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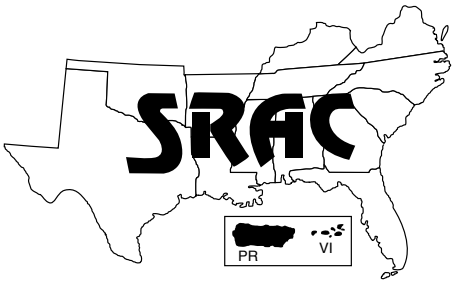

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Refinement of Vitamin Supplementation in Diets for Pond-raised Channel Catfish

Channel catfish, like all other animals, require a supply of vitamins for normal growth and health. By definition, vitamins are nutrients required to support growth and other bodily functions.

Vitamins are often added to fish diets at levels above those required for normal growth. Fortification of diets in this manner may be done for a variety of reasons. Certain physiological processes or conditions such as reproduction, stress, or disease may increase the levels of vitamins needed by the fish to maintain normal growth, metabolism, and health.

Feed manufacturing equipment such as this extruder can lead to the degradation (breakdown) of some vitamins.

The Southern Regional Aquaculture Center has supported research to determine the most appropriate diets and feeding methods to achieve optimal production from intensive catfish production in ponds. The results of these research projects should help producers and feed manufacturers to modify rations and management methods to improve profitability. This publication was compiled by Wendy M. Sealey, James T. Davis, and Delbert M. Gatlin III, based on research conducted by Texas A&M University and Mississippi State University.

Certain vitamins, such as vitamin E, may be supplemented at levels above those required for normal growth to improve flesh quality during frozen storage by increasing the oxidative stability of processed fish products. In addition, some vitamins such as certain forms of vitamin C are susceptible to breakdown during feed processing and storage which reduces the amount of vitamin available to the fish. To compensate for these losses, diets are typically fortified with vitamin C at levels higher than established requirements.

Commercial diets

To insure nutritional adequacy, commercial catfish production diets are typically supplemented with a premix which provides vitamins above previously established requirement levels (Table 1). However, most vitamin requirements have been determined in laboratory studies in which fingerling channel catfish were grown in aquaria and fed purified diets with graded levels of a specific vitamin. Minimum dietary requirements were then established based on weight gain, tissue levels of the vitamin, and the absence of clinical deficiency signs. Recent findings suggest that studies conducted in this manner may overestimate the supplemental vitamin needs of channel catfish which are cultured in ponds and fed practical diets. Catfish apparently can obtain some vitamins from feedstuffs, natural organisms in the pond such as plankton, or some combination of these sources; however, it is not well known how much of the fish's requirement for vitamins can be met by these sources.

Vitamin supplementation of commercial channel catfish diets at levels higher than necessary increases feed costs. Research in recent years has focused on determining the most cost-effective vitamin supplementation levels in practical diets for channel catfish grown in ponds. Vitamins examined include fat-soluble vitamin E and water-soluble vitamins including vitamin C, thiamin, riboflavin, pyridoxine, pantothenic acid, niacin, biotin, folate, and vitamin B_{12}. Research also has been conducted to determine the

stability of vitamins in extruded catfish feeds and to what extent vitamins in feed ingredients and from the pond meet the fish's requirements.

Vitamin E

Vitamin E is required by channel catfish and other animals for maintaining biological membranes through its antioxidant activity. Deficiency signs have been most often observed when catfish were fed diets limited in vitamin E and which contained high levels of polyunsaturated fatty acids. The vitamin E requirement of fingerling channel catfish grown in aquaria has been reported to be as high as 50 mg/kg diet. In addition, vitamin E supplementation at levels above 30 mg/kg diet may improve health of channel catfish and improve the storage quality of frozen fillets.

