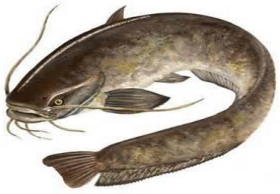
Extension Manual on Quality Low-Cost Fish Feed Formulation and Production

First Edition



TAAT Aquaculture Compact

Authors

Fregene, Bernadette Tosan [1], Rodrigue Yossa[2] Harrison C. Karisa[3], Paul Ibukun-Olu Boloruduro[4] and Ajibola Abeni Olaniyi[1]

Authors' Affiliations

WorldFish Nigeria, IITA, Ibadan, Nigeria[1], WorldFish Headquarters, Penang, Malaysia[2] WorldFish Egypt Office, Cairo, Egypt[3] National Agricultural Extension and Research Liaison services, Ahmadu Bello University, Zaria, Nigeria[3]

Citation

This publication should be cited as: Fregene B. T., Rodrigue Yossa; Karisa, H. C., Boloruduro P. I., and Olaniyi A.A, Extension Manual on Quality Low-Cost Fish Feed Formulation and Production: (First Edition): Technologies for African Agricultural Transformation (TAAT) Aquaculture Compact, WorldFish, 2020

Acknowledgments

This work was undertaken as part of the Technologies for African Agricultural Transformation (TAAT) Aquaculture Compact project funded by African Development Bank. This publication was made possible through support provided by WorldFish and National Agricultural Extension and Research Liaison services, Ahmadu Bello University, Zaria, Nigeria.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

Plate 9: Locally made fish feed being sundried

MODULE 1

1.0.INTRODUCTION

Learning Outcomes/Learning Activity Bundle

Pre-Evaluation with Feedback

1.1: Importance of Good Quality Feeds

1.2: Feedstuffs in fish culture

1.3: Considerations in Choosing Feed Ingredients and Formulation

1.4: Nutrients Requirement of the Fish

1.5: Nutrient Composition of Feedstuffs

1.6: Processing of the Feedstuffs

1.7: Non-Conventional Fish Feed Resources

1.8: Workers' Safety

Leaning Activity

Facilitation Methods:

Learning Materials

Output Evaluation/with Feedback

MODULE 2

2.0. FORMULATION AND PRODUCTION OF AFRICAN CATFISH FEED

Learning Outcomes/Learning Activity Bundle

Pre-Evaluation with Feedback

2.1: Nutritional Requirements of Catfish

2.2: Catfish Feed Formulation and Production

2.3: Considerations in Producing Pellets and extruded Catfish Feed

2.4: Biosecurity in Catfish Feed Production

Leaning Activity

Facilitation Methods:

Learning Materials

Output Evaluation/with Feedback

MODULE 3

3.0. FORMULATION AND PRODUCTION OF TILAPIA FEED

Learning Outcomes/Learning Activity Bundle

Pre-Evaluation with Feedback

3.1: Nutritional Requirements for Tilapia

3.2: Tilapia Feed Formulation and Production

3.3: Considerations in Producing Pellets and extruded Tilapia Feed

3.4: Biosecurity in Tilapia Fish Feed Production

Leaning Activity

Facilitation Methods:

Learning Materials

Output Evaluation/with Feedback

MODULE 4

4.0. FEEDING THE FISH

Learning Outcomes/Learning Activity Bundle

Pre-Evaluation with Feedback

4.1: Fish Feeding Habits

4.2: Quantity of Feed

4.3: Methods of Feeding Fish

4.4: Feeds Storage

4.5: Feed Grades and Feeding Management

Leaning Activity

Facilitation Methods:

Learning Materials

Output Evaluation/with Feedback

MODULE 5

5.0. BUSINESS PLAN DEVELOPMENT

5.1: Purpose of Business Plan

5.2: Business Profile

5.3: Organization and Products

5.4: Description of Management Team

5.5: Market Analysis

5.6: Financial Analysis

5.7: Sourcing for Capital/Grant

Leaning Activity

Facilitation Methods:

Learning Materials

Output Evaluation/with Feedback

Key Terms

Bibliography (Sources)

Additional Resources-Further Reading

Guide for Users

This material has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies to fish feed producers and fish farmers, in order to ensure profitable ventures. The contents are in simple terms for easy understanding. Learning objectives, activities, learning materials and facilitation methods are well highlighted. In addition, other key components of this module are instruments for the evaluation of the pre- and post-course and the course outputs and outcome. Moreover, feedback mechanisms are provided for periodic improvement of the manual. The learning objectives to be accomplished are based on activities properly scheduled and executed. The learning materials are packaged to acquaint fish feed producers and staff with necessary knowledge and skills for sustainable feed production.

The manual is an educational document. Therefore, trainers should run the sessions with necessary adjustments considering the knowledge and experience of the trainees. Training methodologies and technicality of each session are described in detail. These have been carefully planned to ensure active participation of the trainees in the training. Sticking to the methodologies will ensure the active participation of the trainees and the expected outcomes of the session will likely be achieved. The training sessions are arranged in sequences. Necessary information will be discussed within fixed time in each session. If necessary, the trainer, in light of his/her own experience, can change or modify the content of the session keeping main topic as it is. However, timely starting and ending the session is good for both trainers and trainees. Assessing the success of the training programme is important for both trainers and trainees. Therefore, learning of the trainees needs to be evaluated during and after the training. Instruments for evaluation assist in assessing how well the set targets have been met; while feedback enables assessment of overall progress leading to achievement of overall objectives.

Target Audience

The target audience for this manual is aquaculture training and extension specialists. The ultimate beneficiaries of this manual are mainly fish feed millers, including women, men and youth. Any other professional groups interested in active learning are also prospective beneficiaries.

One para about FISH CRP and BP resource development. (Florine can add it and adjust for tilapia production).

Background

Technologies for Africa Agricultural Transformation (TAAT) is a framework developed by the Africa Development Bank as part of its current efforts to foster the development of Agriculture on the continent. It aims to enhance the use of proven agricultural technologies among the stakeholders to foster needed change through farm level productivity and value chain development. Aquaculture is one of the nine commodity compacts with pre-screened technologies that have potentials for increased yield and benefits for up-scaling in 12 countries in Africa. These are: Benin, Burundi, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Ghana, Kenya, Malawi, Nigeria, Tanzania, Togo and Zambia. The TAAT Aquaculture Compact led by WorldFish has been training aquaculture Subject Matter Specialists (SMSs) and youth agripreneurs as facilitators under the capacity development and technology outreach.

Specific objectives of the Aquaculture Compact are: i) Creating an enabling environment for aquaculture technology adoption by the value chain actors; ii) Facilitate effective delivery of technologies to fish farmers and other actors along the aquaculture value chain; iii) Increase aquaculture production and productivity through the identification and dissemination of quality tilapia and catfish seeds, production of low cost fish feeds and value addition.

In Africa, fish feed constitutes 60%-80% of production cost, thereby conditioning the profit margin to fish farmers. Despite their high cost, some commercial fish brands on the market are of poor quality with attendant implications - poor fish growth, pollution of pond water and making fish prone to diseases and increased mortalities. Quality feed formulation is an integral part of profitable fish farming business. The fact that quality fish feeds are often imported, in the context of weak local currency, makes the cost of such products prohibitive for smallholders. Quality low-cost and well formulated fish feed will, among other management practices, improve the productivity of fish farming and increase farmers' income thereby contributing to farm profit, human nutrition and food security. The essence of this manual is to expose training officers and extension workers, feed millers and fish farmers to the best practices in quality fish feed production and facilitation techniques in disseminating the technology.

Rationale

The TAAT Aquaculture Compact has noted that some of the major challenges in fish farming in Africa is the high cost of fish feed and dominance of poor-quality fish brands in the market. These are dis-incentives that hinder the growth of the aquaculture industries across sub-Saharan

Africa. This material has been put together to assist extension workers and other trainers in facilitating and delivering improved technologies on quality and low-cost fish feed production in order to promote the growth of the aquaculture industry in the continent for increased productivity and income, thereby making more fish available for consumption in human diets. African catfish and Tilapia species promoted by TAAT Aquaculture Compact are the major focus in this Extension Manual. They have different nutritional requirements for growth, health and development.

Development Objectives

The development objectives of this material are:

i. Enhanced productivity of Catfish and Tilapia through quality feeds
ii. Increased income to feed millers and farmers, and
iii. Increased the availability of farmed fish on the market for improved nutrition.

Learning Objectives: *changed expected from learners in terms of change in behavior (knowledge, skills, and attitude)*

At the end of this training, participants should:

i. Have enhanced knowledge on nutrients needs of Catfish and Tilapia
ii. Acquire skills on quality fish feed formulation and production
iii. Acquire entrepreneurial skills in business plan development for sustainable venture
iv. Gain skills on how to share knowledge with other feed millers and fish farmers in their respective areas for increased catfish and tilapia production.

MODULE 1

2.0.INTRODUCTION

1ai. Learning Outcomes/Learning Activity Bundle

For each learning outcome, prepare triggering questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module

1aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide and this could be open or close-ended. Ten simple questions should be raised on Module 1

Pre-Evaluation Questions

1. *Which of the following is not a feedstuff for fish?*
   a) *Fish meal*
   b) *Rice*
   c) *Palm kernel*
   d) *Rice bran*
2. *Which of the following is an anti-nutritional factor?*
   (a) Vinegar (b)Leucine (c) Gossypol (d) Palm oil
3. *Why is food important for fish?*
4. *Give at least one importance of carbohydrate in fish feed*
5. *Give at least one importance of protein in fish feed*
6. *Give at least one importance of fats in fish feed*
7. *Give at least one importance of vitamins in fish feed*
8. *Give at least one importance of minerals in fish feed*
9. *Give at least one importance of water in fish feed*
10. *Why is processing of feedstuff important in fish nutrition*

1.1: Importance of Good Quality Feeds

Fish food consists of natural food and artificial (manufactured) feeds. When fish have balanced diet to eat, they grow fast and stay healthy. In natural waters and well-fertilized ponds, microscopic plants (phytoplankton), microscopic animals (zooplankton), insects, crustaceans, copepods and molluscs are examples of natural foods. Natural food organisms in the water will provide essential nutrients.

