INTRODUCTION OF INDIGENOUS RAW MATERIALS IN FISH DIETS FOR SNAKEHEAD MURREL, *Channa striatus* (Bloch, 1801) AND THEIR EFFECTS ON ITS GROWTH AND FEED UTILIZATION

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DEDICATED

TO

MY

BELOVED PARENTS

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CERTIFICATE

This is certify that this thesis entitled "Introduction of indigenous raw materials in fish diets for Snakehead, *Channa striatus* (Bloch, 1801) and their effects on its growth and feed utilization" submitted by Nadia Akter has been carried out under my supervision. This is further to certify that it is an original work and suitable in partial fulfillment for the degree of MS in Fisheries, University of Dhaka

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ABSTRACT

The present study was carried out to the introduction of indigenous raw materials in fish diets for snakehead murrel, *Channa striatus* and their effects on its growth and feed utilization. Wild fish was collected from the kaoran bazaar fish market. The experiment was conducted during 40days in re-circulating system composed of 6 tanks containing 500 L of water each. 16 larvae were stocked per tank. To evaluate the effect of laboratory made feed and commercial feed on growth performance, feed utilization and body composition in *Channa striatus* an experiment was carried out in Department of Fisheries, University of Dhaka. *Channa striatus* with initial weight 82.69±0.05g for the treatment and 81.27±0.50g for the control were reared in the plastic tanks. There were three replicas for each group. Initial length for both groups was 23.48 cm and was fed with two types of feeds, laboratory made feed (LMF) for the treatment and commercial feed (CF) for the control which were isonitrogenus (22% crude protein) in nature. Due to the presence of fish meal, mustard oil cake, soybean grit, rice polish, wheat bran and maize, laboratory made feed (LMF) was proved to be the best protenacious feed between the two feed tested. Significant differences (P<0.05) in body weight gain and protein efficiency ratio were observed in fishes when they were fed with two types of feed such as LMF and CF. There were significant differences (P<0.05) in feed conversion ratio. Specific growth rate and mean body weight were higher in fish fed with LMF feed. Significant differences were also observed in case of final body composition fed with two types of feed. The study suggests that the LMF diets, which led to significantly higher (P<0.05) growth and nutrient utilization than the CF diets in *Channa striatus* will be helpful towards the development of pond culture of these fish species. Wastage of indigenous ingredients due to illiteracy of manipulating will be reduced. Although LMF and CF feed contain same level of protein but LMF feed comparatively cheap and it significantly (P<0.05) provided better performance in all case such as growth performances, body composition and feed utilization of *Channa striatus*.

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbols	**Details**
▫	Degree celcious
G	Gram
Cm	Centimeter
%	Percentage
ANOVA	Analysis of variance
CF	Commercial feed
LMF	Laboratory made feed
ADG	Average daily gain
SPSS	Statistical package for the social sciences
SGR	Specific growth rate
FCR	Feed conversion ratio
PER	Protein efficiency ratio
SR	Survival rate
MBW	Mean body weight

CHAPTER 1
INTRODUCTION

1.1 Status and Importance of Fisheries in Bangladesh

Fish and the fisheries play a large part in the country's economy. Ever since, fish have considerable nutritional importance and human society has been extended to culture aspects of food behavior, beliefs and religion (Kreuzer, 1974). Fisheries resources have plays a dominant role in the nutrition, employment generation, culture, tradition and food habit of the people of Bangladesh, foreign exchange earnings and other areas of national economy.

Fisheries sector is playing a very vital role regarding employment generation, animal protein supply, and foreign currency earning and poverty alleviation. Fisheries sector is contributing 2.46% of the total export earning and 4.39% to the GDP (DOF, 2012). About 12 million people are directly or indirectly involved in this sector. Labour employment in this sector has been increasing approximately by 3.5% annually. During 1980's about 95% fish spawn is produced in the hatcheries.

Appropriate steps have been undertaken by the Department of Fisheries and other public and private institution for the alleviation of poverty, employment generation, and export earnings through boosting fish and shrimp production, management of inland fisheries through community participation, infrastructure development, human resources development, sanctuary establishment and need based technology dissemination.

According to Department of Fisheries the total inland aquatic resources of Bangladesh consist of 4,703,658 hectares which includes pond and ditches (3, 71,309 ha), oxbow lake (54800 ha), shrimp farm (2, 76,492ha), Semi closed floodplain (25, 435 ha) river and estuaries (8, 53,863 ha), beel (141,161) kaptai lake (68,800), flood plain (28, 10,410 ha). These water bodies are highly potential resources for aquaculture development. Moreover, the country enjoys a subtropical climate and fertile soil, which are also in favour of fisheries development. Fisheries contribute about 60% of animal protein in the daily diet of people of Bangladesh.
Bangladesh is an over populated country in the world with about 160 million people. The population growth rate is still high (about 1.48). It is true until now fish provided a major percentage of animal protein in our daily diet. In fact, the people of Bangladesh prefer to

consume fish and the position of fish in the diet of Bangladesh is a place of pride. Unfortunately the daily per capita consumption of fish has decreased markedly. The present per capita annual fish consumption is only about 18.94 kg per person (DOF, 2012) whereas 20.44 kg/ person are the required amount. This low level of fish consumption is due to rapid population growth and decline of catch from open water resources.

1.2 Status and Potential of Culture Fisheries in Bangladesh

The fish culture in Bangladesh has a long history since time immemorial. However, as an agriculture activity the practice started from the beginning of the last century. In the past, people were used to culture fish, mainly for their own consumption and game purpose. In the face of rapid population growth with simultaneous decline in captures fisheries aquaculture emerged as a viable option for increasing production in our country. Freshwater fish culture mainly pond based and to some extent it is done in oxbow lakes. Tremendous efforts have been given to the development of appropriate culture and seed production of different species. Successfully breeding techniques and culture method are now available for a number of fish species. Unfortunately, these are mainly centered on large indigenous carps (rui, catla, mrigal, kalibaus etc.) and exotic fish species (silver carp, grass carp, big head carp, thai pungus, African catfish etc.)

Fish production has been increased to 34.00 lakhs MT in 2012-2013, which was 32.62 lakhs MT in 2011-2012(DOF, 2005c) and 25.63 lakhs MT in 2007-08. This has been possible due to generation adoption of new and appropriate technologies. The high demand for fry/fingerling for aquaculture resulted in the development of infrastructure facilities both in public sector and in private sector are engaged in fish seed production.

In spite of phenomenon achievement in culture fisheries sector, fisheries experts believe that it is possible to double the current level of fish production by shifting from traditional extensive and semi-extensive culture to intensive culture. The present level of per acre production in lower than neighbouring countries, because the productive water bodies of Bangladesh have not been utilized properly for scientific fish culture. On the

other hand, there is need for diversification of the culture species by bringing new species under culture.
Indigenous species, which have great potential for aquaculture, are neglected. Large fishes require large and permanent water bodies as their appropriate habitat. Therefore, sometimes culture of large fishes remains beyond the reach of poor people. Again, exotic fishes may adverse effects on our native fish species. Therefore, culture of native fish species, small fish in particular, would be the viable means for increasing fish production in the country through which the common rural people can be benefited.

A substantial number of derelict and marshy water bodies, approximately 18.37% of total ponds, are available in the country, which is not suitable for culture of carps. In addition to an estimated 1.3 million perennial ponds, there are hundreds of thousands of shallow seasonal ponds and ditches, borrow pits etc. in rural areas. Proper aquaculture as a whole and high density fish culture using supplementary formulated feed in particular is not very popular in Bangladesh. However, there is increasing interest in hardy fishes particularly those of air breathing fish farming in Bangladesh. Among various production inputs, the choice of fast growing species with desirable aquaculture traits is a pre-requisite for augmenting fish production in culture-based fisheries. Natural food based culture of major carp is still in practice in Bangladesh but carp culture could not be widely practiced in the shallow and seasonal ponds. In this regard snakehead fish, tilapia, koi and shingi fish are an excellent fish for growing in the shallow and seasonal ponds in a country like Bangladesh (Hossain et al, 1989) because Bangladesh enjoys very suitable climate and ecological conditions for culture of warm-water species.

1.3 Snakehead (*Channa straitus*) A potential candidate for Aquaculture

Snakehead, *Channa striatus* (Bloch.), a carnivorous air - breather, is a valuable food fish in Asia (Wee, 1982). The main feed source of the fish is trash fish collected on the nature. Nargis and Hossain (1987) investigated on the food and feeding habits of Koi fish *(Anabas testudineus)* and observed that small fish consume more food than that the large one. The mature fish fed less actively in May, due to spawning activity. The fish is an omnivore in nature.

