Feed Management Practices in Freshwater Carp Culture

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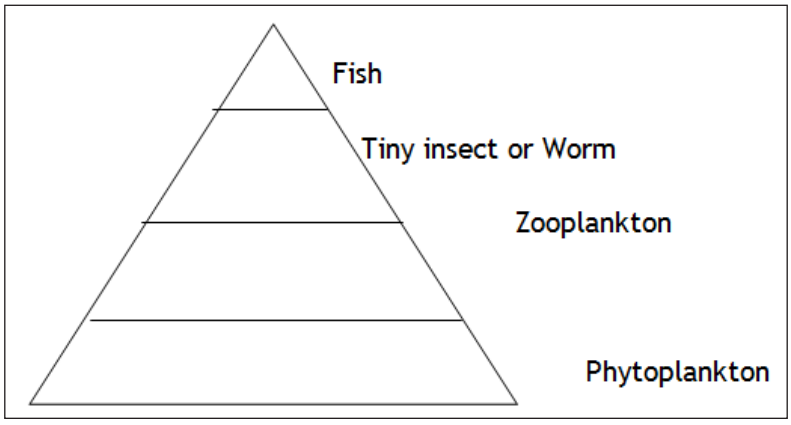
CHAPTER 1
INTRODUCTION

Aquaculture is one of the fastest growing industries in food production sector. However, the future of this growth will depend largely on feed based aquaculture but cost of feed accounts more than 50-70% of the operational cost. Fish consume different kinds of phytoplanktons, zooplanktons, bottom insects/ worms, larvae, caterpillars, larvae of small insects, bottom earthworm, etc. as feed from pond environment. The fish production depends on natural feeds fully in extensive and largely in improved extensive and semi intensive culture managements. The feeds are produced naturally in water bodies with soil and water of average fertility. The plants and animals found in aquatic environment are dependent on each other for food directly or indirectly. As a result, a nutrient cycle is always active in the ponds. This active nutrient cycle is known as food chain. An important part of the cycle is the release of inorganic nutrients by the decomposition of dead animal or organic matters. Therefore, the cycle is also known as saprophytic food chain.

The major elements of the food cycle in the ponds are the phytoplanktons, bacteria, aquatic plants, zooplanktons, small insects and worms of the bottom, fishes, etc. As they all are involved in production and consumption, they are known as producers and consumers. The position of the producers and consumers are at the three levels of the food chain. Such as

First level – Primary producers (Phytoplanktons and bacteria)
Second level – Primary consumers (Zooplanktons and herbivorous animals)
Third level – Secondary consumers (Zooplanktivorous fishes and carnivorous animals)

Fish and prawn eat zooplankton, phytoplankton, bottom insects, caterpillars, larvae of small insects, bottom earthworms, dead organic matters, etc. from pond ecosystem as food for their growth and survival. However, in high density fish culture using



modern technology, these natural foods cannot supply the necessary nutrient demand of fish. As a result, fish gradually become weak and their growth rate reduces that have negative impact on the overall fish production. To sustain normal growth of fish, application of supplementary feed in to the ponds along with maintaining an ecosystem suitable for natural food production is essential. Some of the important roles of supplementary feed in fish culture are given below

- Fish can be cultured at high stocking density.
- Fish reaches marketable size in short time.
- Fish mortality decreases at a large extent.
- More production from small water area.
- Disease resistance of fish increases.

CHAPTER 2
FERTILIZER APPLICATION

Natural food organisms farmed as result of fertilizer application are distributed in different layers of water body. As a result, fish of different species can consume the feed easily. Fishes of different species do not go through much competition for feed because of the adequate feed materials at different layers. Moreover, enough natural feed can be produced by the application of fertilizer for the fish species that do not show much interest for supplementary feed. Different nutrients of a balanced feed such as carbohydrate, protein, lipid, vitamin, minerals, essential amino acids and fatty acids are sufficiently present in natural feed. Accordingly, when fish eat natural feed, they grow rapidly with relatively lower incidence of disease infection and of problems related to nutrient deficiency. Therefore, the importance of post stocking fertilizer application in ponds is indispensable for profitable fish culture.

The two essential nutrients for phytoplankton growth are nitrogen and phosphorus and their easily accessible source is organic and chemical fertilizers. Therefore, regular application of cow dung, excreta of duck and chicken, urea and SSP (Single Super Phosphate) is recommended in the fish culture ponds.

Post stocking fertilizer application following a daily dose is advisable. However, if daily application is not possible, fertilizer can be applied in weekly basis/ installment. Fertilizer are applied either daily or weekly, the doses may differ due to a number of reasons. A model dose of post stocking fertilizer application per ha day is given as follows

Type of Fertilizer	Sample dose
Cow dung or Compost or Duck – chicken excreta	200 – 250 g 300 – 400 g 100 – 125 g
Urea	3-4 g
TSP	4-6 g

If daily application is not possible, then daily dose should be multiplied by 7 or by 15 to calculate the weekly or fortnightly dose.