When natural foods are not available in sufficient quantity to provide adequate nutrients for fish growth and development, **supplementary feeds** that are manufactured or grown outside of the fishpond may be fed at regular intervals (daily, weekly, etc.). These feeds supplement natural foods. They are not nutritionally complete and will not adequately support fish growth in the absence of natural foods. Some examples of supplementary fish feeds are commercially produced rations for chickens and pigs, rice bran, cassava leaves, kitchen refuse, oil seed cakes or other agricultural products and by products. These are used in extensive or semi-intensive culture system.

In the total absence of natural foods as it is the case with recirculating aquaculture and indoor system, **nutritionally complete manufactured** feeds that contain all essential nutrients must be fed to fish. This is applicable only in high technology-based culture systems.

Artificial complete (or balanced) feeds are well-compounded mixture of feedstuffs and can be in mash or pellets form that could be fed to fish. Mash feeds are good for fry and pellets for fingerlings, juveniles and adults depending on pellet size. Although the use of artificial feeds may be costly, especially the commercially compounded ration, they have the following advantages in fish culture:

i. Enable high stocking density (stocking maximization) especially in polyculture system;
ii. They promote faster growth of fish, since food will always be available;
iii. High fish yield is guaranteed relative to the stocking density;
iv. Uneaten artificial feeds in the pond water will be biologically degraded. This acts as fertilizer to promote plankton growth;
v. A fish farmer while feeding the fish can study the behavior (activity) of fish and monitor their health.

Good quality feeds are also known as nutrient-dense diets; which refers to the amount or proportion of a particular nutrient in relation to the total amount of nutrients contained in the diet. Commonly, a nutrient-dense diet refers to being rich in protein and energy, and the amount

of the specific nutrient is represented in proportion to the total energy content of the diet. A simple, nutrient-dense diet can be rich in vitamins and minerals and have a low content of fat and relatively few calories (e.g., many fruits and vegetables are considered vitamin and mineral nutrient-dense foods). Fish feeds in general are nutrient-dense foods and low in calories. Fish feeds are high in protein and contain vitamins, minerals and polyunsaturated acids and omega-3 fatty acids, but low in sodium and total fats.

Good quality feed is key to fish production, without which the farmers will not achieve a profitable venture. Feed has a direct impact on growth rate, productivity and animal health as well as farm profit.

The following are importance of good quality feed:

- Good quality feed increases the income of producer;
- Absence of good quality food can predispose fish to diseases, including nutritional diseases (disease due to deficiency of certain nutrients);
- Good quality feed improves yield or quality of fish product.

1.2: Feedstuffs in fish culture

Feedstuffs are fish food materials/ingredients grown or developed for fish feeding or for manufacturing fish feeds. Artificial feeds are produced by carefully selecting and blending ingredients to provide highly nutritional diets that induce high growth, maintain the health of the fish and increase the quality of fish flesh and associated end products as fish oil and fish eggs.

Feeds and feed stuffs contain the energy and nutrients essential for the growth, reproduction and health of aquatic animals. Dietary nutrients are essential for the construction of living tissues. They also are a source of stored energy for fish digestion, growth, reproduction and the other life processes.

Feedstuffs for fish could be dry or wet (Plates 1 and 2). Dry feedstuffs are easy to store, transport and distribute to farmers or end users. Examples of dry feedstuff include: palm kernel cake, soy bean meal, fish meal, cereals etc. On the other hand, wet feedstuffs require special treatment before they can be fed to fish. Examples of wet feedstuffs include: brewery waste and molasses.



a) Palm Kernel Cake *b) Soyabean Meal* *c) Fish Meal*

Plate 1: Examples of Dry Feedstuff in Aquaculture


a) Brewers' Wastes *b) Molasses*

Plate 2: Examples of Wet Feedstuff in Aquaculture

Feedstuffs are classified into major groups in fish culture - energy feedstuffs and protein supplements.

i. *Energy Feedstuffs*: These are feedstuffs containing less than 20% crude protein. They are essentially of plant origin. Examples are cassava, wheat offal, rice bran, maize, guinea corn, etc.

ii. *Protein Supplements*: These are feedstuffs containing 20% crude protein or more. They are made either of plant or animal materials. Protein of animal origin is of higher quality than those of plant origin. Examples of animal protein sources in fish culture are fishmeal, bone meal, blood meal, poultry meal, etc. Soybean meal, groundnut cake and cottonseed cake are some examples of plant protein materials.

The dietary protein requirements for catfish and tilapia at various stages of growth are shown in Table 1.

Table 1: Dietary Protein Requirements for Catfish and Tilapia

S/No.	Common Name	Fish	% Crude Protein requirement.
1.	Tilapia	*Oreochromis niloticus*	
		Fry	35
		Fingerlings	30
		Juveniles and Adults	25
2.	African Catfish	*Clarias gariepinus*	
		Fry	50
		Fingerlings	40
		Juveniles and Adults	35
3.	Red Mud Catfish	*Heterobranchus bidorsalis*	
		Fry	50
		Fingerlings	40
		Adult	35

More details on the nutrient contains of feedstuffs and the requirements of tilapia, catfish and many other species are available free of charge at https://www.iaffd.com/home.html?v=3.13.

1.3: Considerations in Choosing Feed Ingredients and Formulation

Single feed ingredients may be fed to fish to supplement available natural food in a pond, but it is better to fertilize the pond than to feed a single ingredient. However, combining ingredients may make better quality supplemental feed. As a general rule, fish would grow well on a feed containing 20 to 30% crude protein, of which 2 to 10% of the protein is from animal sources. When natural food is abundant and fish are stocked at low densities, 20 to 25% protein content is suitable. Thirty percent (30%) or more crude protein content is more suitable for commercial operations where fish are stocked at higher densities and water exchanges are frequent.

In choosing feed ingredients, certain conditions must be met to achieve production of good and quality feed:

i. **Cost**: it is well known that feed represent about 70% of production cost in fish farming. It's therefore important to consider the cost of materials or ingredient used in fish feed production and work on reducing cost without compromising quality.

ii. **Age of fish**: the life stage of fish determines the nutritional requirement for the fish. Younger fish need feed with high of quality protein, which is easily digestible. In some species such as catfish, crude protein in feed for fingerlings is above 45% while in adult fish is may be around 30%.

iii. **Specie**: some species of fish are carnivores, while others are herbivores. This feeding behavior determines to a large extent what they accept as feed or food.

iv. **Nutritional composition**: this is the information on the proportion of nutrients contained in feed ingredients; this information includes crude protein, carbohydrates, crude fat, vitamins, minerals, gross energy, etc.

v. **Nutrient digestibility or availability**: this refers to the extent to which nutrients in feed ingredients can be digested and absorbed by the fish. Some feed ingredients have certain nutrients but are unavailable for usage by the fish. When the nutrient composition of these ingredients is determined at the laboratory, they appear present, but in reality, they are present in a form that is not necessarily digestible by fish. An example of such nutrient is phosphorus contained in phytate, which forms complexes with either metals or proteins and thus is not available for fish. i

vi. **Palatability**: this is the preference an animal has for a feed or the ability of the fish to readily start consuming and keep consuming a specific feed.

vii. **Anti-Nutritional factors**: these are biological compounds present in feed ingredient that cause disease in fish and thus reduce nutrient utilization and fish growth. Anti-nutritional factors include: gossypol, tannin, saponin, cyanogenic glycosides, lectins, protease inhibitors, toxic amino acid etc.

viii. **Danger-free**: some feed ingredients may contain harmful substances like plastic, pieces of metals, nylon and even heavy metals.

ix. **Stability**: this is the ability of feed ingredients to maintain unchanged quality when stored.

x. **Inclusion rate**: this the amount of feed ingredients incorporated into a feed formula. Most nutritionist and feed manufacturers have their own unique proportions of inclusion of feed ingredients into a formula to produce the fish feed.

1.4: Nutrients Requirement of the Fish

In general, the farming of aquatic organisms is divided into intensive, semi-intensive and extensive depending on the degree of human intervention in their management, which is gradually increasing from extensive to intensive farming. This intervention can be quantified in a substantial way with the amount and quality of feeds provided the elimination of catabolites (substances produced by the process of catabolism) and the supply of oxygen in the farmed water. Knowledge of the nutritional requirements of farmed fish species, the formulation of animal feed, and the management of animal feed on the farm in recent decades has been the subject of much research.

Nutrient requirement of fish refers to the lowest amount of nutrients necessary for good growth and health in fish. Nutritional requirement varies with species and life stage of fish.