Snakehead can survive in harsh environments with low dissolved oxygen and high ammonia (Ng and Lim, 1990; Qin et al., 1997) and therefore, are often cultured in fingerling ponds at densities of 40 – 80 fish/m , with annual yields ranging from 7 to 156 tonne/ha (Wee, 1982). Ali et al. (1980) studied the ecology of artificial fish pond at Tongi. Bangladesh and recorded pH range at (7.5-9.50 and DO 12.22 mg/l) during the experiment period. The snakehead *Channa striatus* has for long been commercially cultured in many countries for its good taste, market value, and medicinal qualities (Marimuthu and Haniffa, 2004). Snakehead *Channa striatus* is an air-breathing fish highly regarded as a food in Asia because its flesh is claimed to be rejuvenating, particularly for those recuperating from a serious illness .It is easy to keep them alive for longer period in captivity and also transport them alive in semi-dry containers. This characteristic of *channa straitus* gives it the specific market value and consumer's preference. It is often given to sick and convalescent people as in invalid food (Bhatt, 1968). Snakehead is best for healing wounds particularly for patients recovering from surgeries and childbirth. Snakehead contains lower fat than other freshwater fish, beef, mutton, chicken, and seafood. Metals, including calcium, magnesium, copper, iron, manganese, nickel, lead, and zinc are found to be much lower while the fish contains high amount of arachidonic acid, beneficial for blood cloting and cell growth but there is absence of eicosapentaenoic acid. It is also rich in amino acids and glycine , one of the most popular elements for collagen in human skins. Snakehead not only contains biochemical requirements for wound healing, but its extract has an enhanced pain relieving effect like morphine, as has been demonstrated through abdominal constriction test. Snakehead, *Channa straitus* (Bloch, 1801) is also known as murrel and native to freshwater systems of tropical Africa and East-southern Asia. They can be found in the water bodies of rivers, canals, marshes, and rice-fish systems (Smith, 1945).

Presently, snakehead is a target species of intensive farming in the earthen ponds and cages in South East Asia. Ahmed *et al.* (1997) worked on the culture feasibility of African catfish *(Clarias gariepinus* Linn.) fry in glass tank and synthetic hapa system using supplemental diets. Effects of different feeds on growth and survival of African cat fish fry (10 days old) were determined in glass tanks for a period of 42 days. Two tanks and two ponds were taken for the experiment. One tank was named as tank *tubifex* and another tank was named as tank sabinco. One pond as pond tubifex and the other pond as

pond sabinco, live *tubifex* (protein 64.48%) was supplied to tank *tubifex* and pond *tubifex* and sabinco was supplied to the other two treatments. Growth of cat fish fry in *tubifex* pond in terms of both length and weight were significantly higher than those of the other treatments. !n terms of growth performance
and survival rate *tubifex* pond showed better result. The early post -larvae, late post -larvae, fry and fingerlings of the different size groups of *Channa striatus* were reared from hatchling stage (Haniffa et al., 1999). A protocol was developed for weaning larval snakehead from live *Artemia* to formulated feed, but fingerling performance with formulated feed was not evaluated for this variety of murrel (Qin et al., 1997) In *Channa striatus* size and feed dependent cannibalism with juveniles were reported by Qin et al. (1996). **B**airage *et al.* (1988) have made a comparison study between a few selected of Magur fry. They used Artemia, Salina, Naupli Zoo-plankton in alive and frozen from first four weeks of live of the fry of *Clarias batrachus* in aquarium. It was found that there was significant effects of the feed on the growth and survival of cat fish fry live. Artemia, Salina and Naupli gave the best result among the tested feeds.

Mass breeding of *Channa striatus* in an earthen pond have been reported with synthetic hormone 'ovaprim' injection was resorted to (Francis et al., 2000). The mass induced breeding technique is simple and advantageous, as it does not require expensive components like plastic pools, aquaria and hapa (Haniffa et al., 2002). Marimuthu et al. (2001) reported a simple and low-cost breeding technology for breeding the striped murrel, *Channa striatus* in hapas in ponds was developed in India however, and the impact of dietary nutrients on breeding performance is not demonstrated and/or evaluated. Leena *et al.* (2000) worked on the carp growth hormone on lipid metabolism in a teleost, *Anabas testudineus* (Bloch). Three doses of CGH were given as intra peritoneal injections (0. 1, 0.2 and 0.5 mμg/gm/body weight/day) for 10 days. CGH stimulated the activities of two lipogenic enzyme while inhibiting malic enzyme activity. Results indicate a lipogenic action of CGH in *Anabas testndineus* and pattern of lipid mobilization or deposition depends on the concentration of hormone injected. The growth of intensive aquaculture production has led to a growing interest in providing fishes with dietary lipid contents to give higher energy through diet and simultaneously reduce the nitrogen load in the pond system by reducing the protein contents by supplementing the lipid contents. Because the carnivore fishes requires relatively higher levels of dietary animal protein and/or higher dietary energy for rapid growth and better survival (Mishra and Mukhopadhyay, 1996) the dietary protein/energy level has to be more.

Suitable alternative energy nutrients such as oilseed by-products are the most promising sources of lipid and energy for aqua-feed in the future (Hardy, 2000). There was a significant increase in carcass protein and a significant decrease in ash content with progressive dietary protein substitution. Fry fed with high protein diets tended to have lower carcass lipid contents and higher moisture contents (Mohanty and Samantaray, 1996).

The fishes are suitable for monoculture. The culture of fish would prove a more profitable venture for the following reasons

1. Good market demand
2. Comparatively high market price
3. More nutrition and of medicinal value (Shammi, 2002)
4. Contains low fat and fewer intramuscular spines
5. Grow faster, require little rearing period
6. Culture involves low risk and simple management
7. Culture in rejected, weed infested, silt laden, foul water of low oxidation ponds, swaps and in other kinds of oxygen depleted but high ammonia concentrated water bodies, where normal fish fauna may fail to thrive
8. Can tolerate high stocking density
9. Fry withstands salinity up to 5 ppt on direct transfer without mortality (Alikunhi, 1957).

In countries like Bangladesh, commercial feed is simply beyond the reach of most marginal and landless farmers, limiting their ability to intensify aquaculture production. Locally available indigenous raw materials may serve as important ingredients for the formulation and development of cheaper and quality fish feed (Begum *et al*., 2008). However, if fish feed ingredients are locally available, and labor can be drawn from the household at low opportunity cost, production costs can be reduced and profit margins can be increased. Besides fish culture in small-scale farming systems can enhance women's empowerment and status by providing entry into economic participation, as women are typically responsible for the day-to-day management of homestead ponds along with their other household chores.

Hossain *et al.* (1989) have studied on the effects of artificial feeds on the growth of *Labeo rohita (Ham.), Cirrhina mrigala* (Ham.) and *Hypopthalmichthys molitrix* (Vel.) in composite culture in river fertilized mini-ponds are presented. All the specie showed high growth rate with artificial feeding. Protein rich artificial feeds containing wheat bran, fish meal and mustard oil cake gave maximum growth rate. Wheat bran was better than the rice bran. Begum *et al.* (1988) have made study from the effect of various feeds on the hatching of *Cyprinus carpio* in aquarium with reference to temperature. Under laboratory condition a feeding experiment of *Cyprinus carpio* (Linn.) hatching was carried out in glass aquarium for a period of 30 days. They studied on the growth and survival rate of the experimental hatching were studied on seven different feeds of both artificial and natural origin. Growth rate and survival rate showed different pattern depending on the nature of ingredients of the formulated feeds. However know fetal effect was required due totemperature during study (10°C). In 2005, the World Fish center and the University of Guelph/Ontario Ministry of natural resources (uG/oMnR) Fish nutrition Research Laboratory began a systematic study of low-cost alternatives to commercial feeds using locally available ingredients.

Hossain and Shikha (1997) worked on the apparent protein digestibility of locally available feed ingredients such as leucaene, water hyacinth, wheat bran, rice bran and duck weed by the African catfish *(Clarias gariepinus)* at 30% inclusion level using a fish meal and soybean leased feed as the reference diet. The result showed that the APD of reference
diet was fairly high (88.62%). The APD values of other test diets ranged between 80.34 to 83.52%. The APD in rice bran was 71.54 followed by water hyacinth (68.52%), duck weed (66.08%), wheat bran and leucaena. From the protein digestion coefficients obtained in this study, it is suggested that the above ingredients are suitable for inclusion in the diet of
Clarias gariepinus at lower levels.

