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IMPACT OF MARINE ALGAL DIETS ON THE FEED UTILIZATION AND NUTRIENT DIGESTIBILITY OF GRASS CARP, *CTENOPHARYNGODON IDELLA*

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Impact of three species of marine algae, *Ulvafasciata*, *Spyridia insignis* and *Sargassum wightii* as a partial substitute for fishmeal in the formulated diets of *Ctenopharyngodon idella* for a feeding period of 120 days in cement cisterns were studied. The diets were evaluated for their efficacy and suitability through measurements of growth, feed utilization and nutrient digestibility and the studies were conducted separately in plastic troughs and different parameters such as food conversion ratio, food assimilation efficiency, protein efficiency ratio, apparent protein digestibility, apparent fat digestibility and apparent carbohydrate digestibility were studied. The water quality parameters were found to be optimum with only narrow fluctuations. The algal diet fed fishes especially UL-Diet fed ones showed comparatively higher growth and weight increment ($p < 0,01$). *C. idella* recorded good FCR, FCE, FAE, PER, APD, AFD and ACD for UL-Diet followed by SP-Diet, SA-Diet and CL-Diet. The FCR, FCE and PER exhibited significant differences ($p < 0,01$) among diets.

Keywords: Seaweed diets, Ctenopharyngodon idella, Feed utilization, Nutrient digestibility.

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ВПЛИВ ДІЄТИ З МОРСЬКИХ ВОДОРОСТЕЙ НА ЗАСВОЮВАННЯ ЖИВИЛЬНИХ РЕЧОВИН КАРПОМ CTENOPHARYNGODON IDELLA

Експериментально вивчено вплив трьох видів морських водоростей Ulvafasciata, Spyridia insignis і Sargassum wightii як харчових добавок у раціон карпа Ctenopharyngodon idella протягом 120 днів. Ефективність добавок оцінювали за вимірюванням росту риб і різних параметрів засвоювання живильних речовин видом Ctenopharyngodon idella. Наведено, що додавання водоростей у раціон призводило до збільшення накопичення біомаси риб. Установлено достовірні відміни біологічного ефекту трьох досліджуваних видів морських водоростей.

Ключові слова: карп Ctenopharyngodon idella, харчові добавки, морські водорості.

Various kinds of supplementary feeds are being tried to accelerate growth and production of fish per unit area. (Ranjit Singh, Asha Dhawan, 1996). The use of cost effective diets formulated on the basis of nutritional requirements of candidate species is the key to the success of aquaculture (Halver, 1976). There are attempts to develop practical diets for fish in which significant proportion of fishmeal may be replaced by available plant protein sources along with low cost animal based wastes. Aquatic and terrestrial macrophytes, animal wastes and by products are some of the non-conventional feed stuffs worth evaluating for their inclusion in fish diets (Stanley and Jones, 1976, Das and Tripathy, 1991). The availability of nutrients and energy from feed stuffs and practical feeds to the fish is dependent on their digestibility. Digestibility of a feed depends on many factors and the feed utilisation by the fish depends to a greater extent on the digestibility (Kirchgessner *et al.*, 1986). In this regard, several workers have assessed the digestibility of several locally available raw materials as a protein source to different culture organisms. Among these, marine algae had attracted the attention of researchers all over the world (Penaflorida and Golez (1996), Palatzidis *et al.* (1996), Foster and Hodgson (1998), Upatham *et al.* (1998) etc. In India, works on this area are scanty (Bindu, 1994, Chitra, 1996, Sobha *et al.,* 1999, 2001, Bindu *et al., 2003*). This necessitates conducting the present study. The work envisaged to study the impact of three different algal diets made of marine algae *U. fasciata*, *S. insignis* and *S. wightii* on growth, feed utilization and nutrient digestibility of *C. idella.*

MATERIALS AND METHODS

EXPERIMENTAL SETUP

The feeding trial was conducted in 12 large drainable outdoor cement cisterns of 4,5 × 4,5 × 1,5 m capacity each in a completely randomised design. There were three replications for each treatment. Three almost isonitrogenous protein (31,70–34,79 %) diets and a standard fish meal based control diet were formulated following Square method Hardy (1980). The proximate composition of all the dried, powdered ingredients was analysed according to AOAC (1990) (Table 1). Algal diets were prepared by partially replacing fishmeal with algal powders, all other ingredients same as of control diet. In UL-Diet, fishmeal was replaced by marine green alga *U. fasciata*, SP-Diet with marine red alga *S. insignis* and SA-Diet with marine brown alga *S. wightii* respectively (Table 2). Diets were fortified with vitamin and mineral mix (1 %) and were pelletized using a hand pelletizer. Proximate analyses of diets were carried out using standard methods AOAC (1990).