2.1. Fertilizer application methods

Cow dung and SSP (single Super Phosphate) either together or separately should be soaked in three times more water in a bucket or drum for 12 – 24 hours. SSP must be mixed well with water. Before application, urea should be mixed with the solution of cow dung and SSP and then the mixture should be evenly distributed to the entire pond in a sunny day at around 10 – 12 am in the morning.

Lime Application

Cow dung application

2.1.1. The importance of organic fertilizers

- The water retaining capacity of sandy and loamy soil increases as a result of organic fertilizer application.
- Soil fertility increases.
- More or less all nutrient contents necessary for phytoplanktons are available in organic fertilizers.
- Preparation of organic fertilizers is not very costly and ingredients are easily available.
- Organic fertilizers release nutrient in the pond water by decomposition over relatively long duration.

2.1.2. Cautions in fertilizer application

- Fertilizer application should be stopped temporarily if the water turns to deep / excessive green.
- No fertilizer application in a cloudy day or day with low pressure.
- Urea loses its efficiency if kept open in the air.
- Fertilizers are less effective in acidic and turbid water.
- Mixed fertilizers should be mixed well before application.

CHAPTER 3
PRINCIPLES OF FEED FORMULATION

Feed formulation is a complicated process which involves the appropriate selection of feed ingredients and blended to produce a diet with the required quantities of essential nutrients. By selecting various ingredients in correct amounts, a compounded ration which is nutritionally balanced, pelletable, palatable and easy to store and use may be formulated. The process of diet formulation involves a difficult choice between two approaches that can be represented on the spectrum of feed cost. At one end of the spectrum is the approach of basing the formulation solely on nutritional value, thereby producing a more expensive feed that is more productive. The other end of the spectrum is the approach of basing the formulation solely on the total feed cost and attempting to minimize that cost. The vast majority of feed formulation falls somewhere in the middle of the spectrum, but the type of feed being formulated will dictate which determinant, nutritional value or feed cost is more important.

3.1. Pre-requisite information for feed formulation

For feed formulation of fish, we must have the following pre-requisite information

i. Food and feeding habit of targeted fish
ii. Nutritional requirement of targeted fish at different life stages
iii. Local availability of feed ingredients
iv. Cost of locally available feed ingredients
v. Chemical composition of feed ingredients
vi. Digestibility of the nutrients of available feed ingredients
vii. Anti-nutritional factors present in the ingredients
viii. The processing or pre-treatment technique of ingredients for removal of anti- nutritional factors.
ix. Inclusion level of feed ingredients
xi. Information about the additives
xii. Season and environmental conditions (temperature)
xiii. Pellet stability

The above mentioned information should be critically considered before making pellets which may otherwise affect the quality and economics of the feed.

3.2. Food and Feeding habit of finfish

Species	Food habits	Feeding habits
Catla catla	Omnivorous & planktonivorous preferably	Surface feeder
Labeo rohita	Herbivorous & planktonivorous	Column feeder
Cirrhinus mrigala	Omnivorous & planktonivorous	Bottom feeder
Hypophthalmicthys molitrix	Omnivorous & planktonivorous	Surface feeder
Ctenopharyngodon idella	Herbivorous preferably aquatic weeds & planktonivorous (in early stages of life)	Column feeder
Cat fishes	Carnivorous & planktonivorous	Bottom feeder

3.3. Nutritional requirements of targeted fish at different life stages

As species, strain, stages of development, health, water temperature and other environmental conditions affect the nutrient requirement of the cultured species; likewise the requirements of micro-nutrients do not vary widely between species and may generally be met by standard commercial vitamin/mineral premix supplementation. So the feed should be formulated for a particular species with respect to the life stage and accordingly feed for finfishes can be categorized as

i) Larval feed ii) Starter feed or fry feed iii) fingerling feed iv) Grower feed v) Broodstock feed

3.3.1. Estimated dietary protein requirements of carps and prawn

Species	Crude protein level in diet (%)
Catla catla	50-55 (larvae) 40-45 (young and brood stock) 28-30 (adult)
Labeo rohita	50-55 (larvae) 40-45 (young and brood stock) 28-30 (adult)
Cirrhinus mrigala	50-55 (larvae) 40-45 (young and brood stock) 28-30 (adult)

Hypophthalmichthys molitrix	50-55 (larvae) 37-42 (young and brood stock) 30 (adult)
Ctenopharyngodon idella	50-55 (larvae) 38-40 (young and brood stock) 30-33 (adult)
Cyprinus carpio	50-55 (larvae) 38-40 (young and brood stock) 30-33 (adult)
Macrobrachium rosenbergii	50-55 (larvae) 35-40 (young and brood stock) 28-30 (adult)