To achieve optimum growth and production of fish, fish diet must be formulated to meet all nutrient requirements of the fish. There are six classes of nutrients:

i. *Carbohydrate:* serves as a source of energy in fish feed. Meanwhile less of it is needed in carnivorous fishes; they are also used as binders.
ii. *Protein*: this is important for synthesis and building of body tissues, growth maintenance, reproduction, enzymes and hormones, egg production, etc. Protein is a source of small amount of energy.
iii. *Fats*: serves as a source of large amount of energy to fish. They also provide essential fatty acids that are needed for physiological processes.
iv. *Minerals*: these are inorganic chemicals required for normal health and growth, they also control physiological processes.
v. *Vitamins*: these are organic chemicals needed in small amounts and required for normal health and growth; they also control body enzymatic processes.
vi. *Water:* this is the universal solvent, needed in all bodily processes.

Factors that affect nutritional requirements of fish are:

i. *Genetics*: variation in species may also mean variation in nutritional requirement. Growth rate potential and efficiency of absorbing and utilization of nutrients in fish feed will determine the nutrient inclusion.
ii. *Life stage or age*: nutrient requirement is related to stage of maturity of fish and its body weight.
iii. *Reproductive state*: female broodfish producing eggs and male broodfish producing

milt will need nutrient different from a fry. Nutrients that meet present anabolic need of the fish is important.

iv. *Temperature of environment*: nutritional requirement may also depend on ambient temperature of the water derived from the climate of the location of the farm. Digestion of some feed may produce heat and this may be desired for fish raised in cold regions.

1.5: Nutrient Composition of Feedstuffs

In fish nutrition there are six nutrients; water, carbohydrates, lipids, proteins, minerals, and vitamins. Fish derive energy from three of these nutrients: lipids, proteins, and carbohydrates (the chemical energy or heat density available for the animal to use in 1 gram of fat, protein, and carbohydrate is approximately 9, 4, and 4 kilocalories, respectively). The term *nutrient-density* refers to the amount and type of a particular nutrient, or combination of them, contained in a feed, usually a pellet of specific size or volume. For example, a high-performance grow-out pellet may contain a high concentration of protein to supply amino acids necessary to build muscles and support fast growth. The concept of nutrient-density encompasses the overall composition of the diet in relation to nutrients as well as caloric or energy density. The caloric or energy density of a feed is the number of calories that are contained, in relation to the total amount of nutrients, in a feed pellet of specific size or volume.

In order to increase the nutrient and energy density of a feed, something has to be taken out to provide room for the selected nutrient. What is decreased in the diet is usually carbohydrate, particularly in fish feeds. Most species of fish derive energy from proteins and fats more efficiently than from carbohydrates, similar to some terrestrial carnivorous species, such as cats. The moisture content of a feed pellet also will influence its nutrient and energy densities because more water adds weight but no nutrients or calories. Therefore, dry, nutrient-dense feeds will have higher energy and nutrient densities.

A wide range of local feedstuffs such as agricultural by-products, animal meals, and on farm products are available in African countries for farmers to utilize in fish culture (Table 2). The conversion ratio in the table presents the dry weight of feed needed to produce one-unit wet weight of fish. A low conversion ratio means that fish will convert the feed into flesh more efficiently. High ratios indicate less efficient conversion. For example, if a diet were made of a single ingredient, it would take about 4 to 6kg of ground maize and10 to 20kg of cassava peel to produce 1kg of fish flesh.

Table 2: Nutrient Composition of Some Local Feedstuffs and Expected Conversion

Ratio of Feed to Fish Flesh

Feedstuffs	**% Protein**	**% Fat**	**% Fibre**	**% CHO**	**% Dry Matter**	**%Mineral**	**Conversion Ratio**
Maize (*White*)	9.3	5.0	2.4	70.9	88.0	1.8	5
Maize (*Yellow*)	10.8	3.6	3.5	71.2	88	1.9	5
Guinea Corn	11.2	2.5	2.3	74.1	88	1.8	5
PKC	19.1	7.6	43.2	17.9	-	5.5	8
CSC	40.1	8.3	31.9	12.4	91	5.1	5
Rice Bran/Husk	9.9	4.4	40.2	8.7	91	21.8	5
GNC (*Industrial*)	48.0	13.2	8.1	18.9	93	6.3	5
GNC (*Local*)	40.6	23.4	6.0	19.0	93	6.2	5
Raw Soyabean	40.7	22.0	6.3	16.6	90	6.4	4
Soyabean Meal (T*oasted slightly*)	46.2	24.8	4.7	17.2	90	7.9	4
Soyabean Meal (T*oasted severally*)	48.1	23.9	4.1	20.7	90	7.9	4
Fish Meal (*Tilapia*)	57.7	1.8	5.2	-	92	33.6	2
Clupeid (*Large size*)	73.1	80.0	1.1	-	92	20.2	2
Clupeid (*Small size*)	68.5	8.0	0.4	-	92	17.8	2
Cow Blood Meal	86.0	0.7	2.1	6.5	92	5.0	2
Millet	9.0	5.0	0.7	83.2	90	2.3	5

Flour Mill Waste	12.5	14.5	7.5	58.0	-	-	-
Brewers Waste	22.8	17.8	18.8	46.4	93	-	10
Cassava (*Peeled*)	2.6	0.5	0.4	94.1	88	2.4	18
Cassava (*Peels only*)	5.3	1.2	21.0	66.6	88	6.0	18
Cassava (*Unpeeled*)	2.7	0.5	3.1	91.0	88	2.7	18
Cassava Leaves	14.7	8.4	15.6	45.2	88	16.1	18
Mucuna	28.5	0.7	9.5	57.2	91	4.0	4
Water leaf	21.1	1.5	10.3	87.4	-	4.6	-

Source – NAERLS (2002)

Note - *CHO – Carbohydrate; PKC – Palm Kernel Cake; CSC – Cotton Seed Cake; GNC – Groundnut Cake*

1.6: Processing of the Feedstuffs

Most feedstuffs have anti-nutritional factors, which will be harmful to fish. The anti-nutritional factors are substances, which alter the nutritional value of the feedstuffs and at the same time affect the health of fish. They may be inherent in the foodstuffs or contaminants on the feedstuffs. They prevent easy digestion of nutrients in the feed. One of the ways to destroy anti-nutritional factors is to heat-treat the feedstuffs. Heat destroys such factors e.g. tripsin inhibitors in raw soybean or groundnut and gossypol in cottonseed.

Processing feed stuffs may also include one or a combination of grinding, proportioning, mixing, chaffing, soaking, heat treatment, alkaline treatment, urea treatment, tannic acid treatment, pelleting etc.

In their natural environment fish have developed a wide variety of feeding specializations (behavioral, morphological, and physiological) to acquire essential nutrients and utilize varied food sources. Based on their primary diets, fish are classified as carnivorous (consuming largely animal material), herbivorous (consuming primarily plants and algae), or omnivorous

(having a diet based on both plant and animal materials). However, regardless of their feeding classification, in captivity fish can be taught to readily accept various prepared foods which contain the necessary nutrients.

Increased understanding of the nutritional requirements for various fish species and technological advances in feed manufacturing, have allowed the development and use of manufactured or artificial diets (formulated feeds) to supplement or to replace natural feeds in the aquaculture industry. An abundant supply of feedstuffs is available, and fish farmers are now able to prepare their own fish feeds from locally available ingredients. Sources of nutrients for fish feed are:

i. **Proteins and Amino Acids -** Fish meal, soybean meal, fish hydroxylate, skim milk powder, legumes, wheat gluten, and many plant-based concentrates (corn protein concentrate, sunflower concentrate, etc.) are excellent sources of protein.
   Additionally, the building blocks of proteins (free amino acids) such as crystalline lysine and methionine are commercially available to supplement the diet.
ii. **Lipids -** Oils from marine fish, vegetable oils from canola, sunflower and linseed, are common sources of lipids in fish feeds.
iii. **Carbohydrates -** Cooked carbohydrates, from flours of corn, wheat or other cereals, are relatively inexpensive sources of energy that may spare protein (which is more expensive) from being used as an energy source.
iv. **Vitamins and Minerals -** The variety and number of vitamins and minerals are so complex that they are usually prepared synthetically and are available commercially as a balanced and pre-measured mixture known as a vitamin or mineral premix. This premix is added to the diet in generous amounts (1-2%) to ensure that adequate levels of vitamins and minerals are supplied to meet dietary requirements.
v. **Pigments -** A variety of natural and synthetic pigments or carotenoids are available to enhance coloration in the flesh and the skin of freshwater and marine ornamental fish. The pigments most frequently used supply the colors red and yellow. The synthetically produced pigment, astaxanthin is the most commonly used additive (100–400 mg/kg). Cyanobacteria (blue-green algae' dried shrimp meal, shrimp and palm oils, red peppers and yeast are excellent natural sources of pigments.
vi. **Binding Agents -** Another important ingredient in fish diets is a binding agent to provide stability to the pellet and reduce leaching of nutrients into the water.

Carbohydrates (starch, cellulose and pectin) and various other polysaccharides, such as extracts or derivatives from animals (gelatin), plants (gum arabic and locust bean) are popular binding agents.

vii. **Preservatives -** Preservatives, such as antimicrobials and antioxidants, are often added to extend the shelf-life of fish diets and reduce the rancidity of the fats. Vitamin E is an effective, but expensive, antioxidant that can be used in laboratory prepared formulations. Sodium and potassium salts of propionic, benzoic or sorbic acids, are commonly available antimicrobials added at less than 0.1% in the manufacture of fish feeds. Ethoxyquin (EMQ) is also used as a feed preservative in certain countries to prevent mold.

viii. **Stimulant and attractants -** Other common additives incorporated into fish feeds are chemo-attractants and flavorings, such as fish hydroxylates and condensed fish soluble (typically added at 0.5-2% of the diet). The amino acids glycine and alanine, and the chemical betaine are also known to stimulate strong feeding behavior in fish. Basically, attractants enhance feed palatability and stimulant enhance feed intake.

ix. **Other Feedstuffs**. Fiber and ash (minerals) are a group of mixed materials found in most feedstuffs. In experimental diets, fiber is used as a filler, and ash as a source of calcium and phosphorus. In practical diets, both should be no higher than 8–12% of the formulation. A high fiber and ash content reduce the digestibility of other ingredients in the diet resulting in poor growth of the fish.

