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Utilization of Various Dietary Carbohydrate Levels by the Freshwater Catfish *Mystus montanus* (Jerdon)

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Abstract

In order to determine the effect of different levels of carbohydrate in artificial diets on growth and feed conversion of freshwater catfish *Mystus montanus*, six diets with gradual levels of carbohydrates (2%, 5%, 7%, 9%, 12% and 14%) were prepared in pelleted form and fed to the fingerlings of *M. montanus* to evaluate changes in growth and feed conversion. Higher survival (89%) and specific growth rate (1.06% d^{-1}) as well as better feed conversion ratio (1.04) were observed in fish receiving diet a containing 9% carbohydrate level. The growth performance of fish fed different carbohydrate diet levels was statistically significant at P<0.05 level. The carbohydrate dietary level did not significantly influence the carcass moisture, dry matter, biochemical composition and ash. The dietary nutrient levels were not influenced on the carcass composition, because fish fed a low dietary protein (diet C_4; 42% dietary protein) had a high carcass protein (68.8%), but fish fed a high dietary protein (diet C_5; 43% dietary protein) had a low carcass protein (67.2%). The results of the present investigation indicated that the optimum requirements of 9.48% carbohydrate are recommended for better growth of *M. montanus*.

Key words: *Mystus montanus*, threatened catfish, carbohydrate utilization, growth, survival.

Introduction

Carbohydrate specifically refers to the nitrogen free extract portion of a feed, which is physiologically digestible and fetches an energy value of 4.0 kcal/g (Hastings, 1979). Carbohydrates are the cheapest source of food energy but they are not well utilized by all animals. Carbohydrates were of limited usefulness in trout diets (Phillips *et al*., 1948) since large amounts of starch in the diets decreased the digestion of protein (Kitamikado *et al*., 1965). When digestible carbohydrate is consumed in excess of energy requirements, it builds up the visceral fat deposits and fatty infiltration in organs eventually restricting normal body function (Hastings, 1979). However Chinook salmon tolerated relatively higher levels of dietary carbohydrates (30% dietary carbohydrate; Buhler and Halver, 1961) and eels showed faster growth when fed on carbohydrate (30%) rich diets when compared to those fed on diets with a high percentage of protein (50% dietary protein; Degani, 1987).

Tiemeir *et al.* (1965) found that carbohydrate caused a sparing action on protein when fed to channel catfish and the sparing action was greater when diets contained relatively lower levels of carbohydrate (Dupree, 1969). Existing scientific literature indicated that fish differ in their ability to utilize carbohydrate. Hence the present study was carried out with a view to evaluate the utilization of carbohydrate as dietary energy source by *Mystus montanus*, an economically important catfish of South India.

Materials and Methods

Six diets with six different levels of carbohydrate (2%, 5%, 7%, 9%, 12% and 14%) (Table 1 and 2) were formulated using low cost ingredients. The dietary ingredients of each diet were mixed for about 10 min. Cod liver oil was gradually added to the mixture and the ingredients were mixed for another 5 min. Subsequently, a sufficient quantity of water was added to the mixture, which was then blended for another 5 min. and extruded through a pelletizer having 0.1 mm diameter. The freshly prepared moist pellets were shade dried for 15 min. and fed to the fish at 5% of their total body weight.

Thirty-day-old induced bred fingerlings of *M. montanus* (0.75±0.14 g) were used for this trial. Fingerlings were maintained on a pelleted diet throughout the experimental period. Prior to the initiation of the feeding trial, the fish were acclimatized to test diets for one week. Each experimental diet was fed to a triplicate group of fish for 7 weeks. Ten fish were reared in each aquarium (capacity: 25 L) and the aquaria were cleaned and refilled with water (DO 5.8 mg/L; pH 6.8–7.2 and temperature 28±2°C) supplied from a nearby bore well once every other day. The fish were fed twice a day at 10.00 h. and 17.00 h at a rate of 5% of their total body weight per day. Every week samples were weighed to determine growth performance. Mortality was recorded and survival rate was calculated. Faeces