3.3.2. Essential aminoacid requirement (% dietary protein)

Aminoacid	Rohu	Catla	Mrigala	Common carp
Lysine	5.58	6.23	5.8	5.7
Methionine	2.88	3.55	3.18	3.1

3.3.3. Essential fatty acid requirements

Fish/prawn	Requirement
Catla	Combination of n-3 and n-6
Common carp	1% 18:2 n-6 and 18:3 n-3
Grass carp	1% 18:2 n-6 & 0.5-1.0 % 18:3 n-6
Cat fish	18:2 n-6 and 18:3 n-3
M.rosenbergii	HUFA n-3

3.3.4. Carbohydrate requirements

Carbohydrates have been shown to have a sparing effect on utilization of dietary protein in many aquaculture species. Proper dietary balance of carbohydrate would enable fibre to move other nutrients in the gastrointestinal tracts for proper digestion. Carps, Tilapia and Prawns efficiently utilize carbohydrate as energy.

Fish/prawn	Requirements (%)
IMC	22-26
Common carp	30-40
Salmon	6-15(as gelatinised starch)
Freshwater prawn	35-40(as Crude fibre)

3.3.5. Dietary protein: energy ratio

The condition where energy intake is inadequate, energy is drawn from protein sources. Excess protein is not only wasteful and uneconomical but also causes stress to fish and aquatic pollution as well. Diet containing excess energy leads to lipid accumulation resulting in fatty fish. Therefore, properly formulated feeds have a well-balanced protein to energy ratios. Practically to economize the formulation, protein should be adjusted in such a way that it can be only utilised for growth purpose and energy should be obtained from non-protein sources i.e., lipid and carbohydrate.

3.3.6. The optimum P: E ratio is known to be size related and is higher in small fishes

Species	P:E ratio (mg/kcal)
Catla fingerling	97.3(40 % dietary protein)
Rohu fry	113 (40 % dietary protein)
Rohu fingerling	95 (38 % dietary protein)
Common carp	108
Cat fishes	87.6
Freshwater prawn	90-95 (35-40 % dietary protein)

3.3.7. Vitamin requirement

Supplementation of vitamin C and E in broodstock diet increases viable egg production. Larval diet should be over fortified with vitamins particularly with vitamin C, which protect larvae from stress.

Dietary vitamin requirement of carps and prawns

Vitamin	Carps	Prawns
Thiamin (mg/kg)	2-3	**50-100**
Riboflavin(mg/kg)	4-7	**30-58**
Pyridoxin (mg/kg)	5-10	**30-50**
Pantothenate (mg/kg)	30-40	**50-100**
Niacin (µg/kg)	150	**100-150**
Cyanocobalamin	_	**0.02-0.1**
Ascorbate (mg/kg)	30-50	**50-100**
Vitamin A(I.U/Kg)	**1,000-2,000**	**5000-10,000**

3.3.8. Minerals requirement

Phosphorus level in water is generally low; therefore it has to be compensated through dietary supplementation. Other minerals from aquatic sources can fulfill the requirement partly for fish and prawn; so no need to be supplemented through the diet. Calcium and phosphorous ratio should be 2 or 1.5:1 in the diets of carps and prawn. Phosphorus and trace minerals (Fe,Mn and Zn) deficiency in brood stock diet reduce viable egg production.

Species	Calcium (% or mg/kg feed)	Phosphorus (% or mg/kg feed)
Mrigal	0.19	0.75
Common carp	<0.1	0.6-0.7
Cat fishes	<0.1	0.45

3.4. Local availability and cost of ingredients

Ingredients should be selected in a formulation on the basis of local or regular availability and cost without deviating from the quality of feed.

Approximate cost of ingredients of plant and animal origin available in India used for carp and prawn feed formulation is given below.

Ingredients	Cost (Rs/ kg)
Coconut oil cake (COC)	18.00-20.00
Maize	9.00-10.00
Ground nut oil cake (GNOC)	40.00-48.00
Rice bran	8.00-12.00
Fish meal	20.00-30.00
Acetes	50.00-150.00
Poultry waste	20.00-30.00

3.5. Chemical composition of feed ingredients

The composition of feedstuffs are known to vary seasonally, regionally and also with soil fertility and type of processing and storage method adopted. Therefore, it is desirable that each batch of feed ingredient should be analysed for actual nutrient content prior to feed formulation. Chemical compositions of few feed ingredients of fish and prawn available in India are given below.

