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Effect of dietary carbohydrate levels on the growth of fingerlings of Carnatic carp *Barbodes carnaticus* (Jerdon 1849)

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ABSTRACT

Fingerlings of *Barbodes carnaticus* (average size: 9.25 ± 0.43 cm; 7.39 ± 1.18 g) were reared for 60 days in aerated plastic tubs (40 l) providing 5 iso-nitrogenous diets formulated to contain crude NFE (nitrogen free extract) levels ranging from 35 to 50% using pure ingredients. The fish were fed *ad libitum* and were allowed to feed for 6 h and thereafter the unconsumed feeds were siphoned out. The following day, faecal matter was collected, dried, pooled and stored for proximate analysis. Water from each tub was replaced (50%) with freshwater every day after faecal matter collection. Proximate composition of feed and faecal matter was analysed. Crude fiber was used as the reference marker for dry matter, protein and fat digestibility determination. The growth parameters increased ($p < 0.05$) in *B. carnaticus* upto dietary NFE levels of 43.72%, beyond which a decrease was noticed. The food conversion ratio (FCR) and protein efficiency ratio (PER) were the best with the diet containing 43.72% NFE. Proximate composition of fish carcass revealed the highest protein and fat contents in those fed the 43.72% NFE diet. Dry matter and NFE digestibility increased with increasing dietary NFE level upto 43.72%, whereas protein digestibility showed a decreasing trend. The study revealed a dietary NFE requirement of around 44% for the fingerlings of *B. carnaticus*.

Keywords: *Barbodes carnaticus*, Carnatic carp, Carbohydrate, Digestibility

In aquaculture, feed accounts for almost 50% of the cost of production and the cost of protein source ingredients is much more than carbohydrate source (Kushwaha *et al.*, 2012). Being a cheap source of food energy, carbohydrates effectively reduce feed cost, though they are not well utilised by all fish (Shiau, 1997). The nutritional value of carbohydrates varies among fish; warm water fish are able to utilise much higher levels of dietary carbohydrate than cold water and marine fish. No dietary requirement for carbohydrate has been demonstrated in fish; however, if carbohydrates are not provided in the diet, other nutrients such as protein and lipids are catabolised for energy and to provide metabolic intermediates for the synthesis of other biologically important compounds. Thus, it is important to provide appropriate level of carbohydrate in the diets of cultured fish (Wilson, 1994). Herbivorous and omnivorous fish such as grass carp (*Ctenopharyngodon idella*) and gibel carp (*Carassius gibelio*) have been reported to use higher carbohydrate levels (45%) for optimal growth and have the ability to utilise carbohydrate as an energy source (Tian *et al.*, 2012). Protein sparing action of carbohydrate is well known in fishes (Habib *et al.*, 1994; Wilson, 1994; Keshavanath *et al.*, 2002; Stone, 2003; Krogdahl *et al.*, 2005; Cheng *et al.*, 2017).

Barbodes carnaticus (Jerdon 1849), commonly known as Carnatic carp is an endemic species of the Western Ghats of India. It serves as a food and game fish and feeds on leaves and seeds that fall into the water, as well as detritus. The species has been successfully bred and efforts are underway to induct the species into culture systems (Sridhar *et al.*, 2013; Basavaraja *et al.*, 2019). Introduction of a new species for culture requires information regarding its food, feeding habits and digestive physiology, which govern nutrient utilisation (Kushwaha *et al.*, 2012). Evaluation of maximum tolerable concentration of dietary carbohydrate of cultured species is desirable since it is the cheapest energy source (Lee and Pham, 2011). No information is available on the optimum dietary carbohydrate requirement of *B. carnaticus*. Hence, this study was undertaken using five isonitrogenous diets with varying nitrogen free extract (NFE) levels.

Healthy fingerlings of *B. carnaticus* (n=150) of average initial length 9.25 ± 0.43 cm and weight 7.39 ± 1.18 g, procured from the culture ponds of the Regional Research Centre of ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), Hesaraghatta, Bangalore, were distributed randomly into 15 aerated plastic tubs (40 l) at 10 nos. per tub. They were maintained providing control feed for a week.