Table 1. Composition of test diets (% dry matter basis) and calculated percentage of major constituents

Ingredients (%)	C_0	C_1	C_2	C_3	C_4	C_5
Fishmeal	65	65	65	65	65	65
Cod liver oil	4.5	4.5	4.5	4.5	4.5	4.5
Wheat flour	0	8	13	18	23	28
Micro crystalline cellulose (binder)	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin & mineral premix[1]	2	2	2	2	2	2
Nutrient content						
Protein (%)	37.83	39.44	40.44	41.45	42.46	43.46
Lipid (%)	9.02	9.25	9.43	9.61	9.79	9.96
Carbohydrate (%)	1.55	5.02	7.28	9.48	11.69	13.90
Ash (%)	10.75	10.91	11.02	11.12	11.68	11.78
Gross energy (kcal/g)	2.52	2.73	2.87	3.01	3.17	3.28
E/P ratio (g/kcal)	6.66	6.92	7.09	7.26	7.46	7.54

[1]Vitamin mixture providing the following concentration per kilogram diet; vitamin A 5000 IU; vit D 400 IU; vit E 20 mg; thiamin mononitrate (B_1) 4 mg; riboflavin (B_2) 6 mg; nicotinamide 50 mg; pyridoxine hydrochloride 3 mg; calcium pentohenate 10 mg; cyanocobalamine (B_{12}) 2 mg; ascorbic acid (vit C) 100 mg; biotin 0.1 mg. Trace mineral mix use providing the following concentration (ppm) copper 10; iron 100; manganese 50; zinc 50; cobalt 0.05 and iodine 0.1.

Table 2. Biochemical composition of fish meal and wheat flour

Ingredients	Protein (%)	Lipid (%)	Carbohydrate (%)	Ash (%)	Gross energy (kcal/g)	E/P ratio (g/kcal)
Fish meal	58.2	6.02	1.01	20.2	3.93	6.8
Wheat flour	20.14	3.57	44.11	2.1	3.25	16.1

were collected from the aquaria prior to feeding. The unfed food was collected 2 h. after feeding with minimal disturbance to the fish and were dried at 60°C and weighed for further calculations (Haniffa and Arockiaraj, 1999).

The biochemical composition of both the fish and feed ingredients were analysed by appropriate methodologies (protein: Lowery *et al*., 1951; lipid: Bragdon, 1951; carbohydrate: Carrel *et al*., 1956; ash, moisture and dry matter: Mollah and Alan, 1990). Gross energy of the diets was calculated using energy values 4.5 kcal/g for protein, 8.5 kcal/g for lipid and 3.49 kcal/g for carbohydrate (Khan and Jafri, 1991). The scheme of energy budget followed in the present work is that of the IBP formula of Petrusewicz and Macfadayen (1970). The data were subjected to mean, standard deviation, one-way ANOVA and Tukey's Multiple Range Test (Zar, 1984).

Results

The protein composition of the six different diets ranged between 37.8% and 43.4%, lipids ranged between 9% and 9.9% and gross energy ranged between 2.5 kcal/g and 3.2 kcal/g. These deviations between the nutrient composition of protein, lipid and gross energy in the diet are less than carbohydrate composition. It's quite possible that the differences in growth are due to the different dietary carbohydrate levels. This is the reason the present study was focused only on the aspect of different dietary carbohydrate utilization rather than on protein and lipid nutrients. During the feeding trial, the fish readily accepted all the diets and survival rate ranged from 83–89%. The highest specific growth rate (SGR; 1.06±0.03% d^{-1}) was observed in fish fed with diet C_3 (9.48% carbohydrate level) containing 3.01 kcal/g energy with energy to protein ratio of 7.26 g/kcal. Values of SGR ranged from 0.28–1.06% d^{-1} in all experimental diets. Weight gain (%) increased as carbohydrate levels rose from 1.55–9.48% but thereafter weight gain decreased significantly ($P<0.05$; Table 3).