Ingredients	Moisture (%)	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Total Ash (%)	Nitrogen Free Extract (%)
Rice Polish	8.4-12.6	11.4-14.5	15.3-17.3	7.5-11.0	6.0-12.9	41.0-46.8
Rice bran	7.8-10.1	2.9-12.6	4.2-11.3	5.3-19.3	3.1-20.5	36.5-37.5
Deoiled rice bran	7.2-8.1	12.1-14.3	1.3-1.8	15.2-16.7	23.8-29.1	40.4-43.3
Wheat bran	9.0-13.0	8.2-15.8	2.6-6.6	4.0-13.5	0.2-4.2	34.5-37.6
Groundnut oil cake	7.0-10.0	42.0-48.0	7.3-13.8	13.0-13.2	2.5-13.4	25.2-29.2
Sunflower cake	8.0-10.0	31.0-32.6	2.1-2.9	18.4-24.7	1.5-6.2	39.0-40.1
Soya bean meal	3.0-11.8	46.0-32.8	2.1-2.9	18.4-24.7	1.5-6.5	39.0-40.1
Mustard oil cake	8.5-9.2	23.6-30.8	9.3-9.6	6.2-6.3	10.3-10.4	34.9-40.9
Corn or Maize	10.4-10.6	4.6-5.0	7.8-8.0	3.5-4.0	1.0-2.0	72.7-75.0
Wheat flour	12.6-12.9	14.5-15.6	3.7-3.9	2.7-2.9	2.3-2.8	64.2-64.6
Fish meal	9.0-14.6	14.4-72.0	2.5-10.3	0.3-30.0	2.5-20.9	7.0-29.0

3.6. The processing or pre-treatment technique of ingredients for removal of anti-nutritional factors

In-spite of the presence of anti-nutritional factors, these ingredients are incorporated into experimental fish feeds, particularly in case of soyabean,in commercial diet, Wee (1991) reviewed the results of tropical species and concluded that with proper pre-treatment, most of the ingredients can be utilized to replace 20-30 % of fish meal protein without compromising growth.

- Almost all the protein inhibitors are heat labile and will be broken down when cooked.
- Like protease inhibitors, plant haemagglutinins such as lectins are also heat labile.
- The mimosine content of ipil-ipil can be reduced by soaking in water, 5making it suitable for incorporation into fish diets.

3.6.1. Anti-nutritional factors present in different feed-stuffs

Compounds	Found in
Glycosides	Grass and leaves
Phytates	All plant food tuffs
Mycotoxins	Cereal based meals
Cyclopropionic fatty acids	Cotton seed oil and meal
Trypsin inhibitors	Soya and rape seed meal
Glucosinolates	Rape seed meal
Mimosine	Leaves(*Leucaenaleucocephala*)
Gossypol	Cotton seed meal
Tannins	Rape seed meal
Histamine and Putrescine	Fish meal, primarily Tuna

3.7. Inclusion levels of feed ingredients:

In all fish feed formulation, limits are place on the levels of certain ingredients, irrespective of cost. These limits may be upper limits, lower limits or fixed limits, meaning that the level of an ingredient is set at a fixed percent. Upper limits are often placed on ingredients which may contain antinutritional factors or toxicants on ingredients which affect the palatability or pelletability. Lower limits are placed on ingredients which are desirable in the formulation despite their cost. For example, fish meal may be an expensive source of protein in feed formulation and replacing fish meal in the formulations with rendered animal proteins may reduce the feed cost. In general, carp diet should contain 40-45 % protein rich ingredients, 40-50 % carbohydrate rich ingredients and rest fulfilled with lipid and other ingredients.

3.8. Type of feed

The type of feed particle being produced determines to a large extent the limits placed on the levels of many ingredients in a feed formulation. Dry compressed pellets, for example, must contain adequate level of wheat by-products to allow the exterior surface of the pellet to gelatinize during pelleting. If pellets are to be crumbled and screened, additional considerations must be given during feed formulation to ensure pellet hardness. In most pellet or semi-moist pellet formulations, the ingredients must be chosen with the water content of the pellet in mind. Ingredients that act as pellet

binders, such as pre-gelatinised potato starch, must be included at levels that provide sufficient binding capacity to produce a high quality pellet. In formulations containing moisture levels higher than 30-35%,such as those containing liquefied fish products or ground fishery waste, additional binders must be used. In extruded, dry pellet formulations, ingredients that can expand and thus produce low-density pellets must be included. Finally, in semi purified diets, highly refined ingredients must be used to produce diets suitable for experimental use