Table 1

Proximate composition (%) **of feed ingredients** (Dry weight basis)

Feed ingredients	Proximate composition					
	Moisture	Crude Protein	Crude Fat	Crude Fibre	NFE	Ash
Rice bran	8,85	7,35	1,74	11,32	56,61	14,13
Tapioca flour	5,67	2,80	1,68	1,79	85,27	2,79
Groundnut oil cake	10,74	45,75	6,07	3,98	25,68	7,78
Fish meal	7,40	51,34	6,12	10,32	1,27	23,55
Ulva powder	7,11	8,75	1,95	3,08	61,47	17,70
Spyridia powder	4,87	14,45	1,20	6,02	53,26	20,20
Sargassum powder	8,77	10,95	2,15	10,78	40,35	27,00

The experimental animals used were the grass carp, *Ctenopharyngodon idella*, procured from Government hatchery of Fisheries Department of Kerala. Healthy fingerlings (1,99±0,10–2,05±0,13 g live weight) were selected and stocked in their corresponding cisterns (20 nos./cistern). The fish were fed 10 % of their body weight daily, which was split into two equal rations, fed at 8 a. m. and 6 p. m.

Table 2

Proportion of ingredients and proximate composition of the diet

Feed Ingredients	Percentage composition, g			
	CL-Diet	UL-Diet	SP-Diet	SA-Diet
Rice bran	9,83 (0,72)	5,95 (0,44)	3,74 (0,28)	5,12 (0,38)
Tapioca flour	9,83 (0,28)	5,95 (0,17)	3,74 (0,11)	5,12 (0,14)
Groundnut oil cake	40,17 (18,38)	29,37 (13,44)	30,84 (14,11)	29,92 (13,69)
Fishmeal	40,17 (20,62)	29,37 (15,08)	30,84 (15,83)	29,92 (15,36)
Ulva powder	–	29,37 (2,57)	–	–
Spyridia powder	–	–	30,84 (4,46)	–
Sargassum powder	–	–	–	29,92 (3,28)
Vitamin-mineral mix	1,00	1,00	1,00	1,00
Total	100,00 (40,00)	100,01 (31,70)	100,00 (34,79)	100,00 (32,85)
Parameters	Proximate composition (%) of diets			
	CL-Diet	UL-Diet	SP-Diet	SA-Diet
Moisture	6,39 ± 0,28	8,80 ± 0,32	8,09 ± 0,25	7,09 ± 0,19
Crude Protein	38,81 ± 0,85	31,12 ± 0,77	33,56 ± 0,59	32,08 ± 0,72
Crude Lipid	5,20 ± 0,19	4,32 ± 0,23	4,38 ± 0,17	4,46 ± 0,25

Nitrogen free extract	28,50 ± 0,98	35,16 ± 0,84	28,90 ± 0,72	30,03 ± 0,91
Crude Fibre	7,00 ± 0,09	5,80 ± 0,12	6,79 ± 0,18	8,04 ± 0,23
Ash	14,10 ± 0,73	14,80 ± 0,68	18,28 ± 0,55	18,30 ± 0,66

Values are Mean ± SD. Figures in parenthesis indicate the protein percentage contributed by each feed ingredient.

1. Water quality monitoring

Water samples were collected fortnightly at 7.30 a. m. prior to daily feeding from all the experimental cisterns and were analysed (APHA, 1992) in the laboratory for different parameters.

2. Sampling and Growth studies

The specimens were sampled once in every 15 days and a minimum of 15 fishes were collected from each cistern. The length and weight of each fish were recorded. The culture period was for a period of 120 days for each species of fishes and the ration was readjusted based on the growth rate. Nine samplings were carried out during each experiment. At the time of alternate samplings (every 30 days intervals), a minimum of 5 fishes were selected from each treatment for studying growth in terms of length and weight.