Feed formulation is the method of combining selected ground feed ingredients in varying proportions to comply with predetermined nutrient requirements of a fish species. When feedstuffs for desired nutrient composition have been selected, they can be prepared through a process of milling, mixing and pelleting. Milling can be carried out with the Hammer Mill machine (Plate 3).

Mixing of ingredients including the premixes can be performed by hand to form a mash, before adding warm/hot water with stirring to form dough. A mechanical mixer can be used for large scale feed production (Plate 4). If cereals in the formula are not adequate to bind the particles of the feed mixture, cassava starch may be added as a binder.

Some companies are fabricating pelleting machines locally (Plate 5). In Nigeria, the Product Research and Development Agency (PRODA), Enugu, fabricated some attached with hammer

mill for ease of feed production. The common Kitchen Hand Cranker can also be used for pelleting by small-scale farmers (Plate 6).

Plate 3: A Hammer Mill

Plate 4: A Vertical Mixer

Plate 5: A Pelletizing Machine

Plate 6: Hand Cracker Machine

Plate 7: Different Pellet Sizes

After pelleting, the pellets should be dried in the oven (not the direct sun, which can deteriorate some nutrients such as fatty acids) and packed in water impermeable bags e.g. nylon "Ziploc" bags. This is to prevent attack by mould and other pests.

Some considerations in producing pellets:

i Use good quality feed ingredients

ii Particle size of ground ingredients should be uniform. Fine grinding is preferable. Leaf meals should be sun or oven dried before grinding.

iii Weighed ingredients should be mixed thoroughly in desired proportions.

iv Determine what pellet type to produce i.e. whether floating or sinking types for surface feeders or bottom feeding fish, respectively. Sand may serve as sinker when added to pellet. For floating pellet, add or spray oil.

v Particle size of pellets for most adult fish is at least 4.5 mm in diameter.

vi Dry rations, such as rice bran, ground maize and leaf meals, may be stored in a cool, dry place for several weeks. Portions may be taken as needed to feed fish.

vii Moist rations can be prepared daily by adding about 450ml of water per kg of ingredients to form a dough-like mixture. This ration may be stored in plastic bags or containers and divided for morning and afternoon feeding.

1.7: Non-Conventional Fish Feed Resources

Non-conventional feed resources (NCFRs) are feeds that are not usually common in the markets and are not the traditional ingredients used for commercial fish feed production. NCFRs are credited for being non- competitive in terms of human consumption, very cheap to purchase, by-products or waste products from agriculture, farm made feeds and processing industries and are able to serve as a form of waste management in enhancing good sanitation. These include all types of feedstuffs from animal (silkworm, maggot, termite, earthworm, snail, tadpoles, Poultry byproducts, feather meal etc.); plant wastes (jack bean, cottonseed meal, soybean meal, cajanus, duckweed, maize bran, rice bran, palm kernel cake, groundnut cake, brewers waste etc.) and wastes from animal sources and processing of food for human consumption such as animal dung, offal, visceral, feathers, fish silage, bone, blood). They are usually cheaper than conventional feeds and can be recycled to improve their value if there are economically justifiable and technological means (such as fermentation) for converting them into useable products.

It must be noted that when using non-conventional feed, fish may be predisposed to toxic substances and even infections. Therefore, proper treatments should be ensured before feeding to fish.

1.8. Workers' Safety

In a feed manufacturing factory, workers' safety is very important. Workshop must be well ventilated during feed production to ensure both the continuity of quality feed production and safety of the staff and customers. Procedures must be put in place to prevent accidents, contamination of workers by toxic substance or pathogens and consequently the spread of disease in times of outbreaks from feed manufacturer to fish farm or vice versa.

The following measures should be adhered to:

- Workers must wear protective equipment where needed
- Avoid touching of eyes, mouth and ears.
- If applicable, maintain social distance of at least 1 meter among workers and between workers and customers.
- Disinfect production tools and machines regularly or before and after use, where applicable.

1bi. Leaning Activity: *Prepare **l**earning activity that leads to discussion, remembering, memorizing, action. Learning activity should be prepared that leads to discussion, remembering, memorizing, action on Module 1*

1bii. Facilitation Methods:

Facilitation methods to be used by facilitators include:

i. *Lecture with audio-visuals*
ii. *Brainstorming on issues raise*
iii. *Role plays on key issues*
iv. *Group discussion and feed backs in plenary*

1.biii. Learning Materials

Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content

Module sequential narration will be accomplished in simple non-technical form

1biv. Output Evaluation/with Feedback

Prepare evaluation questions based on the content/s you covered (Could be open-ended or close-ended questions). Then prepare answers for learners to check their performance.

10 Questions with Answers should be prepared based on content of this Module

Output Evaluation/with Feedback

1. *Which of the following is a feedstuff for fish?*
   (a) Cassava, (b) Rice; (c) Groundnut cake
2. *Which of the following is not an anti-nutritional factor?*
   (a) Cyanogenic glycosides; (b) Tannin; (c) Chitin
3. *Which of the following is not a conventional feed?*
   (a) Tadpole, (b) Extruded feed; (c) Rice bran
4. *Carbohydrate included in fish feed can serve the purpose of:*
   (a) Binding; (b) Repairing worn out tissues; (c) Enhancement of bodily processes
5. *Protein included in fish feed can serve the purpose of:*
   (a) Binding; (b) Repairing worn out tissues; (c) Enhancement of bodily processes
6. *Fat included in fish feed can serve the purpose of:*
   (a) Source of energy; (b) Repairing worn out tissues; (c) Bodily functions
7. *Vitamin included in fish feed can serve the purpose of:*
   (a) Source of energy; (b) Repairing worn out tissues; (c) Bodily functions
8. *Vitamin included in fish feed can serve the purpose of:*
   (a) Source of energy; (b) Repairing worn out tissues; (c) Bodily functions
9. *Give at least one importance of water in fish feed or to fish.*
10. *Why is processing of feedstuff important before been fed to fish?*

MODULE 2

1.0.FORMULATION AND PRODUCTION OF AFRICAN CATFISH FEED

2ai. Learning outcome/Learning Activity Bundle

For each learning outcome, prepare triggering questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module

2aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide and this could be open or close-ended. Ten simple questions should be raised on Module 2

Pre-Evaluation Questions

1. *Which of the following fish feed is floating feed?*
   (a) Crushed feed
   (b) Pelletized feed
   (c) Powder feed
   (d) Extruded feed
2. *Adult fish needs more protein than fry. True or false?*
3. *Which of the following is not a mineral in fish diet?*
   (a) Selenium; (b) Calcium; (c) Gold; (d) Chlorine
4. *Which of the following is a vitamin in fish diet?*

(a) Manganese; (b) Thiamine; (c) Sodium; (d) Vitamin F

5. *If catfish is omnivorous, tilapia fish is what?*
6. *Can a piscivorous fish eat duckweed?*
7. *Which fish species is more expensive to rear in terms of feeding cost between catfish and tilapia fish?*
8. *Fat have more energy stored up than carbohydrate. True or false?*
9. *What are microelements*
10. *What is microelement*

2.1: Nutritional Requirements of Catfish

Catfish feeds on a wide range of food. They are omnivorous but tend to be predominantly piscivorous. This means they require high dietary protein for good performance in the farming context. Catfish therefore requires feeds with a high crude protein content, 35-50%. Catfish feed requires certain nutrients that will help the farmer optimize the growth as well as increase the profit on their catfish farming business. Below are the 4 classes of nutrients, in order of importance, essential in any feed formulation:

- **Protein**: This class of nutrient is required for building body tissue and replacement of damaged tissue. It also includes physiological molecules such as hormones and enzymes. It can be plants or animal origin.
- **Carbohydrate**: This nutrient provides the energy needed for catfishes. Grains of cereals and cassavas are the major source of this nutrient.

- **Vitamins and minerals**: Growth, health, and body process are controlled by this class of nutrient. Organic and inorganic chemicals are found in vitamin and minerals.
- **Fat**: Fat contains vital fatty acids and also represents the energy source of choice for fish.

There is a need to understand nutritional contents of available feed ingredients so as to understand and select appropriately ingredients that will meet the nutritional needs of your catfish (Tables 3, 4 and 5). Each class of nutrition is analyzed separately below:

Table 3: Nutrient Composition of Common Protein Sources from Animal Origin

Animal Protein	Energy Level (mg/kg)	Crude Protein (%)	Fats (%)	Calcium/ Phosphorus (%)	Methionine (%)	Lysine (%)
Meat meal	11.2	50 – 51	10	8	0.7	2.6
Blood meal	15.2	88 – 90	1	0.4	0.6	7.1
Feather meal	13.7	80 – 85	7	0.4	0.6	2.3
Poultry meal	13.1	60 – 64	13	2.0	1	3.1
Fishmeal	5	55 – 75	3	1.0	1.5	2

Table 4: Nutrient Composition of Common Protein Sources from Plant Origin

Plant Protein	Protein (%)	Energy (call/kg)	Calcium (%)	Lysine (%)	Methionine (%)
Soybean meal	44 – 48	2557	0.20	3.2	1.4
Cottonseed meal	40 – 41	2350	0.66	4.2	1.4
Sunflower meal	46 – 47	2205	0.30	3.5	2.3
Groundnut cake	45.6 – 61.8	3860	1.7	3.2	1.0

Table 5: Nutrient Composition of Energy-Based Ingredients

Ingredients	Protein (%)	Energy (Cal/kg)	Calcium (%)	Lysine (%)
Wheat	13	3153	0.05	0.5
Sorghum	9.0	3263	0.02	0.3
Maize	8 – 11	3200	0.5	0.27
Cassava	2.5	1601	1.6	0.07

More details on the nutrient contains of feedstuffs and the requirements of tilapia, catfish and many other species are available free of charge at https://www.iaffd.com/home.html?v=3.13.