A pond study addressing supplementation of commercial diets with vitamin E was completed at Texas A&M University. A typical commercial diet which was supplemented with a vitamin premix devoid of vitamin E was analyzed and contained approximately 10 mg vitamin E/kg from endogenous sources. This basal diet was supplemented with vitamin E at four levels between 0 and 60 mg/kg. These diets were fed to mixed sizes of channel catfish at commercial densities for a 1-year period. No differences in growth, feed efficiency, and survival of fish were observed throughout the feeding trial. In addition, histological examination detected no signs of overt deficiency. Therefore it appears that the current vitamin E supplementation level (60 mg/kg) can be conservatively reduced by one half. Reducing the presently recommended supplementation level by half could save approximately $2/ton of feed.

Vitamin C

Vitamin C is required in the diet of channel catfish for a variety of biochemical functions. Consumption of inadequate amounts of vitamin C results in reduced weight gain and impaired formation of bone collagen in fish. The dietary vitamin C requirement of fingerling channel catfish grown in aquaria has been reported to be 30 to 60 mg/kg diet.

A study at the Mississippi State University Delta Research and Extension Center (MSU-DREC) investigated vitamin C supplementation of diets for channel catfish grown under conditions of commercial pond production. In this study, channel catfish were stocked into ponds at commercial densities and fed practical diets containing various levels of vitamin C for a period of one year. Based on weight gain, feed conversion, feed consumption, and survival, the amount of vitamin C required in the diet of pond cultured channel catfish is less than 15 mg/kg diet. This requirement is considerably lower than the previously established requirement levels determined with fingerling channel catfish in aquaria. Vitamin C is typically added to commercial diets at levels above 60 mg/kg to compensate for losses which occur during feed manufacture and storage. Based on results of this study, fortification levels may be lowered substantially without affecting fish production.

Vitamin C in an unprotected form is the vitamin most susceptible to degradation during manufacturing and storage.

B vitamins

A constant supply of B vitamins is required by channel catfish because these vitamins are not stored in the body. B vitamins required by channel catfish include thiamin, riboflavin, pyridoxine, pantothenic acid, niacin, biotin, folate, and vitamin B_{12}. These vitamins function in various aspects of cellular metabolism and growth. Requirements of fingerling channel catfish grown in aquaria have been previously reported for thiamin (1 mg/kg), riboflavin (9 mg/kg), pyridoxine (3 mg/kg), pantothenic acid (15 mg/kg), and niacin (14 mg/kg).

In the Department of Biochemistry at MSU, laboratory experiments to reevaluate the riboflavin and niacin requirements of channel catfish have been completed. Fingerlings grown in aquaria were fed purified diets containing graded levels of riboflavin or niacin for 8 and 12 weeks, respectively. The dietary riboflavin requirement was recommended to be 6 mg/kg to maintain normal growth and prevent the appearance of gross deficiency. The dietary niacin requirement was estimated to be 7.4 mg/kg which is about half the previously determined requirement.

Most B vitamins are not appreciably degraded during feed manufacturing and storage.

Bioavailability and stability of B vitamins

Research was conducted at the MSU Department of Biochemistry on B vitamin bioavailability in commercial feedstuffs. Niacin in animal products such as menhaden fishmeal and meat and bone meal was 100 percent available to channel catfish. Plant products such as wheat middlings, cooked corn, uncooked corn, cottonseed meal, and soybean meal had niacin availability

values of 60, 44, 28, 58, and 57 percent, respectively. Based on studies in aquaria and ponds, as well as these bioavailability data, B vitamin supplementation of channel catfish diets can be substantially lowered and niacin supplementation is unnecessary (Table 1).

The stability of B vitamins in extruded commercial channel catfish diets was examined at MSU-DREC. Typical commercial catfish diets either with or without supplemental vitamins were extruded using commercial equipment and conditions. Supplemented and nonsupplemented diets were then analyzed for thiamin, riboflavin, pyridoxine, niacin, and pantothenic acid levels, and compared for differences. It was found that riboflavin, pantothenic acid, and niacin were highly stable with retention values of 100, 100, and 96 percent, respectively. Pyridoxine and thiamin were relatively stable with retention values of 70 and 65 percent, respectively. This research indicates that overfortification of commercial diets to negate manufacturing losses is unnecessary for riboflavin, pantothenic acid, and niacin. Fortification levels for pyridoxine and thiamine can be lowered to more closely meet quantified dietary requirements.