Specific growth rate (SGR) was calculated as,

$$SGR = \frac{\log e\, W_2 - \log e\, W_1}{T_2 - T_1} \times 100,$$

where W_1 is the weight in g of fish at time T_1 and W_2 is the weight in g of fish at time T_2.

3. Feed utilization & Nutrient digestibility

To study the feed utilisation of *C. idella* short term experiments *were* conducted in laboratory in fibre glass tanks of 100 l capacity employing 5 fishes from each treatment for a period of 30 days. Each treatment was replicated three times. The weighed feeds were supplied in Petri dish, which is 10% of their body weight. The unconsumed food, if any, was siphoned out 6 h after feeding. Likewise, faecal matter was also siphoned out the next day prior to the next feeding. The unconsumed food and faecal matter was oven dried at 60 ^{o}C, weighed and kept in a desiccator for proximate analysis. Food conversion ratio, feed conversion efficiency, assimilation efficiency, protein efficiency ratio and nutrient (protein, fat and carbohydrate) digestibility were calculated following Halver's (1972) procedures.

Feed conversion ratio (FCR) = Dry weight of feed consumed (g) / Production (g)
Feed conversion efficiency (FCE) = Production (g) / Feed consumed (g) x 100
Feed assimilation efficiency (FAE) (%) = Assimilation (g) / Feed consumed (g) x 100
Protein efficiency ratio (PER) = Production (g) / Protein intake (g) x100
Apparent protein digestibility (APD) (%) = Protein in feed- Protein in excreta / Protein in feed x100
Apparent fat digestibility (AFD) (%) = Lipid in feed- Lipid in excreta / Lipid in feed x100
Apparent carbohydrate digestibility (ACD) (%) = Carbohydrate in feed- Carbohydrate in excreta / Carbohydrate in feed x100

4. Statistical Analysis

One way ANOVA (Snedecor and Cochran, 1968) was carried out to find significant difference in the final mean percentage increase in length and weight, feed utilization and nutrient digestibility by *C. idella* between treatments and control. Duncan's (1955) multiple range tests (Steel and Torrie, 1980) was applied to find out statistical difference between various treatment means and control mean for the observed parameters.

RESULTS

1. Water quality parameters

The water quality parameters in the experimental cisterns were within the optimum range for growth of *C. idella.* The water temperature ranged from 27 to 30,5 ^{o}C. The pH of water was within the alkaline range (7,2 to 8,1). The dissolved oxygen concentration ranged

from 6,85 to 11,21mg / l and the total alkalinity 35 to 70 ppm. The productivity values were found to be within the range of 2,52 to 12,12 mg C /m^3 /day in different cisterns.

2. Growth studies

At the end of feeding period of 120 days, since there was no significant difference in final average weight of fishes among the replicates ($p < 0,01$) average growth was calculated pooling the three values. Final mean length, weight, specific growth rate, percentage of survival recorded for *C. idella is* given in Table 3. Only slight differences noted in length, but superior growth in terms of weight were obtained by UL-Diet fed fishes followed by SP-Diet, SA-Diet and CL-Diet.

Table 3

Final mean growth and survival of *C. idella* fed with different experimental diets

Parameters	Diets			
	CL-Diet	UL-Diet	SP-Diet	SA-Diet
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Initial length (cm)	5,11±0,09	5,10±0,13	5,09±0,13	5,11±0,09
Initial weight (g)	2,02±0,14	1,97±0,11	1,99±0,13	1,97±0,08
Final length	10,54±0,18	11,83±0,14	10,96±0,15	10,91±0,12
Final weight	17,09±0,19	20,66±1,31	19,85±1,80	18,17±0,61
Net weight gain (g)	15,07	18,69	17,86	16,2
Increasing rate of body weight	8,46±0,28	10,49±0,32	9,97±0,19	9,22±0,25
Mean percentage increase in weight (F ratio 10,5473)*	748,56 [a]±9,40	940,28 [c]±66,07	896,49 [b, c] ±90,14	821,40 [a, b] ±30,87
Specific Growth Rate (SGR) (%)	1,78	1,95	1,92	1,85
Survival (%)	90	94	92	98

Values are Mean ± SD; * – indicates significance ($p < 0,01$); *a*, *b*, *c* – mean values with same superscript do not differ significantly (Duncan's multiple range test).