From the nutritional table of certain feed ingredients, the following simple catfish feed formulae can be generated (Plate 8). These formulae are only illustrative.

Sample 1:

Ingredients	Quantity (kg)
Maize/Wheat/Cassava Flour (any of the three)	25kg
Soya/Sunflower/Cotton seed (Soya preferred)	30kg
Groundnut cake /Beniseed (either of the two)	20kg
Fishmeal (72%)	25kg
Vitamin/Mineral Premix	0.5
Lysine	0.1
Methionine	0.1
Vitamin C	0.1
Salt	0.2
DCP	1
TOTAL	102kg

Sample 2:

Ingredients	Quantity (kg)
Maize	20

Poultry meal	15
Fishmeal (72%)	10
Blood meal	5
Soya	30
Groundnut cake	20
Vitamin/Mineral premix	0.5
Lysine	0.1
Methionine	0.1
Vitamin C	0.1
Salt	0.2
DCP	1
TOTAL	102kg

Plate 8: Catfish Feeding in a Pond

2.2: Catfish Feed Formulation and Production

Feed formulation is an integral part of catfish farming business, especially in tropical Africa. This is due to the fact that imported fish feeds are always expensive due to the cost of logistics

on importation and weak local currency, making the cost of such products to increase significantly.

The environment in Africa allows individual farmers to formulate feed for their fishes in order to reduce the cost of feed production and also to enjoy flexibility in choice of feed ingredients for feed formulation. It has been observed that majority of catfish farmers have little or no knowledge on this aspect of their business. Therefore, some fish farmers depend on the judgment/recommendations of their feed millers without questioning the recommendations resulting to poor fish growth.

Least-cost approach is used to economize cost of feed production. A least-cost computer program is usually used to formulate feeds in feed companies. Farmers formulating feed using this program must have information on the cost of feed ingredients, the nutrient concentrations in feedstuffs, nutrient requirements and nutrient availability from feedstuffs. Knowledge on nutritional and non-nutritional restrictions set by the regulatory authority in the country is also important.

Least-cost feed formulation method has a challenge, the combination of the nutrient levels that bring maximum profit, relative to levels that result in best weight gain. Here are some examples of restrictions placed on nutrients and feed ingredients for least-cost formulation of catfish feeds.

2.3: Considerations in Producing Pellets and extruded Catfish Feed

The main difference between pelleted fish feed and extruded fish feed is that pellet feed has sinking properties while extruded feed is buoyant, they float.

Ideally, the choice of feed ingredient and formula should be guided by the following:

i. **Nutritional requirement of your fish stock**: Adequate knowledge of ingredients and nutritional value of various ingredients, coupled with the nutritional requirement of the fish at various stages, will help a farmer to formulate a quality feed. From ingredients combined, it is possible to calculate the crude protein, energy, and fat in the feed either manually or by inputting it on a dedicated computer program.

ii. **The presence or absence of anti-nutritional or toxic factor**: Some ingredients are better not used due to presence of certain anti-nutritional element(s) in them. For instance, Soya Beans grain must be well processed to remove some anti-nutritional elements in them. Some ingredients like groundnut cake can also support the growth of

Aflatoxin, although this may not be a major concern in catfish farming business unlike in poultry.

iii. **Availability of preferred ingredient**: Certain ingredients are preferred over others. This might not be unconnected with cost and availability of such ingredients. When such ingredients are not available, a farmer is saddled with the responsibility of choosing from a wide range of similar ingredients. For instance, when a flour type is not available, a farmer is faced with the challenge of choosing from energy grains or processed tuber crops to complement the energy requirements of the fish.

iv. **Palatability of available ingredient**: An experienced catfish farmer understands that catfishes have taste preferences. The farmer will ensure that s/he chooses from a variety of ingredients that will suit the taste of his fishes. For instance, groundnut cake has better taste and aroma over its substitute beniseed, and soybean meal is preferred above cotton seed cake.

v. **Cost and benefit of the available ingredients**: Cost factor as well as benefit of the cost, are important factors that must be well considered in feed formulations. The cost of fishmeal (72% crude protein) against its benefit might not make it the best alternative where local fishmeal is available, especially in a situation where most of the imported fish meals in the market are adulterated. Also, there may be many ways to meet up with the protein requirement for fish but animal protein, especially protein from fishes, must not be totally removed from the feed, especially for catfish production; the quality and quantity must be well sustained regardless of your choice of ingredient.

vi. **Available processing technology or method**: This is a crucial factor to be considered when formulating feed. Some ingredients should not be used at all due to crude processing method which might have led to the loss of essential nutrients. Maize should not be used at all if the feed miller does not possess the technology to powder it because fish will not be able to fully digest maize particles that is not well milled.

2.4: Biosecurity in Catfish Feed Production

Fish feed manufacturers are expected to maintain good hygiene and care must be taken to produce proper feed with a balanced diet which will improve growth and general fish health without exposing them to nutritional-deficiency based sickness or infection due to presence of pathogens.

The following protocol should be adopted for production and storing feed:

- Obtain good quality feedstuffs or ingredients from reliable sources. Poor quality feed can also cause disease.
- Feed must be stored in a cool dry place after production so as to retain vitamin C, which is easily oxidized, and to avoid contamination by fungus, which can cause disease.
- Keep feed ingredients and manufactured feed away from rats and other animals, and store it in a cool, dry, secure place to retain the nutritional contents.
- Prevent entry to sensitive areas like places where there can be contact with feed during production.
- Ensure wash down with a broad-spectrum disinfectant on vehicles used in carrying feed ingredients and feed or of visitors, otherwise, the vehicles should be parked away from facilities.
- Wash hand at the factory's entrance, before and after activities.
- Footbath should be installed at facility entrance.

Disinfecting or cleaning equipment and machineries

When equipment is used and left unattended to for long it may become a breeding ground for pathogens or may harbor toxins if not properly cleaned before next use.

Good sanitation and disinfection procedures are as follows:

- Apply appropriate disinfectants (Table 6) at the proper concentrations and duration. • Disinfect all production equipment and machines including transporting vehicles. This should be done regularly as long as production is ongoing, and they must be allowed to dry thoroughly especially in parts of the production chain where dryness of feed is required e.g. packaging room
- In some cases, it may be necessary to wash items thoroughly after disinfection to remove any toxic residues depending on type of disinfectant.

Antimicrobial agents are used for disinfecting non-living objects or surfaces to destroy or inactivate pathogens.

Table 6: Common disinfectants, with dosages and applications.

Disinfectant	Concentration	Duration	Comments
Benzalkonium chloride	250-500 ppm	10-30 minutes	Plastics, floors, footbaths, walls, equipment and furnishings
Didecyl dimethyl ammonium chloride	400 ppm	5 minutes	Plastic, floorss
Phenols	2%-5% active ingredients	10-30 minutes	General disinfection
Chlorine	200-500 ppm	10-60 minutes	All surfaces except plastic. When cleaning tanks, disinfect for 24 hours, neutralize, rinse and dry
Ethyl alcohol	70%-80% ppm	10-30 minutes	Hands, tools, work surfaces
Isopropyl alcohol	60%-80% ppm	10-30 minutes	Hands, tools, work surfaces
Iodine	100-250 ppm	20-30 minutes	Antiseptic on tissues. Follow product label instructions if using for egg surface disinfection
Hydrogen peroxide	3%-30% (weight percentage) 3%-30%	5%-30 minutes 5-15 minutes	General disinfectant Follow label instruction to treat fish or disinfect egg

Virkon® Aquatic 21.4% potassium peroxymonosulfate and 1.5% sodium chloride	0.5%-1% or 50-100g per 10 liters of water	10-15 minutes	General disinfection. Commonly used for footbaths.
Chlorhexidine (most solutions contain 2% active chlorhexidine)	Add 1 ml to 100 liter of water for disinfection	5-10 minutes	General disinfection. Commonly used for footbaths.

Adapted from: Bowker JD, Trushenski JT, Gaikowski MP and Straus DL, eds. 2014. Guide to using drugs, biologics, and other chemicals in aquaculture. American Fisheries Society Fish Culture Section. Yanong RPE and Erlacher-Reid C. 2012. Biosecurity in aquaculture, Part 1: An overview. SRAC Publication No. 4707.

