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REVIEW ARTICLE

Lysine Supplementation in Fish Feed

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Abstract

Currently, lysine supplementation is attaining popularity with the growing aquaculture production. However, with the increasing cost of fishmeal in the recent years, it is an ideal time to replace it with cost effective alternative feed sources in order to meet the increasing demands of fisheries sector. Because these alternatives are deficient in certain essential amino acids especially, lysine therefore their subsequent supplementation with lysine has been experimentally undertaken with the aim to evaluate their subsequent impact on fish growth and weight gain capacity. Results indicated that various fish species fed with higher lysine supplemented feed mixtures attained higher weights, increased fecundity, better immunity and demonstrated rapid growth rates as compared to fishes fed with lysine deficient diets. In addition, lysine supplemented alternatives to fish meal are far more economical and will be available in such a higher quantities to meet the demands. Moreover, it is noteworthy that lysine requirement varies with each fish species, therefore, lysine addition into fish feed will only give effective results when the supplemented amount will be in specific range required by our species of interest.

Keywords: Lysine, Essential Amino Acids, Fish Feed, Fish Meal, Aquaculture.

Introduction

The consumption of fish meal and oil as fish feed components has increased dramatically in order to meet the rising demands of increased aquaculture production (Gatlin et al, 2007). However, due to higher prices and limited supply of fish meal, it has become necessary to search for alternative plant protein sources. It is important to consider that such alternative sources should have balanced dietary components and are capable to maintain high growth rates (Tacon and Metian, 2008).

Fishes need a high protein ratio in their diets (Lovell, 1989). Protein is a complete nutrient which fulfils the energy requirements of the body (Keembiyehetty and Gatlin, 1992). Moreover, there are ten essential amino acids which are the key components of fish feed. These amino acids greatly influence the growth patterns, reproductive performance and development of a fish (Wilson, 2003).

Among these, lysine is one of the most limiting amino acids in fish feed (Small and Soares, 2000). Furthermore, all finfish species require lysine as essential dietary component, especially when alternative protein sources are used instead of fishmeal. It has also been observed that many fish skeletons contain highest lysine concentrations (Ahmed and Khan, 2004). In addition, fishes fed with essential amino acid deficient diets showed reduced growth and higher mortality rates (Ketolea, 1983).

Moreover, one of the major roles of lysine is to regulate the carnitine synthesis in skeletal muscle cells and liver, which in turn play a role in transportation of long chain fatty acids into mitochondria for beta-oxidation. Subsequently, during fasting these fatty acids are oxidised to fulfil energy needs (Walton et al, 1984).

To prevent excessive fat accumulation in the body, carnitine work together with Coenzyme

A in beta-oxidation and remove the short chain organic acids from mitochondria (Ozorio et al, 2003). Furthermore, lysine play an important role in maintaining osmotic pressure and acid-base balance in the body fluids (Chiu et al, 1988).

The required range of lysine as a fish feed component varies between 3.2 to 6.2% of the total dietary protein for different fishes (Wilson, 2002). The unique taste, disease resistant capacity and better growth rate of *Labeo rohita* earns it the status of being mostly cultured fish among Indian major carps (Jhingran and Pullin, 1988).

Lysine and Its Physiological Role

To achieve and establish high growth rates in fishes, it is not only necessary to have protein rich feed mixtures, but, the perfect ratio of all the dietary amino acids is obligatory (Li et al, 2009). Lysine is an essential and one of the most limiting amino acids (Mai et al, 2006; Gatlin et al, 2007), therefore, it is an important fish feed component required for the high growth performance and maintenance of fish population (Zhou et al, 2007).

Dietary lysine supplementation is important in inhibiting fin rotting of a fish and decrease the mortality rates as well (Li et al, 2009). Moreover, it plays a major role in development of gastrointestinal system and immune system function. In addition, it exclusively enhances protein deposition in the body and fillet content (Sveier et al, 2000; Furuya and Furuya, 2010; Hamid et al, 2016).

Lysine is associated with nitrogen retention (Cao et al, 2012) and it reduces the fat proportion in the fish body (Berge et al, 1998; Nguyen et al, 2013). Furthermore, lysine rich diets increase the weight gain capacity of a fish (Khan and Abidi, 2011; Nguyen and Davis, 2016).

