Omega-3 and 6 Fatty Acid Imbalance Found in Tilapia Feed in Various Tilapia Farms of Southeastern Region of Bangladesh

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Abstract: A research work was conducted to know the lipid based feed ingredients used in tilapia (Oreochromis niloticus) culture to justify possible omega-3/omega-6 fatty acid imbalance in tilapia fillet through practiced feeding materials in six districts of Bangladesh from April to October 2012. A total of 30 farms and farmers and one fish feed manufacturer (case study) were surveyed for related data collection. Lipid based feed ingredients e. g poultry fat, canola, corn, cottonseed, linseed, sunflower, soyabean, palm, peanut were found to use in various percentages in farm made feed and formulated feed (fish feed manufacturer). All of those ingredients were very high in omega-6 fatty acid compared to omega-3 fatty acid except linseed oil. There is a possible risk of human health through imbalance omega-3/omega 6 fatty acids in tilapia fillet as it is related with feeding habit and fatty acid composition in feed ingredients. All the farms and farmers were found unconscious about dietary lipid requirement and balanced omega-3/omega-6 fatty acid. In this study it was found that corn, cottonseed, palm and peanut used by the farm and farmer as feed ingredients are very much susceptible to the threat of imbalance omega-3/omega 6 ratios while linseed oil may replace these ingredients to solve the risk. A laboratory based research is therefore needed to determine the actual status of the omega-3 and omega-6 fatty acid in tilapia fillet and feed ingredients with human health risk assessment before dissemination of popular tilapia among the farmer and consumer level.

Key words: Fatty Acid Composition • Consumer Lever • Tilapia Feed • Omega-3 and 6 Fatty Acid

INTRODUCTION

High density fish farming (semi-intensive and intensive) in Bangladesh initiated with farming of mono-sex tilapia using dry pellet feeds and this species are prime consumers of milled pellet feed in the country. The intensive farming of tilapia is rapidly expanding at an annual rate of about 12% and there is currently a great demand for formulated feeds. It is estimated that out of 62,175 ton tilapia produced in 2009-2010, roughly 53,000 ton was produced utilizing milled dry pellets of both sinking and floating types and mostly are consumed by tilapia [1]. Global tilapia aquaculture production has surpassed one million metric tons with more than 80% of the production coming from Asian countries [2]. Tilapia, like other warm water fish, are more inclined to require greater amounts of n-6 fatty acids compared to n-3 fatty acids for maximal growth [3]. High levels of n-3 PUFA have been reported to depress the growth of tilapia [4, 5] and other researchers have showed that no enhancement in growth was obtained when 18:3n-3 or n-3 HUFA (highly unsaturated fatty acids) was supplemented in tilapia diets [6].

Protein percentage is always a major concern both for the feed manufacturer and fish farmer. Everyone try to maintain required protein content in provided feed either readymade or farm made feed. Although protein is the primary material for growth of fish body and flesh, lipids are primarily included in formulated diet to maximize their protein sparing effect [7] by being a source of energy.
Moreover fatty acid composition mostly essential omega 3 and 6 fatty acids must take into concern for human health as the only major source of omega 3 fatty acids required for human is fish flesh. To ensure the supply of beneficial fatty acid from fish it is obvious to provide proper feed to them.

So instead omega 3 fatty acid through fish flesh, imbalance fatty acids may provided to consumers as none of the consumers, farmers or even feed manufacturer are concern about the fact. Recent study and publication about farmed tilapia and omega 3 and 6 fatty acid balance in tilapia fillet depending on feed provided and their concern about human health hazard deserves some attention and justification about the threat. As farming of tilapia and its popularity among the consumers is increasing rapidly in Bangladesh, a study is needed about the omega 3/omega 6 fatty acid composition and its information about practiced feed relation if any in cultured tilapia. Owing to view this the present study was conducted to know about the feed and feed ingredients used as lipid source in tilapia farming and collecting information about lipid and fatty acid composition and also compare the omega-3 and omega-6 fatty acids in feed ingredients used by farm and farmer.