2bi. Learning Activity: *Prepare **l**earning activity that leads to discussion, remembering, memorizing, action on Module 2*

2bii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raised
iii. Role plays on key issues
iv. Group discussion and feed-backs in plenary

2biii. Learning Materials: *Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content*

Module sequential narration will be accomplished in simple non-technical form

2biv. Output Evaluation/with Feedback: *Prepare evaluation questions based on the content/s you covered (Could be open-ended or close-ended questions). Then prepare answers for learners to check their performance.*

7 Questions with Answers should be prepared based on content of this Module

1. Catfish therefore requires feeds with a high crude protein content,
   (a) 35-50% (b) 60-70% (c) 75-80% (d) None of the above
2. Adequate knowledge of ingredients and nutritional value of various ingredients will help a farmer to formulate a quality feed
   (a) True
   (b) False
3. Soya Beans grain must be well processed to remove
   (a) Excess nutrients
   (b) Aflatoxins
   (c) anti-nutritional
   (d) Non of the above

4. Groundnut cake has better taste and aroma over its substitute beniseed
   (a) True
   (b) False
5. Soybean meal is preferred above cotton seed cake
   (a) True
   (b) False

6. It is not necessary to wash items thoroughly after disinfection
   (a) True
   (b) False

7. Groundnut cake can support the growth of
   (a) Aflatoxin
   (b) Virus
   (c) Spores
   (d) All the above

MODULE 3

2.0.FORMULATION AND PRODUCTION OF TILAPIA FEED

3ai. Learning Outcome/Learning Activity Bundle

For each learning outcome, prepare triggering questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module

3aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide and this could be open or close-ended. Ten simple questions should be raised on Module 3

Pre-Evaluation Questions

2. *Which of the following statement is correct?*
   - *(a)* Nile tilapias are omnivores
   - *(b)* Nile tilapias are carnivores
   - (c) Nile tilapias are limnivores
   - (d) None of the above

8. *Adult tilapia fry needs more protein than adult tilapia*
   - *(a) True*
   - *(b) False?*
9. *Which of the following is not a nutrient in fish diet?*
   - *(b) Carbon; (b) Calcium; (c) Protein (d) Manganese*
10. *Which of the following is a vitamin in fish diet?*

(e) Manganese; (b) Thiamine; (c) Sodium; (d) Vitamin F

11. *If catfish is omnivorous, tilapia fish is what?*
12. *Can a herbivorous fish eat duckweed?*
13. *Why can tilapia fish be cheaper to raise in terms of feed as compared to catfish?*
14. *What are macrominerals*
15. *What are microminerals*

16. Are disinfectants important in a feed manufacturing factory?

3.1: Nutritional Requirements for Tilapia

The Nile tilapia (*Oreochromis niloticus)* is a widely cultured species because it grows and reproduces in a wide range of environmental conditions and tolerates stress induced by handling. Nile tilapias are omnivores in feeding habits with an herbivore tendency. Tilapia can thus feed on a wide range of both natural and artificial foods. Nile tilapia has considerable potential for aquaculture in many tropical and subtropical regions in the world. Attributes that contribute to the popularity of Nile tilapia farming in ponds include easy breeding, fast growth, tolerance of adverse environmental conditions, good taste, good market price, high tolerance to low water quality, efficient food conversion, resistance to disease and good consumer acceptance.

The major nutrient requirements of cultured tilapia show that early juvenile fish (0.02-10.0 g) would require a diet higher in protein, lipids, vitamins and minerals and lower in carbohydrates. Sub-adult fish (10-25 g) require more energy from lipids and carbohydrates for metabolism and a lower proportion of protein for growth. Adult fish (>25.0 g) would require even less dietary protein for growth and can utilize even higher levels of carbohydrates as a source of energy.

Protein: Protein requirements for optimum growth are dependent on dietary protein quality/source, fish size or age and the energy contents of the diets and this may vary from as high as 45-50 percent for first feeding larvae, 35-40 percent for fry and fingerlings (0.02-10 g), 30-35 percent for juveniles (10.0-25.0 g) to 28-30 percent for grow-out/finishing (>25.0 g) (Table 6). The best protein digestibility occurs at 25-30 °C and the optimum dietary protein to energy ratio was estimated in the region of 110 to 120 mg per kcal digestible energy respectively for fry and fingerling. Tilapia broodfish require about 40-45 percent protein for optimum reproduction, spawning efficiency and for good larval growth and survival. The crude protein content of the diet is just an indicator of the amino acid composition, because Nile tilapia actually requires amino acids, and not proteins. The amino acid requirements of Nile tilapia are the same ten essential amino acids as other finfishes.

Lipid: The minimum requirement of dietary lipids in tilapia diets is 5 percent but improved growth and protein utilization efficiency has been reported for diets with 10-15 percent lipids. Both n-3 and n-6 polyunsaturated fatty acids (PUFA) have been shown to be essential for maximal growth of hybrid tilapia (*O. niloticus* x *O. aureus*).

Carbohydrate: Carbohydrates are included in tilapia feeds to provide a cheap source of energy and for improving pellet binding properties. Tilapia can efficiently utilize as much as 35-40 percent digestible carbohydrate. Carbohydrate utilization by tilapia is affected by a number of factors, including carbohydrate source, other dietary ingredients, fish species and size and feeding frequency. Complex carbohydrates such as starches are better utilized than disaccharides and monosaccharide by tilapias. Dietary utilization of carbohydrate appears to be higher in bigger fish.

Vitamin: Vitamin supplementation is not essential for tilapia in semi-intensive farming systems, while vitamins are generally necessary for optimum growth and health of tilapia in intensive culture systems where limited natural foods are available. Several vitamin requirements of tilapia are known to be affected by other dietary factors and these must be taken into consideration in diet formulations. For example, the vitamin E (fat soluble vitamin) requirement is influenced by dietary lipid level with Nile tilapia requiring 50-100 mg/kg when fed diets with 5 percent lipid and increased to 500 mg/kg diet for diets with 10-15 percent lipid.

Mineral: There is little information on the mineral requirements of tilapia. Like other aquatic animals, tilapias are able to absorb minerals from the culture water which makes the quantitative determination of these elements difficult to carry out. Despite its ability to absorb minerals from the culture water and the presence of minerals in feed ingredients, tilapia feeds

should contain supplemental mineral premixes. This is to ensure that sufficient levels of dietary minerals are available to protect against mineral deficiencies caused by reduced bioavailability such as when plant phosphorus sources are used in tilapia feeds. Like vitamins, the amount of minerals to be added in the diet will also depend on the source of the element.

Table 7: Protein Requirement of Tilapia across Stages in Freshwater

Life stage	Weight (g)	Requirement (%)
First feeding larvae	-	45-50
Fry	0.02-1	40
Fingerlings	1-10	35-40
Juveniles	10-25	30-35
Adults	25-200	30-32
	>200	28-30
Broodstock	-	40-45

More details on the nutrient requirements of tilapia, catfish and many other species are available free of charge at https://www.iaffd.com/home.html?v=3.13.

3.3: Considerations in Producing Pellets and extruded Tilapia Feed

Tilapia feed formulation and production is like that of catfish above.Inclusion rate and formulation of tilapia feed has been done using the nutritional requirement of tilapia as shown in the Table 5 above.

Plate 9: Locally made fish feed being sundried

3.4: Biosecurity in Tilapia Fish Feed Production

Biosecurity is a set of practices to minimize the introduction, establishment and spread of pathogens. It is a sensible approach to adopt biosecurity practices because disease prevention is better than cure.

Good Feed

The following protocol should be adopted for procuring and storing feed:

- Obtain good quality feed from reliable sources. Poor quality feed can cause nutritional diseases.
- Use feed before the expiry date to retain the nutritional contents and to avoid old feed becoming contaminated with pathogens.
- Keep feed away from rats and other animals, and store it in a cool, dry, secure place.
- Do not use fresh feed (trash fish, bivalves, etc.) that could contain pathogens. Use fresh feed only if it can be treated (cooked) to remove pathogens.

- Commercial pellet feeds are generally safe and when well stored present a low risk of disease transmission.

Check of raw materials

There should be a system of checking quality of raw materials before acceptance for the use of production of fish feed.

Checks could include:

- (a) Microbiological assessment to identify and quantify any pathogens
- (b) Nutritional contents check to identify and quantify antinutritional factors
- (c) Checks for presence of foreign materials like metals, rubber or plastics materials etc. which can endanger the life or health of fish.

Treatment and disposal of wastewater and solid waste

Wastewater and solid waste must be treated strictly in accordance of the local and national regulation on the subject. Below are indicative ways of treating wastewater and solid waste.

- Wastewater and general waste must be properly discharged to avoid environmental issues.
- Proper treatment and discharge will reduce the risk of contamination of feed within the factory and other things in the vicinity.
- Treat wastewater to an acceptable level before discharge to avoid the spread of any disease by following these procedures.
- Effluent from the factory should first go into sedimentation tanks.
- In treatment tanks, chlorinate and dechlorinate wastewater from sedimentation tanks before discharge.
- Dispose of solid waste properly according to local regulations and laws.
- Solid waste materials could be either buried or burnt to prevent the spread of pathogens.

People management

- It is important to minimize the risk of staff and visitors transferring pathogens to the feed factory. Someone who has visited another site (or farm) may be carrying pathogens

that can contaminate the hatchery. Similarly, frequent movement of staff between different sections within the factory can also transmit pathogens.

To avoid contamination from people, the factory should implement the following procedures:

- Restrict the movement of people and staff.
- Use the hand wash and foot bath at the entrance of the factory and of each section of the factory.
- Install signboard on sanitation and disinfection procedure at entrance of the factory.
- Prevent unauthorized people from getting access into the factory.
- Maintain a visitors' logbook.
- A factory personnel should escort visitors into the facility.
- Replace the disinfectant regularly according to the instructions on the label.

3bi. Learning Activity: *Prepare **l**earning activity that leads to discussion, remembering, memorizing, action on Module 2*

3bii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raised
iii. Role plays on key issues
iv. Group discussion and feed-backs in plenary

3biii. Learning Materials: *Write narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content.*

Module sequential narration will be accomplished in simple non-technical form.