Concurrent feeding trials were conducted in ponds at MSU-DREC during 1994, 1995, and 1996 to evaluate the need of supplementing commercial diets with thiamin, riboflavin, pyridoxine, niacin, and pantothenic acid. Channel catfish fingerlings were stocked into ponds in the spring of each year at commercial densities and fed practical diets with various supplemental levels of B vitamins. Fish were sampled in the fall and then over-wintered in ponds and fed according to established feeding schedules. Results from these experiments have shown no positive effects of supplementing commercial diets with any of these vitamins on weight gain, feed consumption, and feed conversion of channel catfish. This suggests that dietary supplementation of B vitamins may not be necessary for growout of channel catfish fed commercial diets in ponds.

Table 1. Dietary vitamin requirements of channel catfish fed chemically-defined diets in aquaria and recommended supplementation levels (previous and current) of production diets for pond culture of channel catfish.

Vitamin	Units	Minimum[a] Requirements	Previously[b] Recommended Supplementation	Currently[a,b,c] Recommended Supplementation
Fat-soluble				
A	IU/kg	1,000-2,000	1,000	1,000
D	IU/kg	250-500	500	500
E	mg/kg	50	60	30
K	IU/kg	Required	4.4	4.4
Water-soluble				
Thiamin	mg/kg	1.0	5.5	2.5
Riboflavin	mg/kg	6.0[c]	13.2	6.0
Pyridoxine	mg/kg	3.0	11	5.0
Pantothenic acid	mg/kg	15.0	35	15
Niacin	mg/kg	7.4[c]	22	None
Biotin	mg/kg	Required	None	None
Folic acid	mg/kg	1.0	2.2	2.2
B_{12}	mg/kg	Required	0.01	0.01
Choline	mg/kg	400	0-275	None
Inositol	mg/kg	Not required	None	None
Vitamin C	mg/kg	11-60	50-100[d]	50[d]

[a]Adapted from Robinson, E.H. 1994. Catfish Feed Manufacture. Mississippi Agricultural and Forestry Experiment Station Bulletin No. 1012, Mississippi State University, Mississippi State, Mississippi.

[b]Recommended levels of vitamins including overages to account for losses during feed manufacture.

[c]Revised based on recently published research reported in this document.

[d]Level to provide in finished feed. Supplementation level may vary with product form.

Commercial diet formulations can reduce vitamin supplementation levels for channel catfish grown in ponds.

Conclusions

Supplementation of commercial channel catfish production diets with vitamin C, vitamin E, and the B-complex vitamins can be substantially reduced or eliminated without significantly altering weight gain, feed efficiency, feed consumption, and survival of channel catfish grown to market size in ponds (Table 1). Channel catfish fed practical diets in ponds are able to meet some or all of their vitamin requirements without costly dietary supplementation due to the presence of these vitamins in pond organisms and/or practical feed ingredients. Additional information on bioavailability of other vitamins in feedstuffs may allow more precise recommendations for vitamin supplementation. Reducing unnecessary supplementation of vitamins can aid the industry by significantly decreasing feed costs.

Reduction of dietary vitamin supplementation, however, should be moderated by the fact that potential benefits other than maintenance of normal growth, feed efficiency, and survival have not been thoroughly investigated under a multiple batch or topping system. Additional study is needed to address benefits of fortification of certain vitamins on immune response, reproduction, and product storage quality. In addition, a better understanding is needed of how much of the fish's metabolic requirements for vitamins can be met by food sources in the pond or endogenous vitamins in feed ingredients. Channel catfish cultured in systems with limited natural productivity, such as high density recirculating systems, may be more dependent on dietary vitamin supplementation.

The newly recommended supplementation levels shown in Table 1 are conservative, but for some vitamins are substantially lower than the previously recommended levels. These conservative estimates allow for losses due to processing and storage and include a margin of safety because environmental factors such as pond productivity and vitamin content of feed ingredients may vary from region to region. Individual producers may choose to raise or lower recommended supplementation levels as environmental and physiological conditions warrant.

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