**MATERIALS AND METHODS**

The present study was based on field survey and home work as well where primary data were collected from individual fisheries farm owner and agro industries that culture tilapia as a major species. The research work had done at Noakhali, Comilla, Laxmipur, Feni, Chittagong and Cox’s Bazar district. All the species and Strain of farmed tilapia were included in the study though the major cultured species were monosex GIFT, GIFU strains of Oreochromis niloticus in Bangladesh in the recent years. Feedstuff used in farmed tilapia in Bangladesh either as formulated feed or farm made feed are compared based on lipid source and fatty acid composition analyzed by other research and publication. All the information about ingredients were collected in such way that can be comparable as International Feed Number (IFN) depending on materials and parts of feed used and preparation process for the ingredients. The study about fatty acid composition of targeted feed ingredients by National Academic Press is used for comparison due to lacking of laboratory study.

After collection of data, these were edited and coded. All the collected data were summarized and scrutinized carefully and recorded. Finally relevant tables were prepared in accordance with the objectives of the study. All the collected information were accumulated and analyzed by MS-Excel and then presented in textual, tabular and graphical forms to understand.

**RESULTS**

**Production Wise Distribution of Farm and Farmer:**

In this study, 30 farm and farmers were surveyed where 16 were farms and 14 were farmers. Production wise distribution of farm and farmer is represented in Figure 1.

**Type of Feed Used by Farm and Farmer:**

In present study it is found that in Noakhali, Laxmipur and Comilla districts farmers is used farm made feed more than 80%. Besides in Comilla district farms are used farm made feed almost 94%. Whereas in Chittagong and Comilla districts farm and farmer use both formulated and Farm made Feed (Figure 2).

**Present Status of Protein and Lipid Sources Contribution in Farm Made Feed:**

All farm and farmer were surveyed in this study are found unconscious about lipid content in feed ingredients and dietary fatty acid requirements of fish. Though the feed ingredients used in farm made feed are mainly targeted on protein percentages some ingredients serves as lipid sources mainly. The feed ingredients used in farm made feed were thus categorized into protein and lipid sources. These lipid sources provide dietary fatty acids also with desired protein. In this study only lipid sources ingredients were taken into consideration.

**Protein and Lipid Sources Used in Farm Made Feed by Farm and Farmer:**

The present studies shows that average lipid sources ingredients used in farm made feed by farms is 33% where 26% by farmers. Farmers of Chittagong districts use lowest (20%) lipid sources ingredients and farms of Laxmipur and Comilla use highest (37%) lipid sources ingredients (Figure 3).

**Protein and Lipid Sources Ingredients Used in Farm Made Feed by Different Production Unit:**

The average lipid sources ingredients used in farm made feed by small, medium and large production unit were 26%, 31%, 32% respectively. Small farm and farmer of Feni districts use...
Fig. 1: Production wise distributions of farm and farmer

Fig. 2: Type of feed used by farm and farmer

Fig. 3: Protein and Lipid Sources used in farm made feed by farm and farmer

Fig. 4: Protein and lipid sources ingredients used in farm made feed by different production unit

lowest (22%) lipid sources ingredients and large farm and farmer in Noakhali districts use highest (35.5%) lipid sources ingredients (Figure 4). Feed Ingredients Used as Lipid Sources in Farm Made Feed: In present study poultry fat, marine weed fish (white), canola, corn, cottonseed, linseed, Sunflower,
Soyabean, palm, peanut etc were found to used in farm made feed in various percentages and combinations.

**Feed Ingredients Used as Lipid Sources in Farm Made Feed in Six Districts:** In Noakhali district poultry fat (7%), Corn (7%), Linseed (5%), Soyabean (5%) were found to be used. Corn flour were found to be used in high percent in Laxmipur (10%) and Comilla (8%) (Figure 5).

**Feed Ingredients Used as Lipid Sources in Farm Made Feed by Farm and Farmer:** In present study small, medium or large farm were found to used lipid based feed ingredients as poultry fat (10%), fish oil (5%), corn (5%), sunflower and soyabean 2% each, palm and peanut 1% each on an average. Besides farmer were found to used corn 7%, soyabean 4%, palm and peanut 2%, poultry fat and fish meal 3% (Figure 6).

**Feed Ingredients Used as Lipid Sources in Farm Made Feed by Different Production Unit:** Lipid based feed ingredients used by different production unit are showed in percentages in Figure 7 in the following.

