given in Table 3. Fish fed diets containing 26.5%, 18.8%, and 11.5% of CHO reached significantly lower weight after 50 days (P<0.05), and about the same weight of fish fed 37.6% CHO diet (P>0.05). Similar results were found for total body weight increase and the relative metabolic growth rate (RmOR).

DISCUSSION

Fish fed the diets containing 11.5, 18.8, and 26.5% CHO showed similar growth. This could suggest that Cichlaxius managuensis juvenile tolerated up to 26.5% dietary CHO without any adverse effect on the growth and feed utilization rates. The growth rates obtained with these diets agree with GUNTHER and BOZA (1991), recalculated, and with ULLOA (1953) using fishes.

Table 3:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1 (35.6%)</th>
<th>2 (26.5%)</th>
<th>3 (18.8%)</th>
<th>4 (11.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial mean body weight (g)</td>
<td>1.4a</td>
<td>1.4a</td>
<td>1.4a</td>
<td>1.4a</td>
</tr>
<tr>
<td>Final mean body weight (g)</td>
<td>3.5a</td>
<td>6.2b</td>
<td>6.6b</td>
<td>6.8b</td>
</tr>
<tr>
<td>Weight increase (g)</td>
<td>2.1a</td>
<td>4.8b</td>
<td>7.2b</td>
<td>5.2b</td>
</tr>
<tr>
<td>RmOR (g/kg0.75/day)</td>
<td>5.1a</td>
<td>10.1b</td>
<td>10.7b</td>
<td>12.6b</td>
</tr>
<tr>
<td>FC</td>
<td>6.7a</td>
<td>1.8b</td>
<td>1.6b</td>
<td>1.8b</td>
</tr>
<tr>
<td>PER</td>
<td>0.4b</td>
<td>1.4c</td>
<td>1.6c</td>
<td>1.5c</td>
</tr>
<tr>
<td>NPU (%)</td>
<td>5.8a</td>
<td>20.9bc</td>
<td>23.0c</td>
<td>20.7c</td>
</tr>
</tbody>
</table>

The mean is in a row with no letter in common differ statistically (P<0.05).
of similar weight. Other warmwater carnivorous species have presented good growth response with comparable dietary carbohydrate levels (GARLING and WILSON 1977; DEGANI and VIOLA 1983). Similar results were obtained for rainbow trout on diets containing up to 32% CHO (EDWARDS et al. 1977, BERGOT 1979).

Increasing carbohydrate from 11.5 to 18.9% improved the protein utilization values (PER 1.60, and NPU, 2.3%). This may be attributed to the relative level of the non-protein energy sources (carbohydrate and lipid) and the balance between them in these diets. This may contribute to the use of protein mainly for growth (GARLING and WILSON 1977, PEPPER and PEFFER 1978, PAPAPARASKEVA and ALEXIS 1986, EL-SAYED and GARLING 1988). Moreover, fish fed diets with 26.5% CHO also showed good protein utilization values which may indicate that protein, carbohydrate and lipid are well used by juvenile C. managuense. These findings agree with earlier studies on rainbow trout (BERGOT 1979, KAUSHIK et al. 1989b, KAUSHIK 1990a), sturgeon (KAUSHIK et al. 1989b) and hybrid striped bass (NEMATIPOUR et al. 1992).

The protein growth response and use of dietary protein were found in fish fed the highest level of carbohydrate (35.6%). This was shown by the lowest PER, NPU, FC and growth rate values. The high carbohydrate level could interfere with digestibility and absorption of nutrients (CHO, lipid and protein) in the high blood meal level could make this diet little attractive to fish (NRC 1983). Furthermore, the lowest food intake was observed with this diet which could reflect a reduction in the palatability. In addition, the ability of fish to digest CHO depends on the dietary level, the molecular structure and the way of processing (BOMMER and HALVER 1961, KAUSHIK et al. 1990a). High amounts of dietary CHO or complex CHO molecules (e.g. wheat meal), without any previous treatment, produced a reduction on the growth performance and an increase in feed conversion (PEPPER and PEFFER 1978, KIM and KAUSHIK 1993). Untreated wheat meal was used in the diet formulation of the present study. This might explain why KAUSHIK et al. (1990b) found in diets with 36-38% protein and 38% CHO (heat treated cereal grains or starches) still good growth in sturgeon and rainbow trout compared to the depressed growth response of C. managuense fed a 35.6% CHO diet. Similar results were reported by KIM and KAUSHIK (1993) testing raw and gelatinized starch at a level of 38% in the diet.

The fish body composition showed lower fat, higher ash and protein contents for those fish fed higher dietary carbohydrate levels while no statistical differences were found in the water content. Similar findings were reported for rainbow trout (AUSTRENG et al. 1977) and hybrid striped bass (NEMATIPOUR et al. 1992). The increase in the level of carbohydrate in the diet led to a decrease in fat body content. Opposite results were found by LIKIMANI and WILSON (1982). This could reflect that non-protein energy sources in the feed and the body fat reserves could be used more effectively. As a result, C. managuense juvenile could convert more dietary protein into tissue as it is shown by the increased body protein content at higher dietary CHO levels.
ACKNOWLEDGEMENTS

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REFERENCES