Lysine increases the muscle growth in fish by rapidly increasing size and length of muscle fibers through hyperplasia and hypertrophy (Valente et al, 2013; Michelato et al, 2016). How-ever, factors like fish species, its age, muscle type and feed composition affect the muscle growth enhancement through these processes (Johansen and Overturf, 2005; Aguiar et al, 2008).

Lysine synthesizes the carnitine which transport fatty acids into mitochondria for their subsequent oxidation (Walton et al, 1984). Lysine is also involved in maintaining acid-base concentrations and to balance the osmotic pressure in the body (Chiu et al, 1988).

It has also been found that lysine along with asparagine, valine and methionine increase mobile spermatozoid concentrations and their motility rates as well (Lahnsteiner, 2010). Lysine is strongly associated with the reproductive system and it has profound effects on the quality of ovarian and testicular tissues, eggs, semen and fecundity (Hamid et al, 2016).

Fish Feed Sources

There are two main types of fish feed sources i.e. fishmeal and alternative (plant and animal) feed sources.

Fishmeal

Fishmeal is a nutrient rich and easily digestible food source for the farmed animals, especially, fishes. It predominantly contains proteins, lipids, minerals and vitamins while a small proportion of carbohydrates as well. Fishmeal is usually prepared from wild caught fishes and small marine fishes. In addition, it may also be manufactured from highly sustainable fish stocks. Actually, four to five tons of fish mass are used to prepare one ton of dry fishmeal. Peru contributes to about 33% of the global fishmeal production annually.

Limitations

The worldwide requirement for the freshwater fish production has dramatically increased up to 30% during the period of 2003 to 2007. At the same time, fishmeal consumption has increased from 15% to 65% during last twenty years (Tacon and Metian, 2008). Consequently, with the increase in demand of fishmeal, its price has significantly risen from US$400 to US$900 per mt until 2005 to over US$1500 per mt in 2006, accordingly (Hardy, 2010). Recently, the price of fish meal has increased to more than twice as compared to few previous years (Ogello et al, 2014).

Firstly, fishmeal supply is limited and is not produced in enough quantity to meet the increased demand of aquaculture. Secondly, the day by day rises in fishmeal cost has stimulated researchers to look for alternative and high quality fish feed sources to fulfil the demand (Tacon and Metian, 2008).

Table 1: Essential amino acid requirements for fishes.

Amino Acids	%age in Fishmeal
Essential Amino Acids	64.5
Lysine	4.72
Leucine	4.48
Tyrosine and Phenylalanine	4.35
Arginine	3.82
Valine	2.77
Isoleucine	2.66
Threonine, Methionine and Cystine	2.31
Histidine	1.45
Tryptophan	0.45

Miles and Chapman, 1993

Table 2: Lysine requirements of different Fishes

Fish species	Lysine %age/total protein
Atlantic salmon	4.0
Catla catla	6.2
Channel catfish	5.1
Chinook salmon	5.0
Chum salmon	5.0
Coho salmon	3.8
Common carp	5.7
Gilthead bream	5.0
Head striped bass	4.0
Japanese eel	5.3
Milkfish	4.0
Mossambique tilapia	4.1
Nile tilapia	5.1- 5.8
Rainbow trout	6.1
Red drum	4.4

Akiyama et al, 1997

Alternative Feed Sources

There is a variety of alternate feed sources broadly classified into two categories.

i. Animal Derivatives

Animal feed sources are palatable, readily available, and cheaper, therefore these are a perfect choice to replace fishmeal (El-Sayed, 1999). The list includes poultry by-product meal (PBM), feather meal (FeM), blood meal (BM), and meat and bone meal (MBM).

Although, these sources are enriched with protein, but, some essential amino acids are still deficient, especially, lysine, methionine and isoleucine (Tacon and Jackson, 1985). Nevertheless, in order to achieve balanced amino acid profile and to compensate the deficiency, these limiting amino acids can be supplemented by mixing the animal meal with complementary protein sources (Davies et al, 1989)

ii. Plant Protein-Rich Derivatives

Plant derivatives resemble the fishmeal with respect to their amino acid digestion capabilities and protein proportions (Hardy, 1996). The list includes soy bean meal, cotton seed meal, wheat gluten meal, corn gluten meal, canola meal, pea seed meal and other oil seed plant by-products (Tacon and Metian, 2008; Ogello et al, 2014).