Five diets were formulated to contain crude carbohydrate levels ranging from 35 to 50% using pure ingredients *viz.*, casein, gelatine, dextrin, carboxymethyl cellulose, cellulose and agar (Table 1). The ingredients were thoroughly mixed in the desired proportions in a mechanical mixer with hot water to obtain a dough to which cod liver oil and vitamin mixtures were added after cooling. The dough was pelletised using a hand palletiser fitted with a 1 mm die and the extruded noodles were sun dried to less than 10% moisture. The sun dried feeds were manually broken into small pieces and stored at room temperature ($26\pm 2^{\circ}\text{C}$) in separate airtight containers till further use.

The fish were fed *ad libitum* and were allowed to feed for 6 h and the unconsumed feed was siphoned out at the end of the feeding period. On the following day, faecal matter was collected from each tub by filtering the water with a fine meshed nylon cloth (15 μm), dried, pooled and stored for proximate analysis. About 50% of water from each tub was replaced with freshwater every day after faecal matter collection. This feeding and faecal matter collection was conducted for a period of 60 days. Proximate composition of feed and faecal matter was analysed (AOAC, 1995). Nitrogen free extract (NFE) was calculated based on the 'difference method' (Hastings, 1976). Crude fiber was used as the reference marker (Kronveit *et al.*, 2014) for dry matter, protein and fat digestibility determination (Maynard and Loosli, 1972). The energy value of feed was obtained by multiplying protein, lipid and carbohydrate contents by factors 22.6, 38.9 and 17.2 respectively (Mayes, 1990) and expressed in kJ g^{-1} .

Water quality parameters (pH, temperature, dissolved oxygen and total alkalinity) were analysed at fortnightly intervals following standard methods (APHA, 1992). The samples were collected between 09.00 and 10.00 hrs.

At the end of the experiment, the length and weight of the fishes were measured. The weight gained by the fingerlings, food conversion ratio (FCR) and protein efficiency ratio (PER) were calculated for each diet. Data was analysed using one-way ANOVA. A significance level of 95% was considered to indicate statistical differences ($p < 0.05$). When significant difference was noticed, Duncan's multiple range test was applied for further analysis (Duncan, 1955). Results are presented as mean \pm standard deviation.

The water quality parameters monitored over the experimental duration ranged as follows: Temperature: 24.7 to 25.6 $^{\circ}\text{C}$, pH: 7.28 to 8.10, dissolved oxygen: 5.67 to 7.86 ppm, total alkalinity: 323.84 to 334.88 ppm.

The growth parameters and PER were higher ($p < 0.05$) in fish fed Diet 3, compared to other diets. FCR was lower

($p < 0.05$) with Diets 2 and 3 (Table 2). No mortality of fish was observed in any of the tubs during the experiment.

Proximate composition of fish carcass revealed highest moisture and lowest crude fat ($p < 0.05$) contents in those fed Diet 1, diets with higher carbohydrate levels recording lower moisture and higher crude fat values. Crude protein content showed an increasing trend upto Diet 3, decreasing thereafter (Table 3). The ash content was higher ($p < 0.05$) in fish receiving high carbohydrate diets.

The digestibility of dry matter and NFE showed an increasing trend upto Diet 3 ($p < 0.05$) (Fig. 1). Protein digestibility showed a decreasing trend with increasing dietary carbohydrate level. Fat digestibility showed no difference ($p > 0.05$) among the diets, except Diet 5, which recorded the lowest ($p < 0.05$) value.

Feeding habit of the fish and the source of carbohydrate affect its dietary requirement. Herbivorous fish can metabolise carbohydrates better than carnivorous species (Cowey and Sargent, 1979; Shimeno *et al.*, 1979). Carps are known to utilise high levels of carbohydrate (Satoh, 1991). Manjappa *et al.* (2009) reported 6.88% higher net weight gain of catla fed a diet containing 46% NFE compared to that with 33% NFE. Good growth and feed utilisation in common carp fed a diet containing upto 52.66% carbohydrate was also recorded by Keshavanath *et al.* (2002). Habib *et al.* (1994) reported that a 30% carbohydrate level was well suited for silver barb, *Puntius (=Barbonymus) gonionotus*. Results of the present study indicated that weight gain increased ($p < 0.05$) in *B. carnaticus* upto 56.70% with dietary NFE levels of 43.72%, beyond which a decrease was noticed. Growth retardation and reduced feed efficiency were reported in Indian major carps fed carbohydrate beyond optimum level of 35% (Murthy, 2003).