Feed conversion ratio (FCR) was better (1.04-1.94) among the groups (diets C_2, C_3, and C_4) where SGR (0.6–1.06 %d^{-1}) and weight gain were also higher. Better SGR (1.06±0.03 %d^{-1}) and FCR (1.04±0.11) values were found in diet C_3 and its energy to protein (E/P) ratio was 7.26 g/kcal protein. Protein efficiency ratio (PER; 2.09 in diet C_3) showed a similar trend like SGR and the highest value was observed in fish fed diet C_3 followed by diets C_4, C_5 and C_2. PER ranged from 0.52 to 2.09 and it increased with the increment of dietary carbohydrate level and decreased after the optimum level (9.48%).

The carbohydrate dietary level did not significantly influence the carcass moisture, dry matter, biochemical composition and ash. High protein content (68.8%) was observed in the flesh of fish fed diet C_4 containing 11.69% dietary carbohydrate level (Table 4). The dietary nutrient levels were not influenced by the carcass

Table 3. Growth performance of *M. montanus* fed different carbohydrate diets (values are given in mean±standard deviation)

Diet Nos.	Initial weight (g)	Final weight (g)	Weight gain[1] (%)	SGR (% d^{-1})[2]	PER[3]	FCR[4]	Survival[5] (%)
C_0	0.75±0.14	1.82^a±0.09	53.5^a±2.5	0.27^a±0.01	0.50^a±0.01	3.79^e±0.48	83.4^a±2.07
C_1	0.75±0.14	2.34^b±0.15	79.5^b±5.0	0.50^b±0.01	0.78^b±0.01	2.58^d±0.33	86.6^b±1.81
C_2	0.75±0.14	2.64^c±0.08	94.5^c±3.3	0.60^c±0.01	1.07^c±0.02	1.95^c±0.11	86.6^b±1.81
C_3	0.75±0.14	4.41^e±0.35	183.0^f±10.5	1.06^e±0.03	2.09^f±0.15	1.04^a±0.11	89.0^c±0.70
C_4	0.75±0.14	3.17^d±0.18	121.0^e±4.0	0.76^d±0.01	1.72^e±0.11	1.29^b±0.12	88.2^c±3.03
C_5	0.75±0.14	2.88^c±0.22	106.5^d±4.1	0.68^c±0.01	1.50^d±0.11	1.50^b±0.11	86.0^b±2.23

Means in a given column having the same letter superscript are not significantly different at $P<0.05$ by one way ANOVA and Tukey's Multiple Range Test.
[1] Weight gain (%) = final weight (g) – initial weight (g)/2 x 100
[2] Specific growth rate (SGR %d^{-1}) = 100 x {(ln final BW) – (ln initial BW)}/ rearing period (days)
[3] Protein efficiency ratio (PER) = weight gain (g)/ protein intake (g)
[4] Feed conversion ratio (FCR) = dry weight of feed given (g)/ weight gain (g)
[5] Survival (%) = 100 x (no of fish stocked – no of fish died)/ no of fish stocked

Table 4. Carcass composition of *M. montanus* fed different carbohydrate diets (values are given in mean±standard deviation; number of samples (n) = 3)