3biv. Output Evaluation/with Feedback: *Prepare evaluation questions based on the content/s you covered (Could be open-ended or close-ended questions). Then prepare answers for learners to check their performance.*

7 Questions with Answers should be prepared based on content of this Module

Output Evaluation with Feedback

1. Tilapia does not need polyunsaturated fatty acuid in their feed.

(a) True

(b) False

2. Tilapia utilizes starch well

(a) True

(b) False

3. Complex carbohydrates such as starches are better utilized than disaccharides and monosaccharide by tilapia

(a) True

(b)False

4. Quality of raw materials before acceptance for the use of production of fish feed include the following except.

(a) Microbiological assessment to identify and quantify any pathogens

(b) Nutritional contents check to identify and quantify antinutritional factors

(c) Checks for sugar concentration

(d) Checks for presence of foreign materials like metals, rubber or plastics materials etc. which can endanger the life or health of fish.

5. Biosecurity is important for the following reasons except

(a) It minimizes the risk of project failure

(b) Leads to eventual loss

(c) Reduces the chance of disease outbreak

(d) Reduces the chance of economic losses due to fish loss

6. Which of the following is not a facilitator of disease outbreak?

(a) Hygiene

(b) Machines and equipment

(c) Visitors

(d) All of the above

7. Which of the following is not a Better Management Practice in waste disposal in a feed manufacturing factory?

(a) Proper treatment and discharge

(b) Discharge water close to intake point or water source.

(c) Dispose of solid waste properly according to local regulations and laws.

(d) Solid waste materials could be either buried or burnt to prevent the spread of pathogens.

MODULE 4

4.0. FEEDING THE FISH

4ai. Learning Outcome/Learning Activity Bundle

For each learning outcome, prepare triggering questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module

4aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learners' behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide and this could be open or close-ended. Ten simple questions should be raised on Module 4

Pre-Evaluation questions

1. *What factors or things reduce feed quality in storage?*
2. *What are limnivores?*
3. *What makes feed to grow mold?*
4. *Is overfeeding good for fish health?*
5. *Which of the following is a feeding habit?*
   (a) Parasitivores; (b) Carnivores; (c) Fishing; (d) Plasticity
6. *Which of the following is not a feeding habit?*

(a) Limnivores; (b) Piscivores; (c) Parasitiviores; (d) Omnivores

7. *Is broadcasting method of feeding effective?*
8. *Why is feed management important?*
9. *What is the advantage of using dry pellet feed?*
10. *Mention disadvantages of trash fish*

4.1: Fish Feeding Habits

Feeds are provided to increase fish yields, and are especially beneficial;

i. When maximum fertilization is not practiced

ii When a pond does not respond well to fertilization

iii. When fish are stocked at high density in a pond

iv. When fish are confined in a cage, pen or other culture facility.

v When fish are held in tanks.

Fish usually feed to satisfy their energy requirements. The quantity of feed fish would consume depends on various factors such as the fish appetite initiated by hunger for food, the feed quantity as well as its palatability. All things being equal, a well-fed fish will grow well and a poorly fed fish will have retarded growth and be prone to diseases. Farmers must supply fish under culture with nutritious diet on regular (daily) basis at the required level (recommended rates).

Generally, fish species have different feeding habits. Some fish are carnivores which mean they feed mainly on flesh foods like fingerlings crustaceans and worms in the water environment e.g. the catfish. Some are omnivores, which means they feed on both plant and animal materials e.g. Tilapia. Some others are herbivores, which means they feed mostly on plant materials e.g. Grass carp. Most fish under culture are able to feed on plant and animal food materials and accept supplementary feeds.

In a polyculture system, fish species can feed at different levels of the food chain in the pond. An example of surface feeder is Tilapia; mid-water feeder, the catfish and a typical bottom feeder, Heterotis. Some fish species are limnivores, which are also known as mud-eaters, feeding mainly on algae and microorganisms in the pond bottom. These kinds of fish are constantly eating, and can be fed with pellets and algae-based foods. A fish culturist should take these feeding habits into consideration in planning pond stocking and feeding practices.

4.2: Quantity of Feed

Quantity of feed is very important in aquaculture as overfeeding has a lot of disadvantages. In the wild, fish hunt their food while in the culture system there is a farmer's control over feeding frequency, feed composition and feed quantity to meet a desired production target. Overfeeding leads to economic loss. Feeding cost represents about 70% of the variable cost in a fish farm, it is therefore not economically wise to allow feed wastage by overfeeding. Overfeeding predisposes the culture system to pollution and water quality problems and may also predispose the fish to infection due to accumulation of waste from uneaten feed and increased waste produced by fish which eat more than they need.

The amount of feed to supply in a pond, also called feeding level or feeding rate, is usually the proportion of the biomass of fish contained in the pond. This amount is usually given in percent biomass; for instance, larvae are fed 8-10% body weight per day, fry are fed 5-7% body weight per day, juvenile are fed 3-5% body weight per day and the grow-out fish are fed 2-3% body weight per day. Hence, it is important to the farmer to estimate the volume of fish contained in the pond on a regular (bi-weekly or monthly basis), through periodic sampling on 2-50 fish, to adjust the feeding level. As an illustration, if a pond contains 200 kg of fish at the grow out phase and the farmer feeds 3% body weight per day, the farmer should weigh and feed 200 kg*3% = 6kg feed in that pond per day. However, daily feed should be distributed in several meals, ideally three meals per day, but two meals per day are also acceptable.

4.3: Methods of Feeding Fish

There are several methods of feeding:

- Broadcasting: this is done by spreading the feed in the pond
- Point feeding: this is done by having designated feeding points. Feeding must be done regularly
- Automatic feeding: this done by programming the system to feed the fish at specified time and specified quantity of feed.
- Demand feeding: this is usually a mechanical system, having a stick which is applied to a slightly bowed plate sitting under a feed hopper. The stick goes straight into the water and when touched by the fish, feed from the hoper is dispensed.

4.4: Feeds Storage

Feed must be stored in a cool and dry place away from attacks by pests like rodents. The

moisture content must be low enough to be stored without spoilage by mold. Feed should not be stored for over three months.

4.5: Feed grades feeding management

Fish feed management involves choosing the right feed, using correct feeding methods, calculating the feed cost and ensuring feed effectiveness.

Importance of feed management:

- Reduction in overall cost
- Healthy growth of fish
- It ensures improvement of water or culture environment (water quality is managed)

Feed can be graded into vegetarian feed, trash feed, pellet feed.

- Vegetarian feed: these feeds are made from plant source. Examples are rice bran, soybean meal, groundnut cake etc.
- Trash feed: these feeds are usually made of small fish, fishing by-catch or waste from fish processing plant
- Pellet feed: this name is given based on shape (ball, tablet) of the feed. There are dry pellet feed and moist pellet feed (about 35% moisture content). The dry pellet feed could be either be pelletized feed or extruded feed.

It must be noted that trash feed has about 70% moisture content, has irregular content, and is more likely to pollute the water. Moist pellet must be stored frozen otherwise spoilage sets in. In the absence of storage facility for moist pellets, production must be for immediate use. Dry pellet feeds are more stable and should be stored in cool dry place. It can last for about 3 months.

4bi. Learning Activity: *Prepare **l**earning activity that leads to discussion, remembering, memorizing, action on Module 2*

4bii. Facilitation Methods

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raise
iii. Role plays on key issues
iv. Group discussion and feed backs in plenary

4biii. Learning Materials: (W*rite narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content)*
Module sequential narration will be accomplished in simple non-technical form

Output Evaluation/with Feedback*1. What are limnivores?*

3. *When the moisture content of feed is too high, the feed grows mold. True or false?*
4. *What are the impacts of overfeeding to the fish, fish health and water?*
5. *Fish eaters are*
   (a) Piscivorous; (b) Carnivorous; (c) Fishers; (d) Plasticity
6. *Which of the following is the feeding habit of fish that feed on mud?*
   (a) Limnivores (b) Piscivorous (c) Parasitiviores (d) Omnivores
7. *Is broadcasting method of feeding effective?*
8. *Why is feed management important?*
9. *What is/are the advantage(s) of using extruded feed*
10. *Mention disadvantages of trash feed*
11. *What factors or things reduce feed quality in storage?*

MODULE 5

5.0. BUSINESS PLAN DEVELOPMENT

5ai. Learning Outcome/Learning Activity Bundle

For each learning outcome, prepare triggering questions that leads to participants' sharing their experience about the intended contents (experiential learning) at the end of the module

5aii. Pre-Evaluation with Feedback

The purpose of pre-evaluation is to assess learner's behavior (knowledge, skills, and attitude) before they start learning. Prepare questions about the contents which you intend to provide and this could be open or close-ended. Ten simple questions should be raised on Module 5

Pre-evaluation questions

1. *What is capital?*
2. *What is a loan*
3. *What is a grant?*

4. *Why must there be a business plan?*
5. *What is brand?*
6. *What are market demographics?*
7. *What is competition?*
8. *What is market segmentation?*
9. *What is profit?*
10. *What is a business profile?*

5.1: Purpose of Business Plan

A business plan is a step by step blueprint of how you will operate your business. It provides direction for every decision made. Primarily, business plan has two purposes.

Firstly, it is used to run a company with more cohesive vision. Secondly, it is needed for access to funding (loans, grants etc.) for business.

A business plan is used to manage an organisation by stating goals, how they will be achieved and exactly when. The plan will also summarize what the business is about, why it exists and where it will go. It serves as a point of reference to partners, investors, employees and management to assess progress with reference to its objectives.

