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

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ABSTRACT

The experiment was conducted in a 16 45 L aquaria recirculation system. The objective was to evaluate the growth of jaguar 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_a) 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 juvenile *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 tigre (*Cichlasoma managuense*) alimentado 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 tasa de crecimiento relativa metabólica y la conversión alimenticia fueron similares con los peces consumiendo la dieta con 11,5%, 18,8% y 26,5% carbohidrato (P>0,05). La tasa de eficiencia de la proteína y la utilización neta aparente de la proteína más alta se obtuvieron con la dieta conteniendo 18,8% carbohidrato. Los valores más bajos de crecimiento, utilización del alimento y sobrevivencia se presentaron en los peces alimentados con la dieta con la mayor cantidad 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 concluye que los juveniles de *C. managuense* crecen bien con dietas conteniendo 40% de proteína y un máximo de 26,5% de carbohidrato.

INTRODUCTION

In feed formulations, carbohydrate (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, BERGOT 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 eel, DEGANI and VIOLA 1987) alike, good growth was maintained administrating up to 25-32% CHO by weight in the diet. By varying the ratio CHO: lipid the role of CHO as an energy source in the diet has been also evaluated (ANDERSON *et al.* 1984, EL-SAYED and GARLING 1988, NEMATIPOUR *et al.* 1992).

Cichlasoma managuense (local name: guapote tigre) is a Central American freshwater fish highly valued for its good taste and meat texture. The carnivorous guapote exhibits positive culture traits like easy year-round reproduction and larval rearing in captivity, acceptance of formulated diets and resistance to handling stress and diseases (GÜNTHER and BOZA 1991).

Previous research on nutritional requirements of juvenile *C. managuense* showed that the best growth was obtained with 35-40% protein diets with 110-120 mg protein per kcal digestible energy (ULLOA and VERDEGEM 1994). The objective of the study was to detect the effect on growth and feed utilization of juvenile *C. managuense* fed different dietary CHO levels in isoenergetic 40% protein diets. Diets were formulated using practical ingredients.

MATERIALS AND METHODS

Diet preparation and analysis

Formulation and proximate composition of the experimental diets are listed in tables 1 and 2, respectively. The diets were formulated to contain four different levels of carbohydrate (36, 28, 20 and 12%). Diets were kept approximately isoenergetic by adding cod-liver oil when needed. However, differences in feedstuff composition produced small unbalances in the energy content. Bone meal was used as a diet filler to adjust dietary carbohydrate levels. In diet 1, blood meal (20%) had to be included instead 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 Utilizable Carbohydrate» by the Anthrone method of CLEGG (OSBORNE and VOOGT 1986). Dietary aminoacid and essential fatty acid contents followed the requirements for channel catfish (NRC 1983) and for warmwater carnivorous fish (TACON 1990).

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

	Diets		(% CHO)	
Feedstuffs	1 (35.6%)	2 (26.5%)	3 (18.8%)	4 (11.5%)
Fish meal	25.00	25.00	25.00	25.00
Blood meal	20.00	12.29	10.96	10.69
Tankage meal	0.67	20.00	20.00	20.00
Soybean meal	5.30	5.00	5.00	5.00
Corn meal	1.21	9.61	-	-
Wheat meal	45.32	23.55	22.17	11.14
Bone meal[1]	-	2.05	14.34	23.80
Cod liver oil	-	-	0.05	1.87
Commercial salt	1.50	1.50	1.50	1.50
Vitamins[2]	1.00	1.00	1.00	1.00
Antioxidant[3]	0.05	0.05	0.05	0.05

(1) Added as diet filler.
(2) (amount/kg premix): 800000 IU vitamin A; 200000 IU vitamin D; 10 g vitamin E; 1 g vitamin K; 2 g Thiamine; 3 g Riboflavin; 15 g Pantothenate; 2 g Pyridoxine; 2 mg B_{12}; 20 g Niacinamide; 0.5 g Biotin; 200 g Ascorbic acid; 1 g Folic acid; 100 g Choline.
(3) Etoxiquinin. Added over 100%.

Table 2.
Proximate composition of the experimental diets

	Diets (% CHO)			
Proximate analysis	1 (35.6%)	2 (26.5%)	3 (18.8%)	4 (11.5%)
Moisture	5.61	5.97	5.15	5.59
Lipids	9.25	11.77	12.12	14.39
Fibre	2.13	1.95	1.99	1.78
Ash	7.13	15.13	22.38	26.06
Protein	40.68	39.55	39.78	40.72
Carbohydrate[1]	35.56	26.54	18.75	11.52
Digestible energy[2] (kcal/g)	3.06	3.00	2.85	2.88

(1) Total utilizable carbohydrate: determined according the anthrone method of Clegg (OSBORNE Y VOOGT 1986).
(2) Calculated according to the nutrient digestible energy coefficients for *Ictalurus punctatus* (NRC 1977).

To obtain the pellets, all dry ingredients were thoroughly mixed during 15 minutes before adding the lipids and afterwards for another 15 minutes. Subsequently, water was added gradually until a desirable paste-like consistency was reached. This paste was forced through a 2-mm mesh screen using a manually operated meat 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 hours). 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 20 fish. Treatments, consisting of four isoenergetic diets with varying CHO levels (table 2), were assigned randomly in quadruplicate over the aquaria.