However, their amino acid composition differs from that of fishmeal which is primarily required by many fishes. It was reported that lysine is the primary limiting amino acid in many plant cereals (Michelato et al, 2016). Corn gluten has very low lysine concentration, wheat gluten is lysine and

arginine deficient whereas soybean meal is methionine deficient (Gallagher, 1994). Plant derivatives also contain anti-nutritional factors which in turn reduce their palatability (Francis et al, 2001). It has been proved experimentally that the plant feed sources do not limit the growth rates of many fishes such as carps, catfish and tilapia when they are supplemented with lysine and methionine (Tacon and Metian, 2008).

Limitations

Animal as well as plant feed sources do not contain a balanced amino acid profile. Animal derivatives are deficient in lysine, methionine and isoleusine (Tacon and Jackson 1985), whereas plant sources do not contain adequate amounts of lysine, methionine and arginine (Gallagher, 1994).

Lysine Requirements for Different Fishes

In fact, the lysine requirement for different fishes is not same, but it varies slightly with each species.

Post Supplementation Evaluation

It was reported that catfish and tilapia were fed with diets that were supplemented with different lysine levels. Results indicated that these fishes show faster growth rates and higher weight gains with the increase in concentration of lysine in their diet but, up to a certain limit (Nguyen and Davis, 2016)

Another study was conducted to evaluate the impact of lysine on growth and reproductive performance of *Rhamdia voulezi*. Consequently, it was concluded that *Rhamdia voulezi* showed an increase in seminal volume as well as a significant increase in weight by enhancing the lysine concentrations in its diet (Hamid et al, 2016).

It has been experimentally observed in Nile tilapia that the addition of lysine in its feed will increase its muscle growth by hypertrophy and hyperplasia. The optimum lysine requirement for large Nile tilapia was found out to be 5.8% of the total dietary protein (Michelato et al, 2016).

Economic Feasibility of Lysine Containing Fishmeal Alternatives

Economic analysis of different feed sources such as cotton seed feed (El-Sayed, 1990), corn gluten meal (Wu et al, 1995) and animal derived meal (El-Sayed, 1998) indicated that these are more economical and a better choice than fishmeal as protein source for Nile tilapia. Another evaluation indicated that blood meal is more economical than fishmeal e.g., a comparative study on tilapia demonstrated that it took 0.79 US dollars by using fishmeal to produce 30g of tilapia whereas tilapia fed with blood meal produced 64g with an effective cost of 0.62 US dollars (Aladetohun and Sogbesan, 2013).

Conclusion

The objective of this review was to evaluate the impact of lysine supplementation in fish feed over fish physiology. Results indicated that various fish species fed with higher lysine supplemented feed mixtures attained higher weights, increased fecundity, better immunity and demonstrated rapid growth rates as compared to fishes fed with lysine deficient diets. In addition, lysine supplemented alternatives to fish meal are far more economical and are available in such a higher quantities to meet the demand. Moreover, it is noteworthy that lysine requirement varies with each fish species, therefore, lysine addition into fish feed will only give effective results when the supplemented amount will be in specific range required by our species of interest. Therefore, I recommend lysine-bound fish meal alternatives to be used on large scale to revolutionize aquaculture industry.

References

Aguiar DH, Bock C, Padovani CR, Dal Pai-Silva M. 2008. MyoD, myogenin and proliferating cell nuclear antigen expression in growing Nile tilapia (*Oreochromis niloticus L.*). Aquac. Res 39:1673-1679.

Ahmed I, Khan MA. 2004. Dietary lysine requirement of fingerling Indian major corp. Aquaculture 235:499-511.

Akiyama T, Oohara I, Yamamoto T. 1997. Comparison of Essential Amino Acid Requirements with A/E Ratio among Fish Species (Review Paper). Fisheries Science 63:963-970.

