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Deficiency of protein, fat and vitamins in freshwater catfish, *Clarias batrachus*: morphological symptoms and impact on growth performance

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Abstract

This paper briefly describes some major nutritional pathologies which have been observed in freshwater catfish, *Clarias batrachus*. These are caused by nutrient deficiencies or dietary imbalances and require attention in aquaculture. Lipids, proteins and vitamins are beneficial nutrients needed for growth and metabolic functions of fish. The nutrients not synthesized by the organism and required in the diet from outside sources are called "essential" or "indispensable" such as unsaturated fatty acids, essential amino acids and vitamins. The deficiency of indispensable nutrients (protein, fat, vitamins A, B, C and E) in the present study limited their synthesis, caused reduced body weight and showed specific morphological symptoms in *C. batrachus*. The fish recovered to a certain extent when fed with these nutrients. Reduced body weight and skin lesions were observed in protein and fat-deficient fish. Vitamin A deficiency resulted in prominent exophthalmia with eroded barbles. The loss of appetite was observed in vitamin B deficient fish. Deficiency of vitamins C and E caused scoliosis (broken back disease) and skin haemorrhage, respectively.

Keywords: Nutritional fish pathology, Nutrient deficiency

Introduction

Fishes are a rich source of nutritive and medicinal ingredients for human beings. They provide amino acids, unsaturated fatty acids and vitamins that are essential for our health. Nutrition plays a vital role in growth and condition of the farmed fish and, therefore, nutritional fish pathology, dealing with symptoms/ailments appearing in the fish due to nutrient deficiencies or dietary imbalances, should be treated without delay to support successful farming. Trichet (2010) has provided a good account of the malnutrition and vulnerability of fish stocks to diseases caused by nutrient deficiencies. The importance of scientific data on nutritional requirements of the fishes and single or multiple nutrient deficiencies has been amply highlighted by National Research Council (1993). Dietary lipids in fishes are the source of essential fatty acids (EFA) such as polyunsaturated fatty acid (PUFA) particularly n-3 and n-6 PUFAs (Sargent et al., 2002). EFA requirement are related to dietary lipid intake by the fish (Takeuchi et al., 1991, 1992; Tacon, 1992). Proteins in the form of enzyme, hormones and immunoglobulins are required for normal body functions. Vitamins on the other hand are micronutrients required in small concentrations to support specific structural and metabolic functions (Gatlin, 2002; Halver, 2002). Diets supplemented with vitamin C and E help in enhancing the macrophage function and antibody production (Blazer, 1992; Gatlin, 2002), and improving disease resistance and stress tolerance in fish (Koshio, 2007; Lim et al., 2008). Vitamins C and E rich diets improve immune response and disease resistance to fish (Ortuno et al., 2000; Clerton et al., 2001; Cuesta et al., 2001; Sahoo and Mukherjee, 2002; Lin and Shiau, 2005, Wang et al., 2006). Vitamin E also reduces susceptibility to stress under crowding conditions (Montero et al., 2001; Trenzado et al., 2007). Fat soluble vitamins viz. vitamin A, D, E and K are deposited in the body along with body lipids, hence fish may not show deficiency symptoms for a long period of time. Water soluble vitamins, however, are not present in substantial amounts in the body; hence they show early remarkable symptoms. The present work was planned to study the specific morphological symptoms resulting from deficiency of particular nutrients in *C. batrachus* and recovery of the fish by providing the deficient nutrient in the diet.

Materials and Methods

Sixty individuals of *C. batrachus* (length=30 ± 5 cm; weight= 180 ± 10gm) were purchased from commercial fishermen, station road, Raebareli (U.P.), during the month of November 2017 and acclimatized to captive conditions for 2 weeks. The water was changed every day and the fish were fed with control diet twice (morning: 7-8 hrs; evening: 17-18 hrs) a day @ 5% of their body weight. The 7 dietary treatments were given to the 7 groups of the fish, each comprising 5 specimens. Diet 1 was offered to the control group which comprised complete diet with no nutritional deficiency; diets 2-7 were made deficient in protein, fat, vitamins A, B, C and E, respectively. The details are given in Table-1. The ingredients of each diet were mixed thoroughly in a mixer grinder and pellets of 1-1.5 cm diameter were made after mixing with 30% de-ionized water, air-dried at room temperature and stored in the freezer until fed.

Table 1. Proximate composition of the experimental diets

Diet	1 (control)	2 (protein deficient)	3 (fat deficient)	4 (vit. A deficient)	5 (vit. B deficient)	6 (vit. C deficient)	7 (vit. E deficient)
Fish meal (protein rich)	35%	-	35%	35%	35%	35%	35%
Nutrela (protein rich)	35%	-	35%	35%	35%	35%	35%
Sunflower oil (fat rich)	6%	6%	-	6%	6%	6%	6%
Cod liver oil (fat rich)	2%	2%	-	2%	2%	2%	2%
Vitamin A tablets/kg	5000 IU	5000 IU	5000 IU	-	5000 IU	5000 IU	5000 IU
Vitamin B tablets/kg	400 mg	400 mg	400 mg	400 mg	-	400 mg	400 mg
Vitamin C tablets/kg	150 mg	150 mg	150 mg	150 mg	150 mg	-	150 mg
Vitamin E tablets /kg	50 mg	50 mg	50 mg	50 mg	50 mg	50 mg	-
Multivitamin tablets /kg	10 tablets	10 tablets	10 tablets	-	-	-	-
Multiminerals tablets/kg	25 tablets	25 tablets	25 tablets	25 tablets	25 tablets	25 tablets	25 tablets

The experimental procedure was divided into 3 parts: (1) fish was made deficient of a particular nutrient, (2) morphological symptoms of nutrient deficiency were observed in the fish and (3) recovery in the nutrient-deficient fish was studied by providing the deficient nutrient in the diet. Seven different batches of fish were observed for different periods of time interval until they showed symptoms of deficiency. After the appearance of deficiency signs, each deficient batch was provided with control diet.