3. Feed utilization Studies

The results of Feed utilisation studies are presented in Table 4. Highest food consumption (10,28 g), good FCR (3,86), highest FCE (25,88 %), FAE (46,69 %) and PER (0,83) were noted for UL-Diet followed by SP-Diet, SA-Diet and CL-Diet. The digestibility of nutrients were highest for UL-Diet (APD 94,27 %, AFD 65,54 %, ACD 70,76 %) followed by SP-Diet, CL-Diet and SA-Diet.

Table 4

Feed utilisation of *C. idella* fed with different experimental diets

Parameters	Treatments			
	CL-Diet Mean ± SD	UL-Diet Mean ± SD	SP-Diet Mean ± SD	SA-Diet Mean ± SD
Initial weight (g) [W_1]	7,20±0,25	7,18±0,46	7,24±0,39	7,23±0,84
Final weight (g) [W_2]	8,58±0,93	9,84±0,55	9,62±0,42	9,48±0,36
Production (g) [$P = W_2-W_1$]	1,38±0,09	2,66±0,17	2,38±0,32	2,25±0,28
Feed consumption (g) [C]	9,25±0,99	10,28±0,99	10,09±0,64	10,05±0,56
Faecal output (g) [F]	6,12±0,42	5,48±0,65	5,39±0,78	5,44±0,41
Relative growth rate [P/W_1]	0,19±0,00	0,37±0,00	0,33±0,01	0,31±0,01
Assimilation (g) [A = C-F]	3,13±0, 90	4,80±0,54	4,70±0,68	4,61±0,91
Metabolism (g) [R = A-P]	1,75±0,06	2,14±0,49	2,32±0,10	2,36±0,23

Food consumption per day in percentage body weight [2C / $t(w_2+w_1)$ x 100]	3,91±0,82	4,03±0,88	3,99±0,73	4,01±0,71
Growth per day in percentage body weight [2(Wt-Wo)/t(Wt+Wo)x100	0,58±0,03	1,04±0,06	0,94±0,05	0,90±0,05
Food conversion ratio [FCR = C/P]**	6,70±0,77[b]	3,86±0,21[a]	4,24±0,56[a]	4,46±0,43[a]
Food conversion efficiency (%) [FCE = P/C x 100]**	14,92±1,88[a]	25,88±2,76[b]	23,59±3,31[b]	22,39±2,91[b]
Food assimilation efficiency (%) [FAE = A/C x 100]*	33,84±3,56[a]	46,69±4,48[b]	46,58±3,87[b]	45,88±4,40[b]
Protein efficiency ratio [PER = Body weight gain (g) / Protein consumption in dry feed (g)]**	0,38±0,06[a]	0,83±0,04[c]	0,70±0,02[b]	0,70±0,02[b]
Apparent protein digestibility (%) [APD]	90,08±5,57[a]	94,27±1,18[a]	92,14±3,20[a]	88,55±3,92[a]
Apparent fat digestibility (%) [AFD]	62,76±2,88[a]	65,54±5,05[a]	65,09±4,43[a]	62,76±3,88[a]
Apparent carbohydrate digestibility (%) [ACD]	68,12±6,40[a]	70,76±5,82[a]	70,24±6,66[a]	69,94±3,99[a]

Values are Mean ± SD; * – indicates significance ($p < 0,05$); ** – indicates significance ($p < 0,01$);
a, *b*, *c* – Mean values with same superscript do not differ significantly (Duncan's multiple range test).

4. Statistical analysis

ANOVA of the final percentage increase in length and weight of *C. idella* showed significant differences ($p < 0,01$) between different treatments. Duncan's multiple range tests showed that the mean percentage increase in weight of all treatments differed significantly from each other. Similarly, ANOVA results showed that the parameters such as FCR, FCE and PER showed significant differences ($p < 0,01$) between different treatments. Duncan's multiple range tests on FCR showed that the treatment groups UL-Diet and SP-Diet did not exhibit any significant difference from each other and they showed differences from other two groups, CL-Diet and SA-Diet. The FCE of treatment groups with algal diets showed significant difference from control group.