Aladetohun NF, Sogbesan OA. 2013. Utilization of blood meal as a protein ingredient from animal waste product in the diet of *Oreochromis niloticus*. International Journal of Fisheries and Aquaculture. 5:234-237.

Berge GE, Sveier H, Lied E. 1998. Nutrition of Atlantic salmon (*Salmo salar*): the require-

ment and metabolic effect of lysine. Comp. Biochem. Physiol 120:477-485.

Cao JM, Chen Y, Zhu X, Huang YH, Zhao HX, Li GL, Lan HB, Chen B, Pan Q. 2012. A study on dietary L-lysine requirement of juvenile yellow catfish *Pelteobagrus fulvidraco*. Aquac. Nutr 18:35-45.

Chiu YN, Austic LE, Rumsey GL. 1988. Effect of feeding level and dietary electrolyte on the arginine of rainbow trout. Aquaculture 69:79-91.

Davies SJ, Williamson J, Robinson M, Bateson RI. 1989. Practical inclusion levels of common and by products on complete diets for tilapia (*Oreochromis mossambicus*). In proc. Third Intl. Symposium on feeding and Nutri. In Fish, Tisa Japan. 325-332.

El-Sayed AFM. 1990. Long-term evaluation of cotton seed meal as a protein source for Nile tilapia, *Oreochromis niloticus*. Aquaculture 84:315-320.

El-Sayed AFM. 1998. Total replacement of fishmeal with animal protein sources in Nile tilapia (*Oreochromis niloticus, L.*) feeds. Aquaculture Research 29:275-280.

El-Sayed AFM. 1999. Alternative dietary protein sources for farmed tilapia, *Oreochromis spp.* Aquaculture 179:149-168.

Francis G, Makkar HPS, Becker K. 2001. Anti-nutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture 197:197-227.

Furuya WM, Furuya VRB. 2010. Nutritional innovations on amino acids supplementation in Nile tilapia diets. Revista Brasileira de Zootecnia 39:88-94.

Gallagher ML. 1994. The use of soybean meal as a replacement for fish meal in diets for hybrid striped bass (*Murune scrrarilis* XM. chrysops). Aquaculture 126:114-127.

Gatlin DM, Barrows FT, Brown P, Dabrowski K, Gaylord TG, Hardy RW, Herman E, Hu GS, Krogdahl A, Nelson R, Overturf K, Rust M, Sealey W, Skonberg D, Souza EJ, Stone D, Wilson R, Wurtele E. 2007. Expanding the utilization of sustainable plant products in aqua feeds: a review. Aquac. Res 38:551-579.

Hamid SNIN, Abdullah MF, Zakaria Z, Yusof SJHM, Abdullah R. 2016. Formulation of Fish Feed with Optimum Protein-bound Lysine for African Catfish (*Clarias Gariepinus*) Fingerlings, Procedia Engineering 148:361-369.

Hardy RW. 1996. Alternative protein sources for salmon and trout diets. Animal Feed Science Technology. 59:71-80.

Hardy RW. 2010. Utilization of plant proteins in fish diets: effects of global demand and supplies of fishmeal. Aquaculture Research 41:770-776.

Jhingran VG, Pullin RSV. 1988. A hatchery manual for common, Chinese and Indian major carps under field condition. ICLARM studies and reviews 11. Asian development bank, manila, Philippines.

Johansen KA, Overturf K. 2005. Quantitative expression analysis of genes affecting muscle growth during development of rainbow trout (*Oncorhynchus mykiss*). Mar. Biotechnol 7:576–587.

Keembiyehetty CN, Gatlin DM. 1992. Dietary lysine requirement of juvenile hybrid striped bass. Aquaculture 104:271-277.

Ketolea HG. 1983. Requirement for dietary lysine and arginine by fry of rainbow trout. J. Anim. Sci 56:101-107.

Khan MA, Abidi SF. 2011. Effect of dietary L-lysine levels on growth, feed conversion, lysine retention efficiency and haemato-logical indices of *Heteropneustes fossilis* (Bloch) fry. Aquacult. Nutr 17:657-667.