Results and Discussion

Different deficiency signs and morphological symptoms in *C. batrachus* were noticed in the absence of a specific nutrient as compared to control. These symptoms were confirmed by observing the affected fish regaining normal health after the deficient nutrient was provided in the diet. The signs and morphological symptoms of nutrient deficiency and recovery of the symptoms of different batches of the fish are summarized in Table 2.

Different batches of the fish showed different deficiency symptoms at different time intervals which are given in Table 3. The different batches of the fish recovered to an appreciable extent when fed with the nutritionally balanced diet.

Table 2. Deficiency signs and recovery of morphological symptoms of different deficient nutrients in *C. batrachus*

Deficient nutrient	Deficiency symptoms	Recovery of the fish
Control	No deficiency symptoms	No symptoms
Proteins	Dorsal/caudal fin erosion Skin lesions on body Reduction in body weight	Dorsal/caudal fins were seen to be recovered Skin regained the normal form Body weight began to increase to an appreciable extent
Fats	Depigmentation of skin Skin lesions on body Reduced body weight Reduced appetite and growth Haemorrhage on fins	Pigmentation of skin was regained Skin lesions were healed Body weight began to increase Appetite and growth were regained Haemorrhage on fins was reduced
Vitamin A	Skin lesions were seen Eroded barbles Exophthalmia was prominent Edema on ventral side Loss of appetite	Broken skin was healed Eroded barbles begin to appear Exophthalmia was seen to be reduced Reduced edema Appetite was regained
Vitamin B	Eroded barbles Haemorrhage of skin and fins Sluggishness/abnormal swimming behavior Loss of appetite Reduced body weight	Eroded barbles begin to appear Haemorrhage on skin and fins healed Normal swimming behavior was observed Appetite was regained Body weight began to increase
Vitamin C	Scoliosis (broken back disease) Caudal fin erosion External hemorrhage Reduced growth	Scoliosis recovered to some extent Eroded fins began to recover External hemorrhage became normal Growth was regained
Vitamin E	Eroded barbles Eroded Skin Caudal fin erosion Reduced weight	Eroded barbles begin to appear Eroded skin repaired Eroded fins recovered Body weight increased

Table 3. Time interval of appearance and recovery of Deficiency symptoms and growth parameters in different nutrient deficient batch in *C. batrachus*

Deficient nutrient	Time interval of deficiency	Recovery time interval*	Initial weight (g)	Final weight (g)	Weight gain/loss (%)	Specific growth rate (% day^{-1})	Survival rate (%)
Control	-	-	180±10.2	187±11.1	+3.9	+16.67	100 %
Protein	4 weeks	5 weeks	177±10.2	166± 8.01	-6.2	-39.28	100 %
Fat	6 weeks	4 weeks	174±10.2	168±9.03	-3.45	-14.28	100 %
Vitamin A	5 weeks	4 weeks	183±10.2	179±10.02	-2.18	-11.43	100 %
Vitamin B	3 weeks	3-4 weeks	175±10.2	170±10.02	-2.86	-23.81	100 %
Vitamin C	2 weeks	3-4 weeks	186±10.2	184±10.02	-1.07	-14.28	100 %
Vitamin E	4 weeks	4 weeks	182±10.2	179±10.02	-1.65	-10.71	100 %

*recovery time interval is noted from the time the fish has been provided the deficient nutrient in the diet.

Protein deficiency caused degeneration of skeletal muscle in *C. batrachus,* resulting in reduced body weight and growth. Fat deficiency led to depigmentation of skin in *C.batrachus*. Nicolaids and Woodall (1962) also reported a similar depigmentation in the skin of Chinook salmon when fed with fat-free diet. Pigmentation was restored when fatty acid was added to the diet. Vitamin A deficiency in the diet caused exophthalmia. This may be due to inadequate amount of this nutrient leading to impairment in the formation of visual pigment rhodopsin. Edema on ventral side of the fish was also observed as it was reported in channel catfish, *Ictalurus punctatus* (Dupree, 1966). The appetite and growth of the catfish also suffered due to Vitamin B deficiency. These symptoms may be due to the deficiency of vitamin B1 as it is involved in oxidation of glucose in cells and is essential for good appetite and normal growth. Eroded barbles were seen which may be due to the deficiency of Pantothenic acid. Similar observations were reported by Murai and Andrews (1978, 1979) in fingerlings of channel catfish. Vitamin C deficiency led to reduced collagen synthesis in the fish resulting into scoliosis (broken back disease) and external haemorrhage. Butthep et al. (1985) also noticed these symptoms. Vitamin E is necessary for muscle cell respiration and lack of this nutrient in the diet caused muscular dystrophy and skin lesions. Earlier, these symptoms were documented by Murai and Andrews (1974) in *Ictalurus punctatus*.

Conclusions

The deficiency of protein, fat, vitamins A, B, C and E were found to be detrimental for fish growth and development. The investigated deficiency symptoms of these nutrients will be useful for taking care of farmed fish that can help to reduce the effect of dietary imbalance on farmed fish health and in turn increase their productivity.

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