B. carnaticus, showed 31.93% decrease in FCR and 86.11% increase in PER upto diet containing 43.72% NFE. Jauncey (1982) and Erfanullah and Jafri (1998) observed a negative relationship of food conversion and positive relationship of PER with dietary carbohydrate level. Keshavanath *et al.* (2002), however, reported no significant difference in FCR but observed increasing PER in common carp fed diets containing NFE levels between 33.35 to 52.66%. Increase in PER values in the present study along with dietary carbohydrate levels upto 43.72% indicates the beneficial effect of carbohydrate inclusion as a non-protein energy source in the diet of *B. carnaticus*.

Manjappa *et al.* (2009) reported 2.99% decrease in carcass protein content in catla with increase in dietary carbohydrate levels from 33.89 to 46.06%. However, Keshavanath *et al.* (2002) recorded no significant difference

Table 1. Ingredient proportion (%) and proximate composition (%) of experimental feeds.

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
<i>Ingredients used</i>					
Casein	33.36	33.36	33.36	33.36	33.36
Gelatin	6.64	6.64	6.64	6.64	6.64
Dextrin	10	16	23	28	34
Cod liver oil	8	8	8	8	8
Carboxymethyl cellulose	12	12	12	12	12
Agar	2.5	2.5	2.5	2.5	2.5
Vitamin mineral mix	4.5	4.5	4.5	4.5	4.5
Cellulose	25	19	12	7	1
<i>Proximate composition (%)</i>					
Moisture	1.04±0.03	1.62±0.10	1.31±0.35	1.0±0.02	1.67±0.07
Crude protein	35.77±0.11	35.59±0.67	36.14±0.52	34.53±1.03	34.06±0.82
Fat	7.66±0.02	7.30±0.08	7.10±0.04	7.56±0.23	7.07±0.07
Ash	6.13±0.06	6.18±0.02	6.29±0.06	6.98±0.03	6.05±0.03
Crude fiber	11.95±0.23	8.19±0.01	3.42±0.09	2.50±0.03	0.41±0.03
NFE	35.51±0.31	39.11±0.92	43.72±0.61	47.43±0.94	50.71±0.90
Gross energy (kJ g ⁻¹)	17.17	17.60	18.44	18.91	19.16