3.9. Feed additives

An increasing diversity of additives in animal feed stuffs, including synthetic amino acids, vitamins, binders, antioxidants, preservatives, prophylactic medicines, hormones and growth promoters. Most of these have very specific uses and may be non-nutritive. The major synthetic amino acids available for supplementation are L-lysine and DL-methionine.These are used as chemo-attractant at the rate of 0.05 % as well as to supplement deficiencies in a compounded feed. Vitamin premix is added to practical diet at levels ranging from 0.5-4 % of the diet. Mineral premixes are concentrates of essential elements that are fortified in practical fish diets to make up for low levels in the formulations or to overcome antagonist interactions among feed ingredients. In plant protein based diet, supplementation of mineral premix is recommended at 1 % level of diet. Binders are substances used in diets to improve their pelletability, water stability, physical stability, etc during storage. Commonly used binders in compounded feeds are Carboxy methyl cellulose (CMC), hemicelluloses, betonites, agar, carrageenan, collagen, guar gum, starch powder, etc. Starch can be added at 20 % level in the diet where as other binders may be added at 1-2 % level in the diet. The commercially available anti-oxidants such as BHT (Butylated Hydroxyl Toluene),BHA (Butylated Hydroxy anisole) and ethoxyquinon at 0.5 % level can be added in the diet to prevent rancidity of lipid in the diet. Probiotics and enzyme (especially phytase) supplements in the diet through spraying on feeds after pelleting are also beneficial.

CHAPTER 4
METHODS OF FEED FORMULATION

4.1. Steps in diet formulation:

i. Balance CP as desirable
ii. Check and balance the energy content and P: DE
iii. Check and balances of EAA, EFA, CF and TA

Diets are formulated to fulfil the energy, protein and energy protein ratio of the diet. If energy and protein content of the diet is satisfied then other nutrients is required, if necessary. Different mathematical techniques are used to balance the nutrient content of the diet.

Three important methods used for feed formulation are; i) Pearson's Square Method ii) Trial and Error Method iii)Quadratic Equation Method

4.2. Pearson and Trial and Error Method

Pearson's Square Method is used to balance the protein followed by reorientation of formulae by Trial and Error Method to finalize protein and energy level in the diet.

i. Pearson's square formula gives preliminary idea about formulation by balancing the protein.
ii. With the help of Trial and Error method, all the nutrient level in the feed will be balanced perfectly. By doing so accurate ingredient incorporation can be calculated.

An example of feed formulation is stated below:-

Example:

Prepare a diet having 30 % crude protein (CP) and 3100 kcal/kg digestible energy (DE) by using the ingredients namely Fish meal (60 % CP and 4060 kcal/kg

DE), Ground nut oil cake (GNOC) (40 % CP and 3500 kcal/kg DE), Deoiled Rice Bran(DORB)(12 % CP and 2110 kcal /kg DE) and Maize (9 % CP and 2200 kcal/kg DE).

First of all, required protein level of the diet should be adjusted using Pearson's Square Method with the following steps,

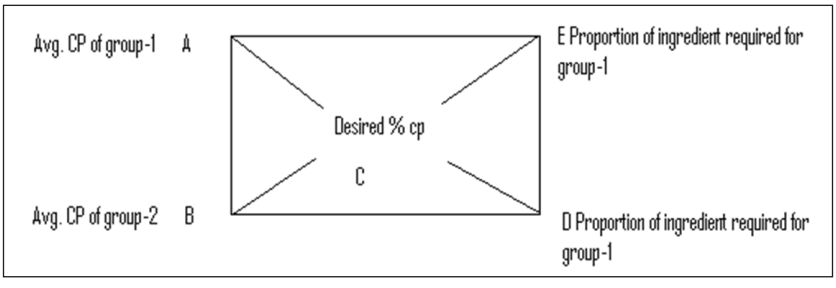
Step-1:

Fix the amount of some selected item (costly ingredients) considering economic point of view. Suppose the fish meal is fixed at 15 %.So, fish meal (15 %) will contribute 9 % protein in the diet (i.e. 15 X 0.60 = 9.0). Therefore, the other 85 % of the ingredient will have to make up rest 21 % of the protein. If this proportion of the formulation is treated separately, the non-fish meal portion of the diet must contain 21 X 100 /85 = 24.70 % of CP.

Step-2:

All the ingredients should be divided into two groups. One group should contain those ingredients having more than 20 % CP (energy rich ingredients). Other group should contain those ingredients having less than 20 % CP (energy rich ingredients). Accordingly GNOC should be placed in one group and DORB and maize should be placed in other group. So group-1 contains GNOC and average protein is 40 %. Similarly group-2 contains rice bran and maize (50:50) and average protein =(10 + 9)/2 = 10.5 %

Step-3:



Step-4:

The actual amount of ingredient to be used.

GNOC= (14.20 X 100) / 29.50= 48.13 %

DRB + Maize (50:50) = (15.30 X 100) / 29.50=51.86 %

So, DORB requirement=51.80/2=25.93 %

Maize requirement=51.86/2=25.93 %

Step-5:

These requirements however should constitute only 85 % of the mixture. Therefore, the amount of GNOC, DORB and maize to be incorporated in the final mix is 40.92 % (48.13 X 0.85), 22.04 (25.93X0.85) and 22.04 (25.93X0.85) respectively.