This would be a part of a more comprehensive study in Bangladesh to make murrel aquaculture more flexible and input efficient. The aims of identifying locally available feed ingredients and applying them to smallholder murrel aquaculture are to:

1. Better utilization of household and locally available resources;
2. Incorporated and improved indigenous technical knowledge;
3. Comparing the quality of local feed materials with commercial feed;
4. Comparing the economic benefits of different production scenarios based on these formulated feed;
5. Formulating low-costs diets from locally available ingredients;
6. Increase self-employment and the economic participation of women;
7. Improve the productivity of smallholder aquaculture in general and thereby increase supplies of fish to farm households and other poor people, help fill the human nutritional need for animal protein, and improve farm incomes to alleviate poverty;
8. Improve watershed management and water productivity; and
9. Assessing the ability of these ingredients to meet the nutritional requirements of *Channa straitus*;

Quality of feed materials produced by various feed manufacturer should be required of standard before and after reaching to the farmers (Megh *et al*., 2006)). Low-cost *Channa straitus* feed that is formulated using available ingredients should be nutritionally comparable with good quality commercial fish feed to maintain productivity. The advantage of alternatives *Channa straitus* feeding regimes that on cheap plant materials such as rice polish, wheat bran, mustard oil cake, soybean grits and maize are good for fish growth. Ray and Patra (1989) conducted a laboratory feeding trial comprising 4 isonitrogenous diets containing 35% protein. The feed were formulated using soybean meal + mustard oil cake (Diet 1), groundnut oil cake + fish meal (Diet 2), ground nut oil cake + goat blood (Diet 3) and ground nut oil cake + animal carcass waste (Diet 4) as protein sources. Fish having an initial weight of 10 g grew within 2 months up to 19g, 21g, 22g and 28g in response to dietary treatments 1 -4, respectively. Food conversion ratio (FCR) ranged from 1.93 (Diet 1) to 1.24 (Diet 4) and protein efficiency ratio (PER) ranged from 1.5 - 2.3. Reducing feed cost without compromising productivity requires formulating a diet comparable to that of a commercial feed but using locally available ingredients. This can be accomplished with great cost savings. Now use by some cage farmers in Bangladesh costs 35 US cents per kilograms. A sample farm formulated feed consisting of rice polish (35%), wheat bran (18%), mustard oil cake (15%), fish meal (10%), wheat flour (2%), duckweed (5%) and snail earthworm (5%) costs 22 cents per kilogram, including 2.2 cents in opportunity cost in cost for collecting earthworms, snails and duckweed and 10 cents for fishmeal, which is by far the most expensive ingredient. Note however that quality of feed prepared on- farm may not be comparable with commercial feeds although minimizing operational costs can help sustain farming even with lower fish productivity.

Rapid and participatory appraisal of local farms, agro-industrial activities and rural markets can often yield suitable ingredients for formulating low- cost fish feed. The feed study aimed to improve culture in ponds in Bangladesh by identifying locally available feed ingredients, using to formulate one low-cost diets and assessing them in different management scenarios. Having consulted secondary sources to compile a provisional list of locally available ingredients, the multi disciplinary team-an nutritionist, an aqua culturist and a socio-economist-held focus group discussions with stakeholders, which yielded transects of the study area that provided a cross-sectional view of the location and distribution of its resources.

Fish meal are used in the fish feed formulation based on the high protein and lipid sources (Tacon 1990).The high value of amino acid, vitamin content and other growth factors make fish meal a better choices (Tacon 1990). The ingredients found locally available in Bangladesh, those with the highest protein content were mustard oil cake, fish meal, soybean, rice polish, wheat bran and maize. Fishmeal is not traditional local ingredients but was included in the study because of their high animal protein content, superior profiles of essential amino acids, and availability, particularly in the vicinity of shrimp-processing plants. Cruz and Laudenccia (1978) studied the protein requirement of Nile tilapia (*Oreochoromis niloticus*) fingerling and concluded that 20-30% crude protein was required in the ration for optimum growth and production.

A few drawbacks of using them in formulating fish feed were noted for each ingredient. Cauch and Zambonino (1997) found that the lack of good growth sea bass larvae (15-50 days) fed a formulated diet due to lack of endogenous enzyme activity. Mustard oil cake can interfere with digestibility unless properly processed. As mustard oil cake and soybean is available only few months of the year, widespread cultivation would be necessary to ensure year-round availability and affordability. The high fat content of mustard oil cake constrains its use as the sole protein source. Feed preparation on small-scale farms is labor intensive, and feed quality can be compromised by deficiencies of amino acids in some ingredients. As on-farm feed preparation is labor intensive, the approach of identifying locally available ingredients and subsequent application in feed formulation could be utilized for resource poor farmers to sustain the farming operation by minimizing operational cost. Clearly, feed prepared using on-farm resources can improve the performances of artisanal aquaculture systems to some extent. Hence, relevance of small-scale aquaculture based on on-farm resources (crop and animal by-product) as feed/pond inputs is highlighted in this study, in the context of small-scale farming systems. Nevertheless, there is limited scope for intensification of fish production system with virtual reliance on feed prepared on-farm essentially to inadequate resources available on-farm and lack of experience among resource-poor farmers in formulating fish feed containing right proportion of ingredients.

Israelsen *et al*. (1981) used linear regression to relate pellet quality to different diet ingredients. They estimated the effect of inclusion of different diet ingredients on pellet durability (%) and energy consumption (kwh/t) of the pellet raw material by substituting barely or cotton seed meal by a number of other ingredients. Encouraging micro-and small feed making enterprises that process locally available resources like crop and animal byproducts has potential for ensuring the supply of low cost Channa straitus feed without compromising its quality and also generating local employment.

The study emphasizes the need for the development enterprises locally formulated feeds can contribute to improvements in aquaculture production in efficient ways that can improve livelihoods and food security of the poor, while making efficient use of low-cost locally available ingredients. Identification and utilization of locally available ingredients for small-scale aquaculture will also encourage individual entrepreneurs and cooperatives based agriculture and animal by-product processing industries, feed mills and nursery operations. This would create further employment and will help to enhance the overall rural economy in developing countries.

1.4 Requirement of nutrients in *Channa striatus*:

In fish farming, nutrition is critical because feed represents 40-50% of the production costs. Fish nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal fish growth and health. The development of new species-specific diet formulations supports the aquaculture industry as it expands to satisfy increasing demand for affordable, safe, and high-quality fish and seafood products.

1.5 Requirement of protein in *Channa striatus*:

It is important to accurately determine the protein requirements for each species and size of cultured fish because protein is very much important part of fish feed (Robinson *et al*., 1998). Proteins are formed by linkages of individual amino acids. Although over 200 amino acids occur in nature, only about 20 amino acids are common. Of these, 10 are essential (indispensable) amino acids that cannot be synthesized by fish. Proteins are composed of carbon (50%), nitrogen (16%), oxygen (21.5%), and hydrogen (6.5%) (Lovell, 1989). Fish are capable of using a high protein diet, but as much as 65% of the protein may be lost to the environment. Most nitrogen is excreted as ammonia (NH3) by the gills of fish, and only 10% is lost as solid wastes. Accelerated eutrophication (nutrient enrichment) of surface waters due to excess nitrogen from fish farm effluents is a major water quality concern of fish farmers. Effective feeding and waste management practices are essential to protect downstream water quality.

According to Tacon (1990) protein levels in aquaculture feeds generally average 18-20% for marine shrimp, 28-32% for climbing perch, 32-38% for tilapia, 38-42% for hybrid striped bass. Protein requirements usually are lower for herbivorous fish (plant eating) and omnivorous fish (plant-animal eaters) than they are for carnivorous (flesh-eating) fish, and are higher for fish reared in high density (recirculating aquaculture) than low density (pond aquaculture) systems. Catacutan and Coloso (1995) while working with effect of dietary protein to energy rations on growth, survival and body composition of juvenile Asian sea bass Lates calcarifer reported that the optimal crude protein specification of dry pelleted diets for juvenile Asian sea bass between 40% and 50%

Protein requirements generally are higher for smaller fish. As fish grow larger, their protein requirements usually decrease. Protein requirements also vary with rearing environment, water temperature and water quality, as well as the genetic composition and feeding rates of the fish (Lovell, 1989). Protein is used for fish growth if adequate levels of fats and carbohydrates are present in the diet. If not, protein may be used for energy and life support rather than growth.

1.6 Requirement of lipids in *Channa striatus*:

Lipids can be utilized to partially spare protein in aquaculture feed because of high-energy nutrients. Lipids supply about twice the energy as proteins and carbohydrates. A recent trend in fish feeds is to use higher levels of lipids in the diet. Although increasing dietary lipids can help reduce the high costs of diets by partially sparing protein in the feed, problems such as excessive fat deposition in the liver can decrease the health and market quality of fish.

Simple lipids include fatty acids and triacylglycerols. Fish typically require fatty acids of the omega 3 and 6 (n-3 and n-6) families. Fatty acids can be: a) saturated fatty acids (SFA, no double bonds), b) polyunsaturated fatty acids (PUFA, >2 double bonds), or c) highly unsaturated fatty acids (HUFA; > 4 double bonds). Marine fish oils are naturally high (>30%) in omega 3 HUFA, and are excellent sources of lipids for the manufacture of fish diets. Lipids from these marine oils also can have beneficial effects on human cardiovascular health.