Diet Nos.	Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Carbohydrate (%)	Ash (%)
Initial	80.3±1.7	19.6±0.8	60.8±2.9	6.6±0.9	0.93±0.05	22.3±2.12
C_0	81.5±1.3	18.4±1.1	65.6±3.1	6.6±1.1	1.08±0.09	24.6±1.33
C_1	81.2±0.9	18.7±0.7	66.4±1.9	6.6±1.1	0.93±0.06	24.1±1.23
C_2	82.3±1.0	17.6±1.0	65.6±2.9	7.3±0.9	1.16±0.04	23.8±2.21
C_3	83.5±1.6	16.4±0.6	68.0±0.9	8.0±1.3	1.5±0.06	22.1±1.95
C_4	83.4±0.9	16.3±1.3	68.8±1.6	6.3±0.9	1.01±0.04	23.5±1.67
C_5	82.9±2.1	17.0±1.3	67.2±1.5	7.0±0.8	1.01±0.03	23.6±1.53

composition, because fish fed a low dietary protein (diet C_4; 42% dietary protein) had a high carcass protein (68.8%), but fish fed a high dietary protein (diet C_5; 43% dietary protein) had a low carcass protein (67.2%). There was no significant change in lipid, carbohydrate and ash content.

Discussion

Protein sparing action of non-protein nutrients such as carbohydrates can effectively reduce feed costs (Shiau, 1997). The PER of the present study is comparable with that of the values of Daniels and Robinson (1986). Lin *et al*. (1997) reported that a better SGR might have partly resulted from better carbohydrate utilization by snakehead fingerling feeding strategy and carbohydrate source. The better carbohydrate utilization by fish may be related to differences in their natural diets. *M. montanus* is omnivorous in nature (ICAR - NATP, 2001; Arockiaraj *et al*., 2004a) and it feeds mainly on a diet containing some carbohydrate during the fingerling stages, mainly on zooplankton (ICAR - NATP, 2001), which contains little digestible carbohydrate. The present SGR values are comparable to those values of De Silva *et al*. (1989). The values of SGR and FCR are good at E/P ratio of 7.26 g/kcal. This value is slightly lower than the values (8–9 g/kcal) recommended for *Ictalurus punctatus* (Page and Andrews, 1973), but comparable to the values of Akand *et al*. (1991) for *H. fossilis* and *C. batrachus*, by Hasan *et al*. (1990) for Indian major carps and by Habib *et al*. (1994) for *Puntius gonionotus*.

Although the carcass protein, lipid and carbohydrate contents increased after feeding the test diets, there was no applicable change in body composition in all the treatments. Deposition of high lipid contents in the fish fed with higher amounts of carbohydrate (diet C_3 and C_5) may be due to the availability of sufficient energy in those diets (Habib *et al*., 1994). A greater percentage of fatty tissue was found in the fish fed higher dietary carbohydrate levels as reported by Wee and Ng (1986). The relationship of body lipid content with protein and moisture content is a common phenomenon in fish and the present results are comparable to those of Stansby and Olcotf (1976) reported for *Ictalurus punctatus*. Inversely, higher amounts of dietary carbohydrate usually retard growth (Austreng *et al*., 1977).

According to Joseman *et al*. (1994), the carnivorous and omnivorous fish effectively utilized feed containing animal sources such as chicken intestine or fish waste, with the pure carbohydrate sources such as dextrin or wheat flour. The present study also confirmed that the growth of *M. montanus* was highly influenced by the animal source of fishmeal along with the carbohydrate source of wheat flour. The omnivorous fish *M. montanus* needs a low amount (9.48%) of dietary carbohydrate for its maximum growth, whereas Habib *et al*. (1994) reported a comparatively high requirement of dietary carbohydrate (30%) for maximum growth in silver barb, which may be due to its herbivorous nature. Haniffa and Arockiaraj (1999) and Arockiaraj *et al*. (1999, 2004b and 2004c) reported that 14% dietary carbohydrate level was necessary for the maximum growth of the stripped murrel *Channa striatus* due to its carnivorous feeding habits. But usually herbivorous fish can metabolize carbohydrates better than carnivorous and omnivorous fish as reported by Cowey and Sargent (1979) and Furuichi and Yone (1982). Based on the results of the present investigation, the optimum requirements of 9.48% carbohydrate are recommended for better growth of *M. montanus.*

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