So, for balancing the 30 % CP level in the ingredients required are Fish meal-15 %, GNOC-40.19 %, DORB-22.04 % and maize-22.04 %.

4.3. Quadratic Equation Method

The simple equations like A+B=100 or A+B+C=100 are used for the preparation of composite feed mixture using 2 or 3 ingredients, respectively. The equations of two ingredients are used for determining the level of any one nutrient, i.e. either CP or TDN/DE/ME, whereas that with three ingredients may be used for the calculation of both protein (CP/DCP) and energy (TDN/DE/ME) contents in the mixture provided the ingredients selected for the preparation of concentrate mixture or complete feed contain lower as well as higher values of the nutrients to be worked out.

Example: 1

Compute a concentrate mixture of 20% CP content with the algebraic method from the following feed ingredients.

Ingredients	CP%
Crushed Maize	9
Mustard Cake	31

Suppose, maize is A and mustard cake is B, then,

	A+B	=	100	equation (i)
And	0.09 A+0.31B	=	20	equation (ii)

Now multiply (i) with 0.31 to get the following equation,

	0.31A+ 0.31B	=	31	equation (iii)

Now solve the equations by subtracting (ii) from (iii),

	0.31A+ 0.31B	=	31
	0.09A+0.31B	=	20
	0.22A+0	=	11
Hence,	A = 11/0.22	=	50

Substituting the value of A in equation (i),

50 + B	=	100
B = 100 – 50		
B = 50		

Thus, the mixture will be prepared by mixing equal amount (by weight) of maize and mustard cake.

Chapter 5
Supplementary Feed

The additional feeds that are applied externally along with the natural feeds in water to ensure rapid growth of fish and to obtain high production in relatively short period of time are known as supplementary feed. To ensure normal growth of fish, presence of necessary amount of all nutrient materials like protein, carbohydrate, vitamin and minerals in fish feed is essential. The normal fish growth hampers if any of the nutrient material of necessary quantity is not present in fish feed. In high density fish culture using modern technology, only natural feedcannot fulfill the demand of fish for all the nutrients. To fulfill these demands of fish, different types of feeds from external sources should be applied in the ponds regularly. The feeds generally applied in fish ponds by the farmers of our country can be divided in to two types based on their sources. Such as plant source and animal source.

Plant origin: Rice bran, wheat bran, broken rice, flour, molasses (sticky), mustard oil cake, duck weed, Azolla, soft grass, banana leaves, papaya leaves, potato leaves, drumstick leaves, Napier grass, etc.

Plant based feed ingredients

Animal origin: Fish meal, powder of prawn/ shrimp head, crab powder, silk worm pupae, snail meat, blood of livestock animals, offal of duck or chicken.

Fish meal

Shrimp meal

5.1. Selection of ingredients

To prepare a fish feed, low cost and high quality ingredients should be selected in such a way that the prepared feed fulfills the nutrimental requirement of fish, the quality of feed is ensured and the feed preparation requires low investment. The supplementary feed able to meet up the nutritional requirement of fish can be prepared from the common feed ingredients available in our country like oil cake, rice bran, wheat bran, fish meal, flour, molasses, etc. Considering the financial ability and nutrient requirement of fish, samples of mixed feed at different ratios are given below.

Dose of different ingredients in the feed preparation for carps

Name of ingredients	Sample 1		Sample 2		Sample 3	
	% used	g / kg feed	% used	g / kg feed	% used	g / kg feed
Rice bran	40	400	20	200	10	100
Wheat bran	-	-	10	100	35	350
Broken rice	-	-	10	100	20	20
GNOC	25	250	40	4000	20	20
Coconut oil cake	15	150	0		0	
Fish meal	10	100	0		10	100
Mustard oil cake	0	-	10	100	0	0
Flour/ molasses	10	100	10	100	5	50
Vit& min mix		1 spoon		1 spoon		1 spoon
	100	1000	100	1000	100	1000

In addition to mixed feed, duck weed, Azolla, soft grass, winter vegetables, banana leaves, papaya leaves, potato leaves, drumstick leaves, Napier grass, etc. should be provided if grass carps are included in carp poly culture. Grass carp can consume green plants up to 40 – 45 % body weight daily. As the individual fish size increases, the feeding rate decreases, however, total amount of feed increases. Daily ration (%) based on the fish size is given in the following table.