Marine fish typically require n-3 HUFA for optimal growth and health, usually in quantities ranging from 0.5-2.0% of dry diet. The two major EFA of this group are eicosapentaenoic acid (EPA: 20:5n-3) and docosahexaenoic acid (DHA: 22:6n-3). Freshwater fish do not require the long chain HUFA, but often require an 18 carbon n-3 fatty acid, linolenic acid (18:3-n-3), in quantities ranging from 0.5 to 1.5% of dry diet (Lovell, 1989). This fatty acid cannot be produced by freshwater fish and must be supplied in the diet. Many freshwater fish can take this fatty acid, and through enzyme systems elongate (add carbon atoms) to the hydrocarbon chain, and then further desaturate (add double bonds) to this longer hydrocarbon chain. Through these enzyme systems, freshwater fish can manufacture the longer chain n-3 HUFA, EPA and DHA, which are necessary for other metabolic functions and as cellular membrane components. Marine fish typically do not possess these elongation and desaturation enzyme systems, and require long chain n-3 HUFA in their diets. Other fish species, such as tilapia, require fatty acids of the n-6 family, while still others, such as carp or eels, require a combination of n-3 and n-6 fatty acids.

1.7 Requirement of Carbohydrates in *Channa striatus*:

Carbohydrates are the most economical and inexpensive sources of energy for fish diets. Although not essential, carbohydrates are included in aquaculture diets to reduce feed costs and for their binding activity during feed manufacturing. Dietary starches are useful in the extrusion manufacture of floating feeds. Cooking starch during the extrusion process makes it more biologically available to fish. In fish, carbohydrates are stored as glycogen that can be mobilized to satisfy energy demands. They are a major energy source for mammals, but are not used efficiently by fish.

1.8 Requirement of vitamins in *Channa striatus*:

For normal fish growth and health vitamins are necessary in the diet. They often are not synthesized by fish, and must be supplied in the diet. The two groups of vitamins are water-soluble and fat-soluble. Water-soluble vitamins include: the B vitamins, choline, inositol, folic acid, pantothenic acid , biotin and ascorbic acid (vitamin C). Of these, vitamin C probably is the most important because it is a powerful antioxidant and helps the immune system in fish.

The fat-soluble vitamins include A vitamins, retinols (responsible for vision); the D vitamins, cholecaciferols (bone integrity); E vitamins, the tocopherols (antioxidants); and

K vitamins such as menadione (blood clotting, skin integrity). Of these, vitamin E receives the most attention for its important role as an antioxidant. Deficiency of each vitamin has certain specific symptoms, but reduced growth is the most common symptom of any vitamin deficiency. Scoliosis (bent backbone symptom) and dark coloration may result from deficiencies of ascorbic acid and folic acid vitamins, respectively (Houliah et al., 2001).

1.9 Requirement of minerals in *Channa striatus*:

Minerals are inorganic elements necessary for normal body functions. Minerals can be divided into two groups (macro-minerals and micro-minerals) based on the quantity required in the diet and the amount present in fish. Common macro-minerals are sodium, chloride, potassium and phosphorous. These minerals regulate osmotic balance and aid in bone formation and integrity.

Micro-minerals are required in small amounts as components in enzyme and hormone systems. Common trace minerals are copper, chromium, iodine, zinc and selenium. Fish can absorb many minerals directly from the water through their gills and skin, allowing them to compensate to some extent for mineral deficiencies in their diet.

1.10 Energy and protein:

The nutritional value of a dietary ingredient is in part dependant on its ability to supply energy. Physiological fuel values are used to calculate and balance available energy values in prepared diets. They typically average 4, 4, and 9 kcal/g for protein, carbohydrate and lipid, respectively (Lovell, 1989). To create an optimum diet, the ratio of protein to energy must be determined separately for each fish species. Excess energy relative to protein content in the diet may result in high lipid deposition. Because fish feed to meet their energy requirements, diets with excessive energy levels may result in decreased feed intake and reduced weight gain. Similarly, a diet with inadequate energy content can result in reduced weight gain because the fish cannot eat enough feed to satisfy their energy requirements for growth. Properly formulated prepared feeds have a well-balanced energy to protein ratio.

1.11 Artificial diets:

Artificial diets may be either complete or supplemental. Complete diets supply all the ingredients (protein, carbohydrates, fats, vitamins, and minerals) necessary for the optimal growth and health of the fish. Most fish farmers use complete diets, those containing all the required protein (18-50%), lipid (10-25%), carbohydrate (15-20%), ash (< 8.5%), phosphorus (< 1.5%), water (< 10%), and trace amounts of vitamins, and minerals (Albert and Tacon, 1990). When fish are reared in high density indoor systems or confined in cages and cannot forage freely on natural feeds, they must be provided a complete diet.

In contrast, supplemental (incomplete, partial) diets are intended only to help support the natural food (insects, algae, small fish) normally available to fish in ponds or outdoor raceways. Supplemental diets do not contain a full complement of vitamins or minerals, but are used to help fortify the naturally available diet with extra protein, carbohydrate and/or lipid. Fish, especially when reared in high densities, require a high-quality, nutritionally complete, balanced diet to grow rapidly and remain healthy.

1.12 Objectives:

1. To explore a quality feed from indigenous ingredients.
2. To analyze the nutrient content of the *Channa striatus*.
3. To investigate the growth performance of *Channa striatus* by feeding laboratory made feed (LMF) and commercial feed (CF).
4. To investigate the feed utilization of *Channa striatus* fed with LMF and CF feed.

CHAPTER 2
MATERIALS AND METHODS

The study on Laboratory made feed and commercial feed in *Channa striatus* diets was investigated on same percentage of protein 22%. *Channa striatus* with an average size of 23.48cm, 82.69±0.05g of body weight for the treatment and 81.67±0.50g of body weight for the control were stocked at the rate of 16 fish per 500 liters circular fiber tanks at the aquatic laboratory of Department of Fisheries, University of Dhaka.

2.1 Place and duration of experiments:

This experiment was carried out in the tanks with diets of laboratory made feed and Commercial feed *Channa striatus* . The culture tanks were set up in aquatic laboratory of Dhaka University, started from 29 January to11 March, 2014. Proximate of raw materials, artificial feed and *Channa striatus* carcass composition was analysis in Fish Nutrition Laboratory; water quality was analysis in the aquatic Laboratory, Department of Fisheries, University of Dhaka.

2.2 The experimental model fish:

The freshwater *Channa striatus* was used as the experimental fish species because it can thrive on such adverse environment. It is a native freshwater fish species in Bangladesh locally known as shoal.

Classification of shoal:

- Kingdom: Animalia
- Phylum: Chordata
- Class: Actinopterygii
- Order: Channiformes
- Family: Channidae
- Genus: *Channa*
- Species: *Channa striatus*

Figure 2.1: *Channa striatus*, Bloch, 1972.

2.3 Collection of ingredients:

Ingredients were collected from Chokbazar of Dhaka city. Only indigenous ingredients was used in this study. These ingredients are available in Bangladesh. Properties of those ingredients were used in the study in the following:

A) MAIZE

Bangla name: Bhuttar Kura

English name: Maize bran

Source:

Corn/Maize plant (*Zea mays*)

Used part:

Seed

Physical properties:

Powder like and yellowish in color.

Availability:

Available all over Bangladesh and peak season is in the month between April and May.

Application:

By mixing with other feed ingredients. Mainly used in polyculture.

B) RICE POLISH

Bangla name: Chaler kura

English name: Rice polish

Source:

Paddy (*Oryza sativa*)

Used part:

Outer layer of seed

Physical properties:

Brownish in color. Powder in form.

Availability: Commonly available throughout Bangladesh. Peak season is in the months between December-February and April-May.

Application:

Used in carp polyculture mainly, generally applied individually or by mixing with other ingredients.

C) WHEAT BRAN

Bangla name: Gomer bhushi

English name: Wheat bran

Source:

Wheat plant (*Triticum aestivum*)

Used part:

Waste part of seed after processing

Physical properties:

Yellowish colored coarse particles.

Availability:

Commonly available throughout Bangladesh. Peak season is in the months between April and May.

Application:

Used in carp polyculture mainly, generally applied individually or by mixing with other ingredients.

D) SOYBEAN GRITS

Bangla name: Soybean Khoil

English name: Soybean grits

Source:

Soybean plant (*Glycine max*)

Used part:

Waste part of seed after oil processing

Physical properties:

Light yellowish in color and granular or irregular shaped fish feed ingredient.

Availability: Commonly available Faridpur, Noakhali and some other districts of Bangladesh. Peak season is between November and January.

Application:

Used in polyculture, generally applied by mixing with other ingredients.

E) MUSTARD OIL CAKE

Bangla name: Shorishar Khoil

English name: Mustard oil cake

Source:

Mustard plant

Used part:

Waste part of seed after oil processing

Physical properties:

Brownish or blackish to grayish colored irregular shaped fish feed ingredient.

Availability:

Found all over Bangladesh and peak season is January to March.

Application:

Used in polyculture, generally applied by mixing with other ingredients.

F) FISH MEAL

Fish meal

Bangla name: Fish meal or machher gura

English name: Fish meal

Source:

Various types of fishes especially those are considered trash.

Used part:

Almost all parts of the fish body.