**Contribution of Omega-3 and Omega-6 Fatty Acid in Lipid Sources Feed Ingredients:** The total percentages of n-3 and n-6 fatty acid of lipid sources ingredients used in this study were established by the publication of National Academic of Science [3]. The feed ingredients used by the farm and farmer were compared
by the International Feed Number (IFN) to estimate the n-3/n-6 fatty acid profile in feed ingredients used in Bangladesh.

The following Figure 8 shows that all the feed ingredients used as lipid sources have much higher n-6 fatty acid than n-3 fatty acid except linseed oil.

**DISCUSSION**

To date, research on the fatty acid requirements of tilapia has produced contradictory results. This could be due to various factors such as length of experiment, nutritional history of the experimental fish, size of fish, source of dietary lipids, water temperatures, etc.

Considering the fact that fish are not able to synthesize both the omega-3 and omega-6 series of fatty acids and require them in their diets and based on fatty acid requirements determined for other fish species, it is recommended that until further research data is forthcoming, a provision of about 0.5 to 1.0% of both omega-3 and omega-6 PUFA should be included in the aquafeeds of tilapia (Table 1, 2, 3). The ability of Nile tilapia to synthesize the physiologically more important C20 and C22 HUFA from C18 n-6 and n-3 PUFA has been confirmed by Olsen *et al.* [8] using radiolabelled 14C-18:2n-6 and 18:3n-3. However, the elongation and desaturation of these essential C18 fatty acids to their HUFA end products is probably insufficient to supply the needed amounts and dietary supplementation with preformed HUFA may still be necessary.

In this study both the farm made and formulated feed some ingredients are practicing as lipid based which are providing a high percentages of omega-6 fatty acid with a very low percentages of omega-3. More research is still needed to understand the activities of the various desaturation elongation pathways in tilapia. Chou and Shiu [9] reported that a minimum of 5% dietary lipid should be provided in feeds for hybrid tilapia. Fitzsimmons *et al.* [10] did not find any significant differences in growth, feed utilization efficiency and fillet fat levels in Mozambique tilapia fed diets containing 3, 6 or 8 % dietary lipid and suggested that lower levels of dietary lipid could be used in tilapia feeds for intensive recirculation production systems provided the energy value of the diet is provided by suitable carbohydrate sources. Commercial tilapia feeds currently contain about 5% dietary oils, mostly fish oils, which meet the minimum requirement of dietary lipids in most culture systems. However, optimum dietary lipid level for various tilapia species has been reported to be between 10% and 15% depending on dietary ingredients used [9,11]. Studies on *T. zilli* [11] indicated that graded levels of dietary oil up to 15% improved protein utilization efficiency. Recent technological advances in aquafeed manufacturing has permitted the inclusion of high levels of dietary oils to produce energy dense diets, especially in salmon diets which usually contains 20 to 40% added oils. With the availability of such technology and the increasing environmental challenges facing intensive aquaculture today, more research is needed to evaluate whether higher dietary lipids in commercial tilapia feeds might give added benefits to both the fish farmer and the environment.

Using semi-purified casein-based diets, Huang *et al.* [5] reported that hybrid tilapia (*Oreochromis niloticus* x *O. aureus*) fingerlings fed 8% soybean oil or fish oil showed no difference in growth and feed utilization efficiency after 10 weeks on the diets. Oxidative stress (as measured by TBARS test) in fish fed soybean oil or fish oil was similar but significantly higher than fish fed diets containing lard. No significant differences were detected in growth of *O. aureus* fed diets supplemented with 10% menhaden oil, catfish oil or soybean oil but
growth was depressed in fish fed diets supplemented with beef tallow [12]. Gaber [13] reported good growth of Nile tilapia fed soybean oil-based diets. Hybrid tilapia fed diets supplemented with vegetable oils such as sunflower oil, crude palm oil (CPO), crude palm kernel oil or palm fatty acid distillates (PFAD) showed comparable or slightly higher growth compared to fish fed a fish oil-based diet [14]. Other studies currently conducted in lab similarly showed that the use of vegetable oils such as linseed, soybean and various palm oil products do not significantly affect growth performance and feed utilization of tilapia (unpublished data). This is consistent with fish oil replacement studies conducted on other fish species [14, 15].