A metabolic ration of 15 g/kg$^{0.8}$ liveweight/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 siphoned 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): $(W_f - W_i / t) / BW^{0.8}$

The daily weight increment: $[(N_f * W_f) - (N_i * W_i)] / t$

The feed conversion (FC):

Feed given (dry matter, g) / wet weight gain (g)

The protein efficiency ratio (PER):

$(W_f - W_i) / (TF * CP)$

The apparent net protein utilization (NPU_a):

$$(W_f * BP_f - W_i * BP_i) / (TF * CP)$$

Where W = average individual weight; t = number of days;

$BW^{0.8}$: $(((W_i - W_f)/2)/1000)^{0.8}$= arithmetic mean metabolic body weight;

N = number of fish; TF = g of feed consumed; CP = percentage of crude protein in the diet; BP=body protein (% as wet basis); $_i$=initial and $_f$=final. 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, NO_2^-, total NH_4^+, temperature and dissolved oxygen) remained within the range for fish culture during the experimental period (BOYD 1988). Results of the ANOVA on all parameters measured or calculated are given in table 3. Fish fed diets containing 26.5%, 18.8% and 11.5% of CHO reached similar weights after 50 days (P>0.05), and about twice the weight of fish fed a 35.6% CHO diet (P<0.05). Similar results were found for total body weight increment and the relative metabolic growth rate (RmGR).

The feed utilization parameters presented similar FC values for diets with 11.5%, 18.8% and 26.5% CHO (P>0.05). However, the PER and the NPU_a tended to be higher at diet with 18.8% CHO (P<0.05) than at diet with 26.5% and 11.5% CHO. The worst FC, PER, NPU_a and growth values were found at 35.6% CHO level (P<0.05). Similar survival rates were observed with diets containing 26.5% (71.6%), 18.8% (82.7%) and 11.5% CHO (78.9%) (P>0.05), while the survival of fish fed diet with 35.6% CHO was remarkable lower (30%, P<0.05).

At higher dietary CHO level, a lower body fat content was found (P<0.05). The opposite was observed for body protein and body ash (P<0.05). No differences were found in moisture content between diets (P>0.05, table 4).

DISCUSSION

Fish fed the diets containing 11.5, 18.8 and 26.5% CHO showed similar growth. This could suggest that *Cichlasoma managuense* 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 GÜNTHER and BOZA (1991, recalculated) and with ULLOA (1993) using fishes

Table 3.
Total average values of growth and feed utilization of juvenile *C. managuense* fed different carbohydrate levels

	Diets (% CHO)			
Parameters	1 (35.6%)	2 (26.5%)	3 (18.8%)	4 (11.5%)
Initial mean body weight (g)	1.4a	1.4a	1.4a	1.4a
Final mean body weight (g)	3.5a	6.2b	6.6b	6.8a
Weight increment (g)	2.1a	4.8b	5.2b	5.3b
RmGR ($g/kg^{0.8}$/day)	5.5a	10.1b	10.7b	10.6b
FC	6.7a	1.8b	1.6b	1.6b
PER	0.4a	1.4b	1.6c	1.5bc
NPU_a (%)	5.8a	20.9bc	23.0c	20.7b

abc: means in a row with no letter in common differ statistically (P<0.05).

Table 4.
Proximal body composition (% air-dry basis) of juvenile *C. managuense* fed different dietary carbohydrate levels

Diets (% CHO)	Moisture (%)	Ash (%)	Lipid (%)	Protein (%)
Initial fish	74.4a	8.1a	33.9a	57.1ac
4 (11.5)	74.4a	9.2b	36.5a	53.2a
3 (18.8)	74.7a	11.5c	31.9ab	55.6ab
2 (26.5)	75.2a	13.8d	26.1bc	59.5ab
1 (35.6)	76.0a	16.5e	22.0c	60.4bc

abcd: Means in the same column with no letter in common differ ($P<0.05$).

of similar weight. Other warmwater carnivorous species have presented good growth response with comparable dietary carbohydrate levels (GARLING and WILSON 1977, DEGANI and VIOLA 1987). 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 18.8% improved the protein utilization values (PER 1.60, and NPU_a 23%). 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, PIEPER and PFEFFER 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.* 1989a), sturgeon (KAUSHIK *et al.* 1989b) and hybrid striped bass (NEMATIPOUR *et al.* 1992).

The poorest growth response and use of dietary protein were found in fish fed the highest level of carbohydrate (35.6%). This was showed by the lowest PER, NPU_a, FC and growth rate values. The high carbohydrate level could interfere with digestibility and absorption of nutrients (CHO, lipid and protein) or the high blood meal level could make this diet little attractive to fish (NRC 1983). Furthermore, the lowest feed 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 (BUHLER and HALVER 1961, KAUSHIK *et al.* 1989a). 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 (PIEPER and PFEFFER 1978, KIM and KAUSHIK 1992). Untreated wheat meal was used in the diet formulation of the present study. This might explain why KAUSHIK *et al.* (1989ab) 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 (1992) 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.

The results showed that juvenile *C. managuense* may tolerate dietary carbohydrate levels up to 26.5% without adverse effects on growth performance and feed utilization parameters.

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