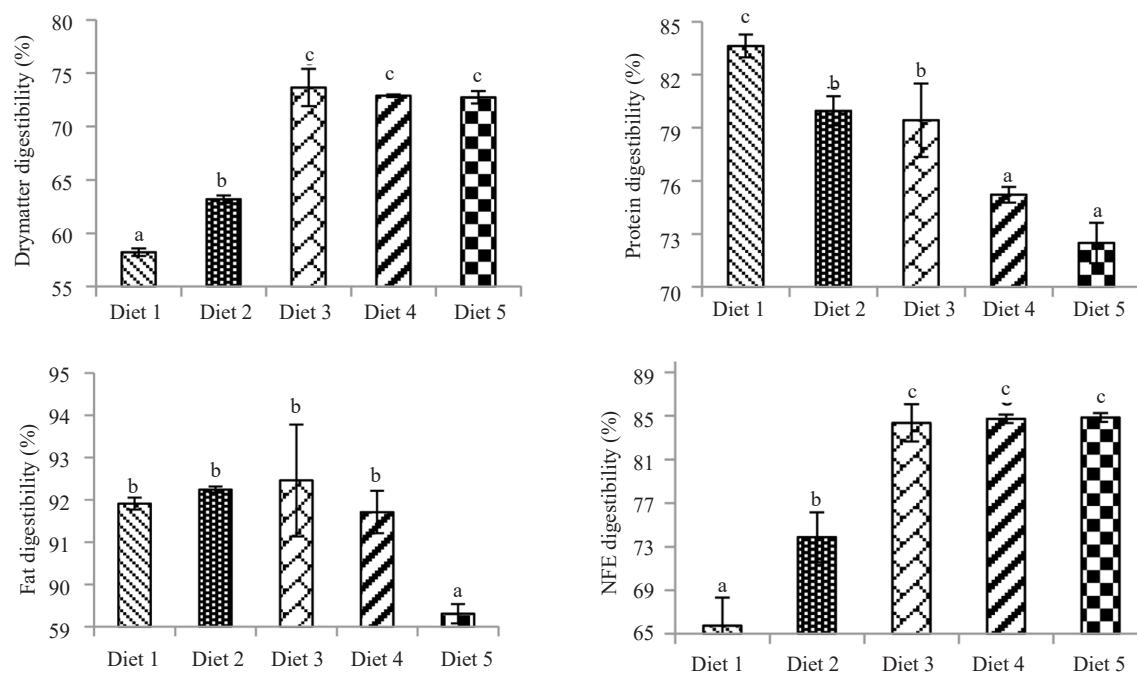


Fig 1. Digestibility (%) of dry matter, protein, fat and NFE from the experimental diets.

Table 2. Growth parameters (Mean± SD) of *B. carnaticus*.

Growth parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Initial weight (g)	7.57±0.10	7.59±0.18	7.48±0.12	7.59±0.15	7.57±0.06
Final weight (g)	9.51±0.29 ^a	9.96±0.14 ^{ab}	10.52±0.08 ^c	9.38±0.13 ^a	9.12±0.14 ^a
Weight gain (g)	1.94±0.33 ^a	2.37±0.32 ^{ab}	3.04±0.20 ^b	1.79±0.20 ^a	1.55±0.18 ^a
Specific growth rate (%)	0.38±0.06 ^a	0.45±0.06 ^{ab}	0.57±0.04 ^b	0.35±0.04 ^a	0.31±0.03 ^a
Food conversion ratio	3.47±0.64 ^{ab}	3.00±0.38 ^a	2.63±0.17 ^a	4.54±0.48 ^{bc}	5.27±0.61 ^{cd}
Protein efficiency ratio	0.36±0.06 ^a	0.47±0.15 ^{ab}	0.67±0.04 ^c	0.42±0.10 ^a	0.54±0.14 ^a

Values with different superscripts in a row are significantly different (p<0.05)

Table 3. Carcass composition (% on wet weight basis) of *B. carnaticus*.

Feeds	Moisture	Crude protein	Fat	Ash	NFE
Diet 1	74.86±0.32 ^b	18.38±0.21 ^b	3.30±0.03 ^a	3.36±0.04 ^a	0.10
Diet 2	73.29±0.57 ^a	19.24±0.28 ^c	4.03±0.01 ^c	3.32±0.08 ^a	0.12
Diet 3	72.72±0.24 ^a	19.31±0.27 ^c	4.08±0.11 ^c	3.66±0.08 ^b	0.23
Diet 4	73.44±0.36 ^a	18.25±0.12 ^b	3.82±0.03 ^b	3.96±0.07 ^c	0.53
Diet 5	73.86±0.42 ^a	17.36±0.24 ^a	3.81±0.02 ^b	3.84±0.05 ^{bc}	1.13

Values with different superscripts in a column are significantly different ($p < 0.05$)

in carcass protein content in common carp fed increased dietary carbohydrate levels. On the other hand, our study revealed 5.06% increase in protein and 23.64% increase in carcass fat content with carbohydrate levels upto 43.72%, showing a decreasing trend thereafter. Anderson *et al.* (1984), Wee and Ng (1986) and Keshavanath *et al.* (2002) also reported high carcass fat in fish fed with high carbohydrate levels.

Mohapatra *et al.* (2003) employed six different levels of carbohydrate in the diets of rohu fry and observed best carbohydrate digestibility with the diet containing 51.7% carbohydrate. In the present study, NFE digestibility increased with increasing carbohydrate level up to 43.72%. Species specific differences exist as far as digestibility of nutrients is concerned. Protein digestibility showed a decreasing trend, illustrating that energy need of *B. carnaticus* is met by carbohydrates in the diets. We (1991) concluded that undigested carbohydrate passed rapidly out of the gut taking some undigested protein with it, thus affecting protein digestibility. Fat digestibility from the different diets did not show any significant difference upto 47.43% NFE incorporation. This may be due to similar levels of fat in the diet. Manjappa *et al.* (2009) reported no difference in lipase activity of catla fed varied levels of carbohydrate. The lower fat digestibility recorded with 50.71% NFE diet may be due to the energy requirement of *B. carnaticus* being met by dietary carbohydrate, as is the case with protein. The results of this study indicated a carbohydrate requirement of around 44% for *B. carnaticus* fingerlings.

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