Physical properties:

Powder like but the particles are not fine, some minute bones may present and usually of light brownish or yellowish color.

Availability: 3 grades of fish meal are available in Bangladesh. Fish meal is produced from different fish feed industries of the country. These industries are located in Chittagong, Cox's Bazar, Khulna, Bogra, Mymensingh etc. districts.

Application:

Mainly used for high-valued culture species. Applied in both polyculture and monoculture farming, but magnitude and extend of application is much higher in monoculture than polyculture especially in Tilapia culture (monosex and GIFT), Thai-Climbing perch culture, Pangas culture etc.

2.4 Experimental design:

A set of six circular tanks, each tank had a volume of 500 liters was used for the feeding trial of *Channa striatus*. Murrel fry of average 82.69±0.05g of body weight for the treatment and 81.67±.50g of body weight for the control and 23.48cm of initial body size were purchased from Kaoranbazar fish market of Dhaka city. Fish were selected with the same market. Ninety six murrel were stocked. Six tanks were assigned in three replications to two experimental diets. The fish culture tanks were covered with net to prevent the fish escape. Fish were stocked in 500 liters circular tanks and acclimated and fed with the commercial feed (22% crude protein) and then all fishes were randomly sampled into the experimental tanks. Fish were fed with experimental diets at 3% of the body weight per day at twice daily (9-10 am and 4-5 pm). Fish samplings were monitored weekly to adjust the amount of feed given. All fish culture tanks were provided with gentle aeration throughout the cultural period. Water exchange was done weekly at 80-90% in all tanks. Tap water was used as the mediate for fish culture. Two experimental diets culture tanks with three replications for each were designed as follows: Control for commercial feed with 22% crude protein and treatment for laboratory made feed with 22% crude protein. Fish were sampled randomly about 10 fishes starved one day prior, killed and minced for initial proximate composition analysis at the beginning of the experiment. At the end of the experiment, the fish was starved one day prior weighing. Fish of each tank were taken randomly, killed and minced for analysis of final proximate composition. Water quality parameters such as temperature, p^H and dissolved oxygen were measured in tanks. Dissolved oxygen and p^H were measured weekly. Temperature was monitored two times per day in the morning and afternoon by using meter.

Figure 2.2: Circular tank was used for culture with aeration.

2.5 Chemical analysis:

The percentage of proximate composition of fish was determined by conventional method of AOAC (2000). Triplicate determinations were carried out on each chemical analysis.

A) Estimation of moisture:

The initial weight of the sample was taken then samples were dried in an oven at about 105°C for about 8 to 10 h until constant weight was reached and the samples were minced in an electric grinder. The percentage of moisture content was determine

B) Protein determination:

The protein content of the fish was determined by micro Kjeldahl method (AOAC, 2000). It involves the conversion of organic nitrogen to ammonium sulphate by digestion of flesh with concentrated sulphuric acid in a micro kjeldahl flask. The digest was diluted, made alkaline with sodium hydroxide and distilled. The liberated ammonia was collected in a boric acid solution and total nitrogen was determined titrimetrically. The percentage of protein in the sample was calculated.

Figure: 2.3: Microkjeldhal digestion unit for the determination of protein content of fish

C) Estimation of fat:

For the estimation of fat content, the dried samples left after moisture determinations were finely grinded and the fat was extracted with chloroform and methanol mixture (AOAC, 2000). After extraction, the solvent was evaporated and the extracted materials were weighed. The percentage of the fat content was calculated.

D) Estimation of ash:

The ash content of a sample is residue left after ashing in a muffle furnace at about 550-600°C till the residue become white. The percentage of ash was calculated by subtracting the ash weight from initial weight.

2.6 Feed preparation:

All experimental diets were contained 22% protein (in dry matter), which mixture of raw materials such as fish meal, soybean, mustard oil cake, rice polish, wheat bran and maize. Oil was also provided in the mixture to satisfy energy balance. The chemical composition of ingredient was presented in Table 2.1. The experiment sets up of diets depend on the protein from fish meal, soybean and mustard oil cake. Rice polish and wheat bran served as carbohydrate source. Vegetable oil, mustard oil cake and rice polish served as lipid source. Vitamin and mineral premix were added to the diets as micro ingredient. The diets were completed process as pellets in laboratory.

Table 2.1 Proximate composition (%) of ingredients used in experimental diets.

Ingredient (%)	Fish meal	Mustard oil cake	Soybean grits	Maize	Rice polish	Wheat bran
Moisture	8.05	8.53	11.52	10.73	6.38	11.93
Ash	24	7.10	7.52	1.35	13.2	3.59
Crude lipid	12.88	20.95	34.42	5.20	29.13	26.27
Crude protein	51.34	28.47	31.7	7.20	10.01	12.92

The experimental diets were processed according to method of small-scale feed processing .Balancing ratios of feed were calculated with the percentage of protein, lipid, moisture and ash from ingredients, respectively. Protein ration first was computed due to the major and most expensive component of the diets. Desirable energy levels were then adjusted to the diets by adding high-energy sources especially from lipid. Formulation of Laboratory made feed was presented in Table 2.2. All the proximate composition of feedstuffs such as; moisture, protein, lipid and ash of raw materials were analyzed and calculated before preparation of the artificial feed (Table 2.1). Experimental diets were prepared as follow describe: first weighted all ingredients which desired then place in the bowl and mixing. Mixed all dried ingredients by hand until very well blended. Remove a small part of these mixtures to mix with micro ingredients (vitamin and mineral) and added the liquid source (oil), mix thoroughly too homogenous mixture.

Subsequently, the water about 30% was added to the dry mixture and passes it through a meat grinder. Finally, the moist pellet then transferred to an oven and leave overnight at 60°C.

Table 2.2: Formulation of the laboratory made feed (%)

Sl. No		Ingredients (%)	
1	LMF	Fish meal	22
		MOC	11
		Soybean grit	12
		Wheat bran	13
		Rice polish	14
		Maize	20
		Wheat flour	3
		Vegetable oil	2
		Salt	1
		Vitamin premix	2

Thereafter moist pellet were dried, feed were place in covered plastic containers and stored in airtight until used. The experimental diets after formulation were also analyzed to determine the proximate composition presented in Table 2.3.

Table 2.3: Composition of the experimental diets (%)

Sl.No.	Name of feed	Crude protein	Lipid	Ash	Moisture
1	Commercial feed	22	7.05	11.08	12.5
2	Laboratory made feed	22	9.73	10.65	11.5

2.7 Feeding trial:

Each diet was fed to fish by 3% of total fish weight per tank per day. The daily frequency was offered in two individual meals, one at 9.00-10 am and another at 16.00- 17.00 pm. The feeding trial continued for a period of 40 days. Fish were randomly sampled 5% weighted at 7 days interval to adjust the feed intake following to change of body weight. Feed given are based on the average weight gain of fish in each treatment.

2.8 Water quality measurement:

Water quality such as p^H, dissolved oxygen was monitored in the tanks regularly following different procedures. Temperature was measured every day, dissolved oxygen and p^H was measured weekly. The temperature was measured directly in the water column two time everyday (minimum and maximum) after feeding by meter. Dissolved oxygen (DO) was measured directly in the water column of tanks every week by using oxygen meter. p^H was measured directly in the water column of tanks every week during experiment by p^H meter.

2.9 Fish growth performance:

Data on growth of fish were gathered. Fish were weighted to the gram using an electronic balance. Fish fed with experimental diets. All fish growth parameters were calculated on performance such as mean final fish weight, daily weight gain (g/f/d), percentage of weight gain (%) and specific growth rate, SGR (%/day). The procedure of calculation as follows:

$$\text{Mean daily weight gain (g/f/d)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Culture period (days)}}$$

$$\text{Percentage of weight gain (\%)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Mean initial weight}} \times 100$$

$$\text{Specific growth rate (\%day}^{-1}\text{)} = 100 \times \frac{(\ln[\text{final body weight}] - \ln[\text{initial body weight}])}{\text{no.of days}}$$

2.10 Feed utilization:

Fish were fed at 3% of body weight. Food conversion ratio (FCR), protein efficiency ratio (PER) in murrel fed laboratory made feed and commercial feed were determined at the end of the experiment as follow:

$$\text{Food conversion ratio (FCR)} = \frac{\text{Total weight of feed given (G)}}{\text{Total weight gained by fish (g)}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Wet weight gain (g)}}{\text{Dry protein intake (g)}}$$

At the termination of experiment, fish were counted and survival rate to calculate as follows:

$$\text{Survival rate (\%)} = \frac{\text{Fish number of fish}}{\text{Initial number of fish}} \times 10$$

2.11 Statistical analysis:

Average final fish weights, food conversion value (FCR), protein efficiency ratios (PER) and specific growth rate (SGR) were calculated for each dietary treatments at the end of experiment. Analysis of variance was used to test the significance (P<0.05) of all fish growth performance among dietary treatments.