DISCUSSION

Even though there are a lot of references on the nutritive potential of marine algae, impact of algal diets on the feed utilization and nutrient digestibilities of fish and other culture animals are meagre. In the present study, the marine algae incorporated diets showed very good response in terms of growth and feed utilization of *C.idella.* Higher growth response, good FCE and PER values were obtained for UL-Diet followed by SA-Diet, SP-Diet and CL-Diet. Several researchers have described better food utilisation studies for carps when fed with plant meal based diets of land and aquatic origin. Mohanty and Das (1995) obtained best growth and feed utilisation for *L. rohita* when reared with 60 % *Azolla* based diet. The FCR values obtained for *C. idella* in the present study can be coincided with the statement of Singh *et al.* (1967) who reported that *C. idella* have the capacity to ingest 100 to 150 % of its total body weight per day. Ray and Das (1995) obtained better FCE and PER for *L. rohita* when fed with a diet containing 15 % *Pistia stratiotes* meal. Vijayakumara Swamy and Devaraj (1995) obtained better food conversion, FCR and PER for *C. catla* on waste mulberry leaf based diet. Patnaik *et al.* (1991) reported good FCR values for *L. rohita*, *C. catla* and *C. mrigala* when fed with two plant meals *Ottelia alismoides* and *Nymphoides indicum* and opined that, plant meal based feeds appear to be better utilised than animal based diets for carps. The better growth response of *C. idella* in all the three marine algae incorporated diets compared to fishmeal based control diet in the present study can be correlated to its herbivorous feeding habit. Moreover,

marine algae contain essential amino acids and other growth promoting substances, and they are reported to be having the capacity of texturising well and can be used as a binder for different feed ingredients in formulated diets (Penaflorida and Golez, 1996). The higher growth of *.idella* in algal diets may be due to their high water stability and lower disintegration, which are limiting factors in carp culture, as carps are slow feeders. Olin *et al.* (1995) observed that the incorporation of the marine algae in formulated diets increased the water stability of pellets because of the nature of the phytochemicals and stabilisers present in them.

Jafri and Farooq Anwar (1995) stated that proteins from plant sources showed higher digestibility than animal proteins. In the present study, the APD values were found to be slightly higher or equal in algal diets than the fishmeal based control diet. Nose and Toyama (1966) attributed low protein digestibility of various fishmeal to the reaction between protein and oxidised oil during the drying process. This may be the cause for comparatively lesser growth and feed utilisation in fishes fed with fishmeal based control diet. High digestibility of fats for single ingredient of animal and plant origin has also been reported in other warm water fishes like channel cat fish by Lovell (1977). Das and Ray (1989) reported higher digestibility of carbohydrate for a pellet with 90 % dried duck weed *Lemna polyrhiza*. Ray and Das (1994) in another study reported high apparent carbohydrate digestion coefficient in *Eichhornia crassipes* (98,2 %) and *Nymphoides cristatum* (98,2 %) for fingerlings of *L. rohita* which is very much higher than the present values.

Growth and digestibility studies regarding sea weeds and algae based diets for culture species are very meagre in India, although some outstanding and promising works were carried out in foreign laboratories (Olin *et al.,* (1995), Penaflorida & Golez, 1996). Certain researchers worked on the suitability of sea weeds and other algal meal based diets on the growth of other culture species. Studies of Chitra (1996) showed that fishmeal mixed with the marine algal powder *S. wightii* gave better growth and weight increment of *Oreochromis mossambicus*. Bindu (1994), Sobha *et al.,* (1999), Bindu *et al*., (2003) assessed the nutritional value of *U. fasciata* as a feed ingredient for *L. rohita* and *O. mossambicus* and found that *U. fasciata* can be better used as a feed supplement to aquaculture practices. According to Olin *et al.,* (1995) and Upatham *et al*. (1996), in USA and Thailand, sea weeds and sea weed based diets are the most widely used grow-out feed for abalone culture, because they support good growth, survival and has a minimal impact on water quality.

From the present study, it can be concluded that *C. idella* grows well with the pelleted feed containing marine algae and they can efficiently utilize proteins, fats and carbohydrates from *U. fasciata*, *S. insignis* and *S. wightii* in addition to other aquatic macrophytes so far tried. Superior and statistically significant data is indicative of the possibility of utilizing these algae for growth promotion in fish, hence they can be better recommended as a diet ingredient for cost effective aquaculture practices.

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