Relationship between weight of fish and ration size

Average weight (g)	Daily ration (%)
1 – 5	10
5 – 10	5
10 – 50	4
50 - 500	3

5. 2. Preparation of supplementary feed

Fish feed can easily be prepared using different ingredients. Fish farmers can also prepare feed by themselves. If possible feed can be prepared using feed pelleting machine. The preparation techniques of mixed fish feed is described briefly here.

Oil cake soaked in water

- Required quantity of oil cake should be soaked in double quantity of water at least 20 – 24 hours. ago and oily water from the surface of the mixture should be thrown away.
- Rice bran and fish meal should be sieved properly.
- Broken rice should be boiled, if used.
- All the ingredients should be mixed thoroughly in a container.
- Flour should be boiled in necessary water to make it sticky.
- Ingredients should be mixed with sticky matter to form paste and finally small feed balls should be prepared.

5.3. Supplementary feed application

Normally fish feeds during the day. For that reason, the daily ration should be

divided into two portions. One portion should be applied in the morning at around 10 – 11 am and other portion in the afternoon at 3 – 4 pm. Feed should be applied in feed trays to avoid feed loss and to maintain good water quality. To feed carps, the feed trays should be placed 1 foot below the water surface. If feed tray is not possible by any reason, feed should be applied daily in a few particular locations of pond bottoms.

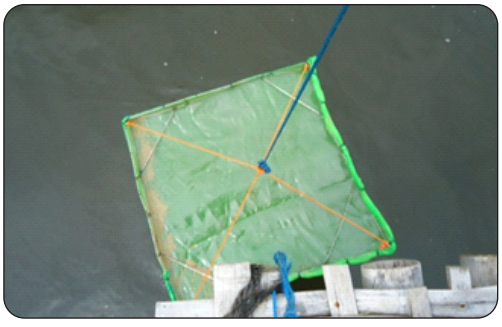
5.3.1 Green feed application:

The feed for grass carp and puntius should be applied in rectangular or circular feeding rings made by bamboo split or other materials. The frame should be set at 1- 2 m distance from the embankment. For a 0.3 ha pond the volume of the frame is, generally, 10.76 square feet. Leafy plants should be applied as pieces in the frame. Banana leaves need to be made into small pieces as well.

5.3.2. Feed tray:

Feed application in trays saves money and ensures proper utilization of feed. In addition, estimation of feed quantity becomes easier.

Making of feed tray: The size of feed tray can be 10.76 square feet or 80×80 cm. The tray can be prepared with a mosquito net tied in a bamboo or wooden frame. The height of the frame should be 4 inches. Two, four and six feed trays should be placed, respectively, in 0.3 ha, 0.6 ha and 1 ha ponds. If used, feed trays should be cleaned regularly.



Checking tray

5.3.3. Cautions in feed application

- Feed should be applied daily at the same time and same location.
- Feed trays should be checked now and then to examine the amount of feed consumed (if thereany leftover) and readjust feed quantity.
- If water turns to deep green, feeding should bereduced or stopped for the time being.

Feed broadcasting by boat

CHAPTER 6
FEEDING STRATEGIES

There are some unique practices followed by the Andhra fish farmers in feeding and feed management based only on their experience. Fish fed to satiation through demand feeding shows higher growth rate in terms of weight gain and protein gain. Specifically defined feeding strategies have been adopted to minimize feed wastage and nutrient loss by leaching and to maximize growth. Andhra Pradesh remains a pioneering State in Indian aquaculture because of the innovative thinking and experimental ability of its fish farmers, who have developed their own successful feeding strategies that have contributed to boosting aquaculture production in the country. The feeding strategies employed are outlined below.

6.1. Bag feeding

Mainly for carps they practice a different type of feeding termed as "bag feeding" in which, the semi-moist mash of feed ingredients are filled in perforated bags and suspended in the water column by tying from dykes or with the help of small boats based on the size of the pond. The fishes feed by nibbling through the holes of the bag upto their satiation level, thus avoiding over feeding and thereby reducing pollution of the pond water to a greater extent. The bags are replenished with the mashed feed twice a day, in the morning and evening respectively. The number of feed bags that has to be provided ranges from 20-25 per hectare and the FCR rangesfrom 1:2.5 to 1:3.5.

Bag feeding

Broadcasting

6.2. Broadcasting

A section of the fish farmers of Andhra Pradesh also use commercially available feeds since the cost of feed ingredients fluctuates frequently. The available feeds are either sinking or floating type; mainly sinking feeds are used for carps, whereas floating feeds are used for Pangasius. The market price of the available pelleted feeds ranges from Rs. 18-24/kg of feed. The feed pellets are broadcast from the dykes or with the help of small boats based on the size of the pond; broadcasting is done twice a day. They report an FCR of 1:1.2 to 1:1.5 with the use of commercial feed pellets. Also the water quality deterioration is much less with the use of commercial pelleted feeds when compared to mash feed.