CHAPTER 3
RESULTS

Laboratory made feed and commercial feed diet was performed on the culture of *Channa striatus* for 40 days. The commercial feed was set as the control. Commercial feed was also fed fish to compare performances with those fed with laboratory made feed diets. Result of this study was presented as following:

3.1 Water quality performance:

All water quality parameter were concluded in the Table 3.1. Changes in those water quality parameters were presented in Figures 3.1 and 3.2.

Table 3.1: Limnological and hydrological parameters (Average value) studied during the experiment

Sl.No.	Limnological parameters	Laboratory made feed	Commercial feed
1	DO (mg.l^{-1})	$5.57 \pm 0.23_a$	$5.60 \pm 0.23_a$
2	P_H	$6.82 \pm 0.31_a$	$6.80 \pm 0.25_a$
3	Temperature (°C)	$22.37 \pm 0.32_a$	$22.28 \pm 0.30_a$

Dissolved oxygen and p^H during the experimental period were analyzed at weekly intervals in tanks throughout a culture period of 40 days. Average DO concentration was 5.57±0.23mg/L in the treatment and 5.60±0.23mg/L in the control tanks. While average p^H in the treatment was 6.82±0.31 and in the control tanks was 6.80±0.25. Significant differences ($P<0.05$) in DO was not observed. p^H Between treatment and control tanks during the study period was not statistically significant ($P<0.05$).

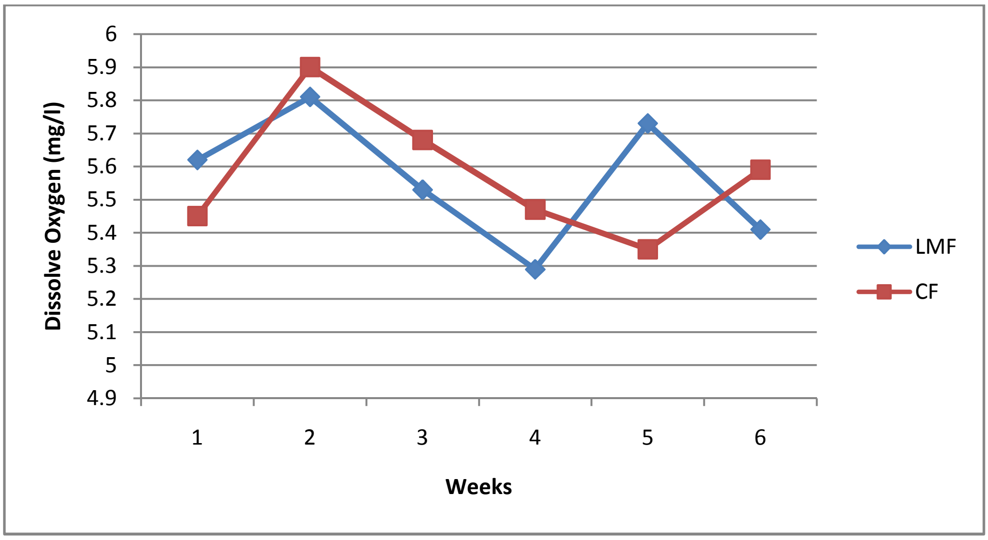

Figure 3.1: Weekly changes in dissolved oxygen concentration (mg/L) in culture tanks.

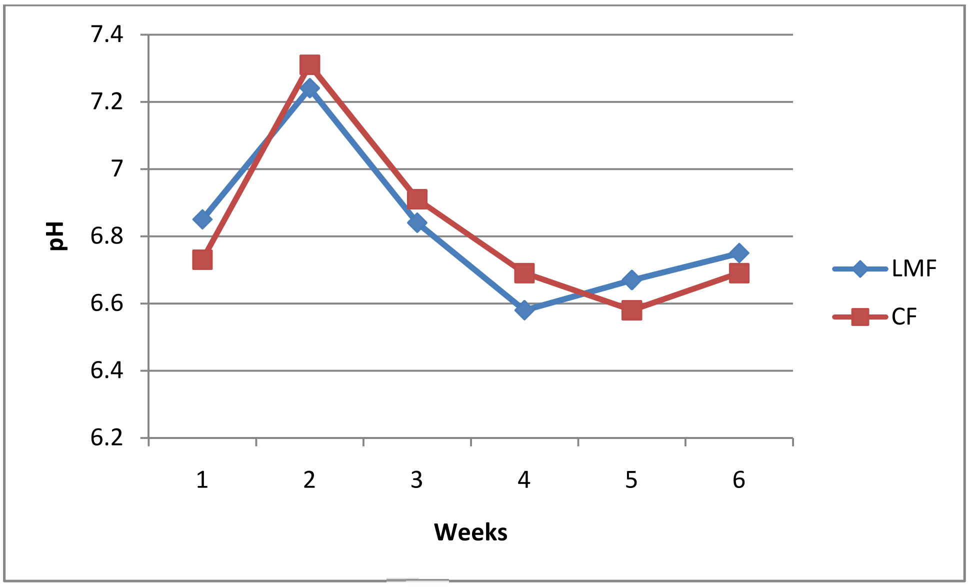

Figure 3.2: Weekly changes of water P^H in culture tanks throughout the culture period

3.2 Growth performances of murrel:

Relatively slow growth of fish was observed in all tanks during the last weeks of culture periods, thereafter, a significance of slow growth appeared in all tanks. All growth performance was calculated in Table 3.3. Mean initial body weight of fish was

82.69±0.05 and 81.67±0.50 for diet laboratory made feed and commercial feed respectively. Mean body weight changes of fish showed in the Figure 3.3.

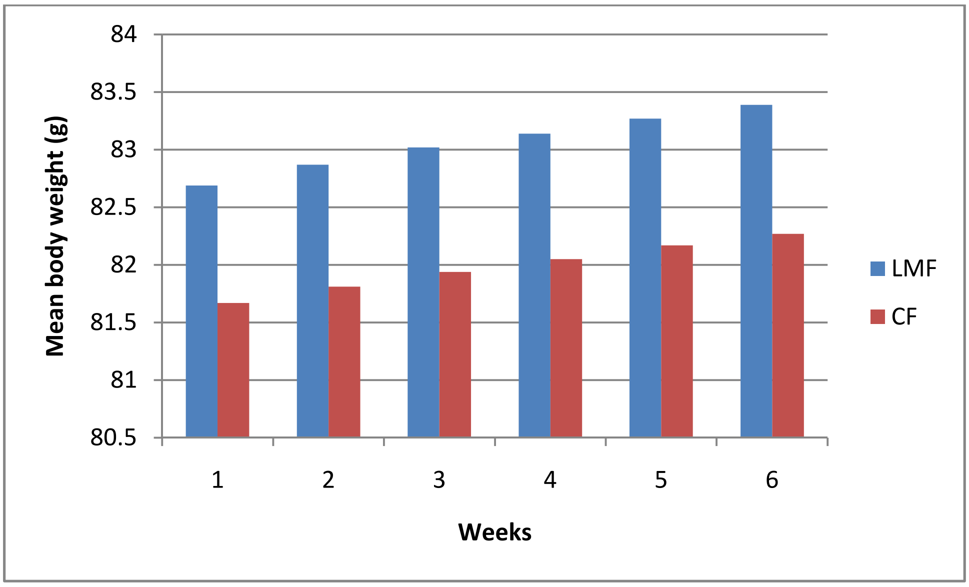

Figure 3.3: Mean body weight (g) changes of *Channa striatus*

All those performances were significant differences ($p<0.05$) between treatments and controls such as mean final body weight, mean daily weight gain, percentage weight gain, specific growth rate and survival rate, respectively.

Average daily weight gain of fish fed with laboratory made feed showed higher (0.017) than those fed with commercial feed (0.015).

Percentage of weight gain showed the highest at the fish fed laboratory made fed (0.85) while the lowest in fish fed commercial feed (0.73) (Table 3.3)

Specific growth rate also showed higher with fish fed Laboratory made feed (0.021±0.05) than those fed with commercial feed (0.018±0.04). Specific growth rate of fish showed in the Figure 3.4

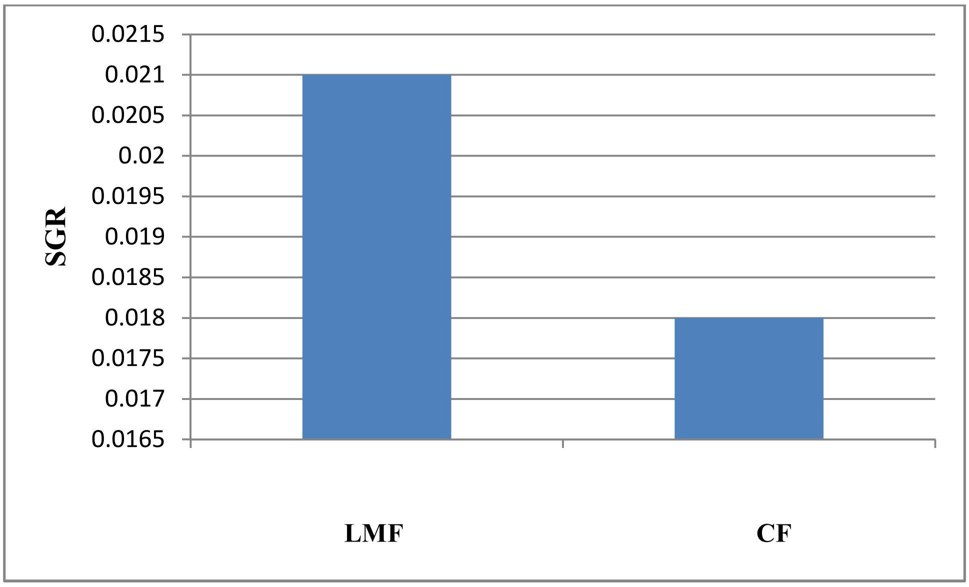

Figure 3.4: Specific Growth Rates (SGR) of *Channa striatus* at the end of experiment period in response to different diets.