Lahnsteiner F. 2010. A comparative study on the composition and importance of free amino acids in semen of gilthead sea bream, *Sparus aurata*, and perch, *Perca fluviatilis*. Fish Physiol. Biochem 36:1297-1305.

Li P, K Mai, J Trushenski, G Wu. 2009. New developments in fish amino acid nutrition: Towards functional and environmentally oriented aqua feeds. Amino Acids 37:43-53.

Lovell RT. 1989. Nutrition and feeding of fish van Nostrand Reinhold, New York, NY. 268.

Mai KS, Zhang L, Ai QH, Duan QY, Zhang CX, Li HT, Wan JL, Liufu ZG. 2006. Dietary lysine requirement of juvenile Japanese seabass, *Lateolabrax japonicus*. Aquaculture 258:535-542.

Michelato M, Xavier TO, de-Moura LB, de Almeida FLA, Pedrosa VB, Furuya VRB, Furuya WM. 2016. Dietary lysine requirement to enhance muscle development and fillet yield of finishing Nile tilapia. Aquaculture 457:124-130.

Nguyen L, Davis DA. 2016. Comparison of crystalline lysine and intact lysine used as a supplement in practical diets of channel catfish (*Ictalurus punctatus*) and Nile tilapia (*Oreochromis niloticus*). Aquaculture 464:331-339.

Nguyen MV, Rønnestad I, Buttle L, Lai HV, Espe M. 2013. Imbalanced lysine to arginine ratios reduced performance in juvenile cobia (*Rachycentron canadum*) fed high plant protein diets. Aquacult. Nutr 20: 25-35.

Ogello EO, Munguti JM, Sakakura Y, Hagiwara A. 2014. Complete Replacement of Fish Meal in the Diet of Nile Tilapia (*Oreochromis niloticus* L.) Grow-out with Alternative Protein Sources: A review. International Journal of Advanced Research 2:962-978.

Ozorio ROA, Verreth JAJ, Aragao CR, Vermeulen CJ, Schrama JW, Verstegen MWA, Huisman EA. 2003. Dietary carnitine supplements increased lipids metabolism and decreased protein oxidation in African catfish. J. Aquacult. trop 18:225-238.

Miles RD, Chapman FA. 1993. The Benefits of Fish Meal in Aquaculture Diets. National Research Council, Nutrient Requirements of Fish, National Academy of Sciences, Washington, DC.

Small BC, Soares JH. 2000. Quantitative dietary requirement of juvenile striped bass. Aquacult. Nutr 6:207-212.

Sveier H, Raae AJ, Lied E, 2000. Growth and protein turnover in Atlantic salmon (*Salmo salar L.*); the effect of dietary protein level and protein particle size. Aquaculture 185:101-120.

Tacon AGJ, Jackson AJ. 1985. Protein sources in fish feeds. In: Cowey CB, Nackie AM, Bell JG. (eds). Nutrition and Feeding in Fish. Academic Press, London, U.K. 120-145.

Tacon AGJ, Metian M. 2008. Global overview on the use of fish meal and fish oil in industrially compounded aqua feeds: Trends and future prospects. Aquaculture 285:146-158.

Valente LMP, Moutou KA, Conceição LEC, Engrola S, Fernandes JMO, Johnston IA. 2013. What determines growth potential and juvenile quality of farmed fish species? Rev. Aquaculture 5:168-193.

Walton et al. 1984. The effect of dietary lysine levels on growth and metabolism of rainbow trout. Br. J. Nutr 52:115-122.

Wilson RP. 2002. Amino acid and protein, fish nutrition, 3rd ed. Academic press, London. 162-164.

Wilson RP. 2003. Amino acid requirement of finfish and crustaceans, in: D'Mello, JPF. (ed.), amino acid in animal nutrition, second ed. CABI Publishing, Wallingford, UK. 427-447.

Wu YV, Rosati RR, Sessa D, Brown PB. 1995. Utilization of corn gluten feed by Nile tilapia. Progressive Fish Culturist 57:305-309.

Zhou QC, Wu ZH, Chi SY, Yang QH. 2007. Dietary lysine requirement of juvenile cobia (*Rachycentron canadum*). Aquaculture 273:634-640.