6.3. Stop feeding

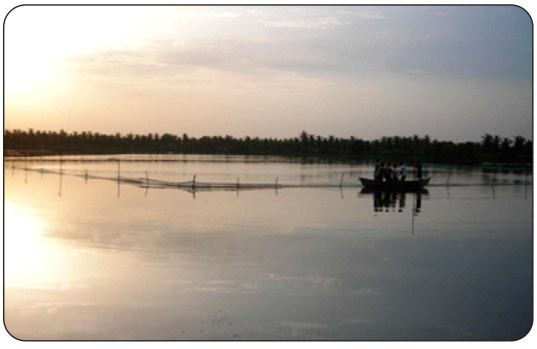
These farmers employ a simple feed management practice of not feeding the fishes at regular intervals. Generally, the fishes are not fed one day in every ten days and this allows the farmers to eliminate the cost of feeding for that particular day and ultimately the cost of production is cut down significantly. This practice of stop feeding is scientifically well supported by the fact that starvation and subsequent feeding enhances feed intake and improves growth rate through compensatory growth mechanism.

6.4. Break feeding

One of the basic principles in feed management is that, an increase in the feeding frequency will lead to a uniform size of the population. When the total feed ration per meal is applied at a single time, the larger fishes or shooters dominate and consume most of the feed and the relatively smaller fishes only get the leftovers. This leads to largely unequal size of fishes during harvest which affects the market price of the produce. To solve this problem, these farmers have devised anew technique known as break feeding in which the ration for each meal is split into two portions and applied at an interval of 20-30 minutes. The dominant fishes are fed to their level of satiation by the first portion, so that the smaller fishes also get to feed to satiation from the second portion of the ration and this helps to minimize size variation at harvest.

6.5. Feeding enclosures

The fish farmers are so concerned about every single penny they invest in the farming. This is the reason why some of them maintain a feeding enclosure in each pond while using floating pelleted feeds. The feeding enclosure is a small area in the centre of the pond enclosed on all sides by netting which extends one foot above and below the surface of the water column and is fixed in place using bamboo poles. The floating feed pellets are broadcasted only inside this netting enclosure to ensure that the pellets do not drift and accumulate in the shoreline of the pond due to wind action. In this way the feed is made easily accessible to the fishes in a specific area where the fishes can aggregate and feed, thus preventing wastage of feed.



Feeding Enclosure

Gelatinization process

6.6. Gelatinisation

Gelatinisation is a process by which the bound starch granules in some plant based feed ingredients is converted into an easily digestible and more bio-available form by means of cooking. Some of the fish farmers in Andhra Pradesh practice a method of cooking broken rice and feeding it to the fishes as a mash mixture in feedbags simply based on the common sense that cooking improves digestibility and thereby enhances growth. However, this method of cooking is not generally practiced for carps, but is used mainly in the case of catfish production.

Chapter 7
Feed and Ingredients Storage

Feed storage is keeping of ingredients for longer time and without significant alterations in their physical form, chemical composition and feeding value.

Dos and Don'ts

- Purchase required quantity of ingredients so that you do not need to keep great quantity in stock.
- Always keep the store clean.
- Make small sack.
- Ensure that ingredients are clearly and neatly labelled.
- Don't walk over the feed bags.
- Feed should not be stored in direct sun light. This would adversely affect the vitamin and lipid quality of the feed.
- Feed should be used within 2-3 months of manufacturing.
- Feed should be stored on wooden spacers not more than 5 bags high to maintain air circulation.
- Feeds store should be 100% water proof and damp proof.
- Proper ventilation should be provided.
- Dry feed should be stored under cool and dry condition with temperature of < 20°c and humidity < 70%.

7.1. Record keeping in feeding

Record keeping is an important part of aquaculture practice which helps to identify the mistakes in any of the steps. In case of on-farm produced feed, the following parameters like date and time of manufacture, source and cost of each ingredient should be kept in record. Other details to be recorded are coming under the category of the feeding procedure and the effectiveness of the feeding which includes, date and time of feeding, amount of feed per feeding, growth rate, response of the fish to feed, any mortality, quantity harvest and special comments.

CHAPTER 8
CONCLUSION

Plankton plays a major role in sustaining fish growth and optimizing FCR. The contribution of phytoplankton to the nutrition of the fish is of major importance,as it comprises the majority of the naturally produced feed, and is the preferrednatural feed of the dominant species, rohu. However, the feed that is derived from the natural productivity of the pond water is not taken into consideration when calculating FCR.The production from the water bodies can easily be increased to more than five folds by the application of supplementary feed along with ample natural feed in semi intensive type of fish culture.With the ever increasing demand of fish it has become very important to turn the fish production from aquaculture for which feed inputs would be required to sustain stocks at higher densities.

Notes