Higher survival rates was found in the fish fed with Laboratory made feed was 81.25% and low survivals was performed in Commercial feed 75%.

3.3 Feed utilization:

Feed utilization of *Channa striatus* fed two types of feed was performed as protein intake, food conversion ratio (FCR) and protein efficiency ratio respectively. There was a significant effect of Laboratory made feed and commercial feed in diets on those performances of feed utilization ($P<0.05$).

However, Food conversion ratios exhibited lower in fish fed Laboratory made feed (1.41) but higher was at fish fed Commercial feed (1.53). While, protein efficiency ratios (PER) exhibited higher in fish fed Laboratory made feed (3.60) but lower was at fish feed Commercial feed (2.27).

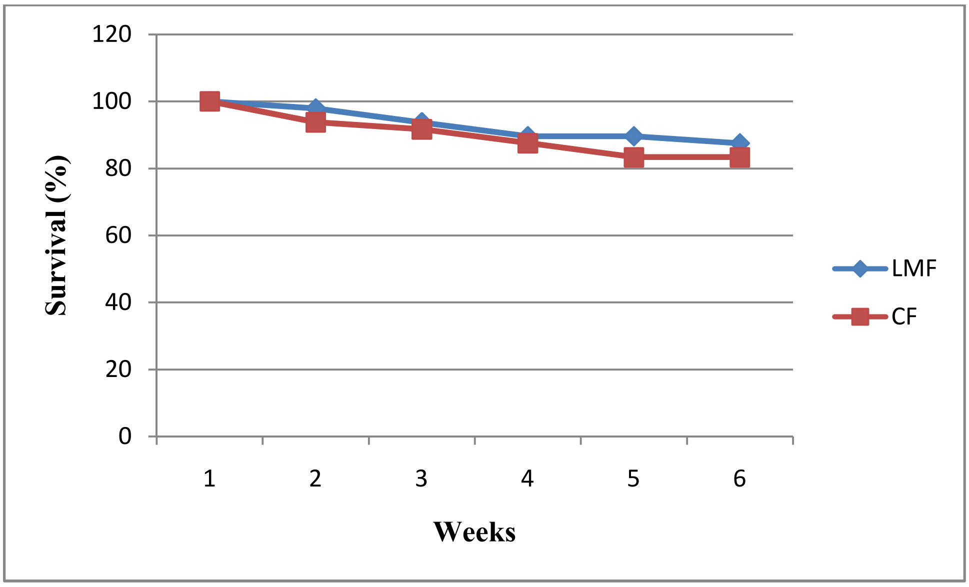

Figure 3.5: Survival (%) of *Channa striatus* fry fed on different experimental diets

3.4 Proximate composition:

The proximate composition of experimental fish fed laboratory made feed and commercial feed was determined at the initial and at the end of the experiment. The initial carcass composition of fish was 80.14%, 18.014%, .371% and 1.578% for moisture, protein, lipid and ash respectively.

Moisture contents of fish at the end of experiment were 78.20±0.057 and 79.08±0.04%, respectively for fish fed Laboratory made feed and Commercial feed. There was a significant effect of feed on final body carcass composition between treatment and control tanks ($P<0.05$). Significant protein contents of final body composition were appeared (Table 3.2). The growth performance and nutrient utilization were appeared in (Table 3.3). The protein contents of fish were 19.948±0.25 and 18.83±0.14 for fish fed with laboratory made feed and commercial feed, respectively.

At the end of the experiment, percentage of ash contents in *Channa striatus* showed significant differences between treatment and control ($P<0.05$). The ash content was higher in fish fed with laboratory made feed (1.83±0.04).

All experimental fish had higher lipid contents than the initial lipid composition. The lipid composition for climbing perch were 0.68±0.05 and 0.56±0.03 for fish fed with laboratory made feed and commercial feed, respectively

Table 3.2: Whole body proximate composition of *Channa striatus* fed with laboratory made feed and commercial feed (% fresh weight basis, mean ± SD)

	Initial	Laboratory made feed	Commercial feed
Moisture	80.14 ± 0.06$_a$	78.20 ± 0.05$_a$	79.08 ± 0.04$_b$
Crude protein	18.02 ± 0.09$_a$	19.948 ± 0.25$_a$	18.83 ± 0.14$_b$
Crude lipid	0.371 ± 0.05$_a$	0.68 ± 0.05$_a$	0.56 ± 0.03$_b$
Ash	1.58 ± 0.03$_a$	1.83 ± 0.04$_a$	1.77 ± 0.00$_b$

Table 3.3: Growth performance and nutrient utilization of *Channa striatus fed* Laboratory made feed and Commercial feed (mean ± SD).

	Laboratory made feed	Commercial feed
Mean initial weight (g)	82.69 ± 0.05	81.67 ± 0.50
Mean final weight (g)	83.39 ± 0.09$_a$	82.27 ± 0.10$_b$
Mean final weight gain (g)	0.7 ± 0.05$_a$	0.6 ± 0.02$_b$
% weight gain	0.85 ± 1.25$_a$	0.73 ± 1.26$_b$

Feed efficiency	$70.80 \pm 0.07_a$	$66.32 \pm 0.04_b$
Initial length (cm)	$23.76 \pm 0.03_a$	$23.64 \pm 0.02_a$
Final length (cm)	$24.56 \pm 0.06_a$	$24.04 \pm 0.29_b$
Specific growth rate (% day^{-1})	$0.021 \pm 0.05_a$	$0.018 \pm 0.04_b$
Feed conversion ratio	$1.41 \pm 0.03_a$	$1.53 \pm 0.06_b$
Protein efficiency ratio	$3.60 \pm 0.19_a$	$2.27 \pm 0.16_b$
Final survival rate (%)	$81.25 \pm 3.39_a$	$75 \pm 1.28_b$

3.5 Cost analysis

Indigenous ingredients were bought from Chokbazar of Dhaka city. Commercial feed was bought from Nimtoli of Dhaka city. Vitamin premix, vegetable oil, wheat flour (Binder) and salt used in LMF feed were also bought from Nimtoli of Dhaka city. Price of per kg used ingredients like fish meal, mustard oil cake, soyban grits, rice polish, wheat bran and maize were 75, 25, 48, 25, 25 and 25Tk. respectively. Price of per kg vitamin premix, vegetable oil, salt and wheat flour (binder) were 330, 120, 30 and 40 Tk., Respectively. From known value of per kg ingredients, the price of per kg LMF feed was calculated. The price of LMF feed found 45 Tk/kg and price of CF feed was 50 Tk/kg.

CHAPTER 4
DISCUSSION

For successful culture of any fish suitable feed is one of the most important prerequisites. Before feed formulation of LMF every collected indigenous ingredients were analyzed for proximate composition. The percentage of protein in fish meal, soybean grits, mustard oilcake, rice polish, maize and wheat bran were 51.34%, 31.70%, 28.47%, 10.01%, 7.2% and 12.92%, respectively.

The results obtained from experiments showed that the growth responses of fish fed with diets commercial feed on term of weight gain (WG), daily weight gain (DWG), percentage of weight gain (PWG), specific growth rate (SGR), survival rate (SR), and also the feed efficiency such as feed intake (FI), food conversion ratio (FCR), protein efficiency ratio (PER) were decreased. In this experiment, fish fed diets containing Laboratory made feed showed the best growth rate, feed efficiency and significantly higher percentage of weight gain than commercial feed.

These results indicated that growth rate of fish is higher when fed diets containing Laboratory made feed. These related to the palatability of diets. The increase in fish growth has been caused by an improvement in essential amino acid in the diet fed with Laboratory made feed.

Survival rate of fish were significantly different between experimental diets. These controls had problem with feed intake, may be related with commercial feed contained in the diet that caused low palatability. The feed intake in control diet were significantly lower than the other treatment diets ($P<0.05$). The Average survival rate of fish was 81.25±3.39% in fish fed with CF feed and 75±1.28% in fish fed with LMF feed. Mookerjee and Mazumdar (1946) in a study with climbing perch with prepared feeds (containing 35-45% CP) observed survival rate ranging from 75-89%. By Feeding *Channa striatus* formulated diet using local ingredients Mustafa *et al.* (2004) also found survival rate 88.23% during their study.