The study shows that farm made feed ingredients used by farm or farmer in six districts used poultry fat, corn, canola, cottonseed, palm and peanut in different compositions which are high in omega-6 fatty acid.
This fact may contribute in increasing omega-6 in tilapia fillet, though some farms and farmers were found to use linseed oil cakes which have higher omega-3 fatty acid.

Despite the lack of growth effects when using vegetable oils to replace fish oils in fish diets, fillet fatty acid profile is known to be markedly influenced by dietary fatty acid compositions. The use of vegetable oils (lacking in EPA and DHA) in tilapia feeds will decrease the concentrations of beneficial omega-3 HUFA in fish fillets destined for the human consumer. EPA and DHA are known to provide positive health benefits such as decreasing the risks of degenerative diseases such as cardiovascular diseases, cancer and many others.

As consumers, we take wild fish as they come, but the body composition of farmed fish can be altered. Fish feed can be supplemented with protein and lipids to make the body composition more favorable for humans and to promote maximum growth. Justi et al. [16] report that the Oreochromis niloticus, which ’received, during 30 days [the longest exposure], a diet with the addition of flaxseed oil [high in n-3 fatty acid] presented the highest index for n3 PUFA and the best n6/n3 ratio’. It is logical to expect that, over time, the n-3 FA content would increase and therefore the n-6:n-3 ratio would improve. This shows that it is possible to favorably change the body composition of tilapia through changes in diet [17].

It is important, however, not to neglect the health of fish as dietary changes are made. Just as humans consider EFAs, fish farmers consider the EFAs of tilapia. They want fish to provide the nutrition humans need and also be healthy. Teshima et al. [18] report the highest weight gain in Tilapia nilotica with diets of 1% 18:2n6 (LA) or 20:4n6 (AA), indicating that T. nilotica requires n6 fatty acids such as 18:2n6 and 20:4n6 rather than n3-fatty acids in contrast to other fishes. Sargent et al. [19] also concede that 18:2n-6 is an EFA for both species. This could explain why there is more n-6 than n-3 in the farmed tilapia. However there are studies that show the opposite*that better growth occurs with feeds supplemented with n-3 FAs [20]. The challenge is finding a balance between the nutritional needs of the fish and the alterations that can be made for optimal human nutrition. Figure 5 shows the ratios of n-6 to n-3 FA totals from the compared studies, even though the ratio is an ambiguous and unreliable number. The majority of these studies show small n-6:n-3 ratios close to 1. As shown in Figure 4, there is a positive effect of feeding tilapia the diet supplemented with n-3 FAs, where a finishing diet would drive the ratio even lower. This figure shows that the natural diet provides n-6:n-3 ratios B1. Weaver et al. [21] also report an AA:EPA ratio of 11:1. This number is misleading and proves the effect that number manipulation has on the public. Whelan [22] shows that DHA, not EPA, has proven effects to lower the risk of cardiovascular disease. The amount of DHA in tilapia in these studies is consistently higher than EPA. A ratio of AA:DHA would be much lower and more accurate and more relevant to human health. In order to evaluate the FA composition findings of these studies, several conversions were performed to arrive at numbers that could be compared at face value. Table 3 presents the data in its original reported form. It is no wonder the ratio is used; it is the easiest way to compare results between studies. However, in terms of human health, the ratio is a misleading way to report data. With a ratio, it is impossible to know whether the actual amounts are large or small. The magnitude of these numbers is important because the human body deals with absolute amounts. We can appreciate the confusion that the public must feel when the data are not reported in a consistent manner and, therefore, are difficult to compare. To avoid the negative perception and the confusion that this controversy has caused, it would help to know the amount of n-6 and n-3 (and specific FAs) humans require. Steffens [17] states that optimum requirements are assumed to be 0.3-0.4g/day of long-chain n-3 polyunsaturated fatty acids. Under deficiency conditions, the demand may even be considerably higher. In a balanced diet the n-3/n-6 polyunsaturated fatty acid ratio should be approximately 1:10.

REFERENCES