The FCR of treatments and controls in this study were 1.41±0.03 and 1.53±0.06, respectively. In this study FCR was also greater than one. The FCR was statistically significant ($P<0.05$) between two groups fed with diet LMF and CF, respectively. These values slightly increased in commercial feed diets because the utilization of commercial feed was lower than laboratory made feed. As the good quality of protein in the diet increases, the FCR gets smaller. This means that it takes less feed to produce a kilogram of fish. According to Catacutan and Coloso (1997) found that FCR ranged from 1.21 to 1.65 in sea bass fed with diets varying carbohydrate and lipid levels. Potongkam (1972) reported that FCR of climbing perch fed on trash fish and pellet were 2.07 and 1.89, respectively.

The PER was statistically significant ($P<0.05$) between two groups fed with diet LMF and CF, respectively. In the present study, protein efficiency ratio (PER) was 2.27±0.16 for the fish fed with CF feed and 3.60±0.19 for the fish fed with LMF feed. The protein utilization of commercial feed was lower so PER also lower in fish fed with commercial feed in diet. The PER in these study were slightly higher than the data reported by Catacutan and Coloso (1997) and Boonyaratpalin *et al.* (1998), ranging from 2.4 to 2.49 and 1.32 to 2.98, respectively which are also nearest value with our findings.

SGR was decreased at the end of the experiment in case of both treatment and control. But SGR was higher in fish fed with laboratory made feed. The finding resembles the Medwars (1945) fifth law 'The specific growth declines more and more slowly as the organism increase in age. The present study followed same trend. The SGR was statistically significant ($P<0.05$) between two groups fed with diet LMF and CF. SGR were found 0.018±0.04 in control and 0.0.021±0.05 in treatment. Minot (1908) was the first person to recognize that for most animals the specific growth rate is highest early in life and it typically decreases with increasing age, becoming zero in some animals and his epigram. "Organisms age fastest when they are young" is expressed by Medwars (1945) fifth law. The SGR% value of shol fish in our experiment also shows the same trend mentioned in Medwars (1945) fifth law.

The initial fish carcass trended to have higher moisture (80.14 %) than those of fish at the end of the experiment. The final body moisture was statistically significant ($P<0.05$) between two groups fed with diet LMF and CF, respectively. The percentage of moisture in experimental fish carcass 78.2±0.05% in fish fed with LMF feed and 79.08±0.04% in fish fed with CF feed. Fish fed diet containing Commercial feed was slightly higher moisture than fish fed Laboratory made feed. Catacutan and Coloso (1995) reported that high protein content on a dry matter basis as well as the high moisture content was affected by feed quality. The result in this study moisture was higher.

The final body protein content was statistically significant ($P<0.05$). In present study carcass protein was highest in fish fed diet containing laboratory made feed and lower in fish fed diets containing commercial feed. The results presented in this study showed that carcass protein level 19.948±0.25% in fish fed with LMF feed and 18.83±0.14% in fish fed with CF feed. The present study was based on same percentage of level so final fish body composition showed good protein level in fish fed with LMF feed. Rahman *et al*. (2007) found 37% crude protein when they carried out their study, effects of dietary vitamin C on the feed utilization and growth performance in climbing perch. Using local ingredients Mustafa *et al*. (2004) found 18% crude protein in climbing perch. In this study similar level of protein was also found.

Fish fed higher dietary protein showed a higher carcass lipid. A similar trend for crude lipid has been reported by Murari et al. (1985) in *Cyprinus carpio.* The fat content was higher in fish fed with Laboratory made feed diet. Fat levels in treatment fed with LMF feed was 0.68±0.05% and in control was 0.56±0.03% at the end of experiment were in the body of climbing perchfish. According to Catacutan and Coloso (1995) suggested that body lipid content reflected the lipid content of the diets. The present study also reflected the lipid content of the diets.

Water quality was widely acknowledge to be one of the most important rearing conditions that could be managed to reduce diseases exposure and stress in intensive fish culture (Wedemeyer, 1996). Lawson (1995) reported that the physical, chemical and biological environmental parameters were interrelated in a complicated series of physiochemical reactions that affect every aspect of fish culture (survival, growth and reproduction).

DO was not statistically significant ($P<0.05$) among the tanks. Due to aeration supply, DO concentration was 5.57±0.23 and 5.60±0.23 for the treatment and control, respectively among the tanks. However, DO concentration in this was probably good.

The p^H in all tank water was alkaline throughout the experimental period which be due to tap water. According to Swingle (1967), p^H from 6.5 to 9.0 is suitable for pond fish culture and p^H more than 9.5 is unsuitable. p^H Both in control and treatment tanks was not statistically significant (P<0.05). The average p^H of the water in this study was 6.82±0.31and 6.80±0.25 for the treatment and control, respectively that was suitable.

CHAPTER 5
CONCLUSION

CONCLUSION

Snakehead fish *Channa striatus* is a popular type of fish in the village level due to its high nourishing quality and prolonged freshness. It is found in most of the fresh water bodies

Ignorance in processing and formulating, rural people were unable to use the locally available feed ingredients. Present study tested nutritional quality of six selected available indigenous ingredients where their nutritional quality was able to meet up the demand of *channa striatus*. How to process and formulate the ingredients was described in this research.

The growth performance and feed utilization from these study were significantly lower in commercial feed ($P<0.05$) than Laboratory made feed.

Commercial feed showed significantly adverse effect ($P<0.05$) on growth performances in term of weight gain (WG), percentage weight gain (PWG), average daily gain (ADG), specific growth rate (SGR) and also showed adverse affect on feed efficiency when focus on feed intake (FI), feed efficiency (FE), food conversion ratio (FCR).

The protein quality of *Channa striatus* diets contained Commercial feed was decreased ($P<0.05$) when emphasized on protein efficiency ratio (PER). Percentage of protein and lipid were better in body of fish after fed with LMF feed than CF feed.

The price of LMF feed was also less than the CF feed. After observing all situations this study recommend that LMF feed would be best for *Channa striatus*

Many people especially in rural area do not know indigenous ingredients is how effective for the culture of fish. As local indigenous ingredient are much nutritious proved in this study, so by using LMF feed farmer can save money as well as they would get better production. Adopting this trend, unemployment will be removed and economy of Bangladesh will be increased.

The present study was done for only 40 days. It is necessary to take long time for culture to observe the growth performance. Only six ingredients were used in this study. Many known and unknown ingredients still present in Bangladesh those are not used. So taking different ingredient further study can be done to investigate the growth performance, feed utilization and body composition of fish.

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APPENDICES

APPENDICES

Table 4.1: Test of Homogeneity of Variances

DO

Levene Statistic	df1	df2	Sig.
.527	1	10	.484

Table 4.2: ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.004	1	.004	.139	.717
Within Groups	.316	10	.032		
Total	.321	11			

Table 4.3: Test of Homogeneity of Variances

pH

Levene Statistic	df1	df2	Sig.
.357	1	10	.563

Table 4.4: ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.002	1	.002	.032	.861
Within Groups	.663	10	.066		
Total	.665	11			

Table 4.5 : Test of Homogeneity of Variances

MBW

Levene Statistic	df1	df2	Sig.
.128	1	10	.728

Table 4.6: ANOVA

MBW

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.488	1	3.488	59.582	.000
Within Groups	.585	10	.059		
Total	4.074	11			

Table 4.7: Test of Homogeneity of Variances

SR

Levene Statistic	df1	df2	Sig.
.000	1	10	1.000

Table 4.8: ANOVA

SR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	117.188	1	117.188	2.195	.169
Within Groups	533.854	10	53.385		
Total	651.042	11			

Table 4.9: Test of Homogeneity of Variances

protein

Levene Statistic	df1	df2	Sig.
4.175	1	10	.068

Table 4.10: ANOVA

Protein

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.553	1	3.553	53.751	.000
Within Groups	.661	10	.066		
Total	4.214	11			

Table 4.11: Test of Homogeneity of Variances

lipid

Levene Statistic	df1	df2	Sig.
.501	1	10	.495

Table 4.12: ANOVA

Lipid

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.026	1	.026	10.439	.009
Within Groups	.025	10	.003		
Total	.051	11			

Table 4.13: Test of Homogeneity of Variances

moisture

Levene Statistic	df1	df2	Sig.
.773	1	10	.400

Table 4.14: ANOVA

Moisture

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.034	1	2.034	5.673	.038
Within Groups	3.585	10	.359		
Total	5.619	11			

Table 4.15: Test of Homogeneity of Variances

ash

Levene Statistic	df1	df2	Sig.
.115	1	10	.742

Table 4.16: ANOVA

Ash

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.013	1	.013	1.372	.269
Within Groups	.097	10	.010		
Total	.110	11			