5.2. Business Profile

A business profile is a list of basic details about a company which emphasize the strength of the company to prospective clients and customers. It is a form of résumé for the company. A business profile tells about a company's values, objectives, services, and products and current status.

A simple business profile format includes:

- Business Name
- Head Office Address
- Phone Number
- Website Address
- Company Status
- Contact Information of the Person in Charge (name, phone, email address)

5.3. Organization and Products

Business organization details include:

- Date of registration and commencement of business
- Main areas of activity of business
- Main product lines
- Main services
- Principal customers in industries and across geographical boundaries
- Business capacity in terms of:
    - Human resources - Business organization and number of employees
    - Financial - Financial circumstances of business (Optional)
    - Technical - Company capacity for project in terms of staff qualifications/certification.
    - References to success stories in a similar project.

5.4. Description of Management Team

The management team is the group of individuals that organize the business strategy and ensure business objectives are met. They operate at the higher level of an organization and are responsible for day-to-day managing of other teams or individuals. The description of a management team should help third parties to recognize what sets the business apart.

5.5. Market Analysis

Market analysis is a qualitative and quantitative assessment of a market's attractiveness and its dynamics such as market size (volume and value), buying patterns or preferences of customers, degree of competition, economic environment including demand and supply forces, and various customer segments. Market analysis helps to gain an insight or understanding of potential customers and competitors and is therefore useful in identifying a niche for the business or in developing a marketing strategy. The process involves the following:

1. Demographics and Segmentation: Market demographic segmentation is the division of the market according to age, race, gender, family size, religion, ethnicity, education and income. They provide direct information on market size, target market and market need. The first step in the process of market analysis is measuring the market size. Market size refers to the maximum total number of sales or customers your business has or the total potential number of customer or sales in a given year. Measurement of market size can take two approaches - volume and value. Volume deals with the number of

customers while value is the estimated monetary worth of the proposed business. The number of customers available to buy fish feed in an area can be compared with the value they attach in that area.

If in an area, 50 small fish farms (potential customers) are willing and capable of buying fish feed at the rate of ₦7,500 per bag, while in another area 5 small fish farms (potential customers) are willing and capable of buying fish feed at the rate of ₦10,000 per bag. It may be better to establish in the first area where there is a larger volume. Though smaller value and with higher competition, there seem to be a chance of a more stable and accessible market.

2. Target Market: is the group of potential customers a company wants to sell its products or services. No one can effectively target everyone; therefore, it is wise to target a niche market which enables small businesses to compete with large established ones.
3. Market Need Assessment: involves knowing why customers buy the product.
4. Identify competitors' strength and weaknesses, which your company could use to better position itself in the market. Competition between companies selling similar products and services are daily occurrence in business. A quick way to do the market analysis is to compare your competitors with your business using a simple table containing some important drivers of demand (Table 8). This will give a reasonable view of businesses you are competing against and will help you find your competitors' weaknesses which your company could use to better position itself in the market.

   The aim of comparing competitors' fish feed product and services with 'my company' is to be able to discover their key weaknesses and take advantage of it to gain customers' attention. For example, from Table 8 below, the second competitor does not offer delivery services to customers while third competitor offers delivery at ₦1,000. 'My company' can leverage on that by offering free delivery to customers which has given it an edge over 2 competitors out of 4. Only the second competitor produces live food, while others are into pelletized fish feed production. This may mean that there are more customers who buy compounded feed or it could be that there is a barrier to entrance of new fish feed companies. It is therefore important to do a market analysis by comparing and studying competitors.

Table 8: Hypothetical Competitors' Analysis

Company	**1st competitor (Fingerlings feed (1.5-2mm))**	**2nd competitor (Live food for hatchlings)**	**3rd competitor (Feed for growout (4-6mm))**	**My company** (4-6mm feed for grow out)
Revenues	₦ 10,000,000	₦ 500,000	₦ 1,007,000	₦ 800,000 (first year target)
Employees No.	5	2	7	4
Size	1feed mill and 3 sales outlets	1 feed mill and 1 sales outlet	1 feed mill and 1 sales outlet	1 feed mill and 1 sales outlet
Price	Low	High	Low	Low
Quality	Average	Low	Low	Superior
Delivery	Free	No	₦ 1,000	Free

In fish feed, there are a lot of different alternative options in the market from which fish farmers can choose, due to product similarities (most companies have feed sizes for the different stages of fish such as 1.5mm, 2mm, 3mm, 4mm, 6mm and 9mm). The company producing the fish feed has to have a competitive advantage if it must succeed. There are factors that gives a feed manufacturer a competitive advantage:

- A unique geographic location: a fish feed manufacturer located in the midst of fish farms or very close to a fish farm dominated area is more likely to make sales than one from afar off.
- Access to novel technology: a fish feed manufacturer that is able to develop a unique way of producing its feed, which for example gives less problem to fish farmers. The problems include rate of water pollution due to feed and feed efficiency among several others.
- Access to natural resources that are restricted from competitors, especially foreign feed manufacturers. Some feed ingredient may not be available to foreign fish feed manufacturers which may be available locally and if harnessed could be a competitive advantage for the locally manufactured feed.
- The ability for a manufacturer to produce fish feed at the lowest cost means being able to sell to farmers at a relatively low cost which can give it a competitive edge.

Fish feed takes over 70% of total operating cost. Therefore, a reduction in price means a consequent reduction in production cost of fish farmers and a possible increase in profit by 30%. Most fish farmers will buy from manufacturer with a cheaper product and uncompromised fish feed quality.

5. Barriers to Entry: barrier to entry are obstacles or hindrances that make it difficult for a new company to enter an existing given market. Analysis of barriers will answer two main questions:
    i. What prevents new entrants from coming in and taking off a good percentage of your customers?
    ii. What makes you think you will be able to break the barriers and successfully enter the market?

There are many barriers to entry. Some of the barriers to fish feed production business are:

- Investment: fish feed production is capital intensive, and this is a barrier to many who would have entered the industry.
- Brand loyalty: consumers' attachment to existing fish feed producers or their products
- Brand cost: a huge marketing cost is needed to receive certain level of recognition
- Economies of scale: existing fish feed producers benefiting from lower average cost due to scale (size) of production. Inputs can be acquired in bulk, hence lowering the cost of production appreciably.
- Being 'the first mover': some companies earn a strong position because they are the first to enter and dominate a market.
- Regulations: these are rules and guidelines made by governing bodies to control the way something is done, or the way people behave. A fish feed producer is expected to comply to these regulations that may affect production activities. These regulations vary from one country to another.

5.6. Financial Analysis

Financial analysis is the evaluation of the viability, stability and profitability to justify investing into the business or project. It can be used to build a long-term plan to draw business activities. There are countless methods of financial analysis. In this module we shall use Cost-Benefits Analysis (CBA), Profit Margin and Return on Investment (ROI) using Nigerian example of fish feed production as shown in Table 9 for financial analysis.

i. Cost-Benefits Analysis (CBA): is a process by which organizations can analyze decisions, systems or projects, or determine a value for intangibles. The model is built by identifying the benefits of an action as well as the associated costs and subtracting the costs from benefits. This is often used in capital budgeting to analyze the overall value of money for undertaking a new project. The CBA produces a ratio: Benefit-Cost Ratio (BCR) which is an indicator that shows the relationship between the relative costs and benefits of a proposed project. It can be expressed in monetary or qualitative terms.

The Cost-Benefit Analysis Process

A detailed or exhaustive list of all the costs and benefits associated with the project will be made. The costs involved in a CBA might include the following:

- Direct costs including direct labour involved on the farm, equipment and machineries, seed cost, feed cost and all form of farm inputs.
- Indirect costs are electricity, overhead costs from management, rent, utilities.

If a project has a BCR greater than 1.0, mean that benefits outweigh costs. This implies that the business is feasible and worth investing in. For example, a BCR of 1.20 means that for every dollar spent in costs there is a financial gain of US$20 cents more.

Net Present Value (NPV) is the difference in the sums of discounted benefits and discounted costs. A positive NPV means the project is feasible while a negative one means the project is not worth investing in and the business should not be considered.

The rule guiding the use of NPV or CBR:

1. *If separate, unrelated projects is being assessed, and the budget for funding the projects **is not** limited, use NPV or BCR.*
2. *If separate, unrelated projects is being assessed, and the budget for funding the projects **is** limited, the projects can be ranked with BCR. NPV should not be used*

For small to mid-level capital expenditures, businesses which have short to intermediate time to completion, an in-depth cost-benefit analysis may be dependable for a sensible decision making. For very large businesses with a long-term time horizon, a cost-benefit analysis allows for calculation of the present value of money through discounting. The BCR is computed as a ratio of discounted benefit stream divided by discounted stream of costs. Inflation is accounted for by deflating prices using price indices.

ii. Profit Margin: is the amount by which revenue from sales exceeds cost in a business. There are four levels of profit margins.

Profit Margin = Net Profit/Revenue

These are gross profit margin, operating profit margin, pre-tax profit margin, and net profit margin. A company takes in sales revenue, which pays direct costs of the products or services. The cost of the product or service is subtracted from sales revenue. What's left is gross margin. Advertising, the indirect cost is also subtracted. What is left is operating margin. Interest on debt and any unusual charges or inflows unrelated to the company's main business are subtracted with pre-tax margin left over. Taxes are paid, leaving the net margin, also known as net income, which is the very bottom line. The Profit Margin:

- Measures the degree to which a company or a business activity makes money, by dividing income by revenues.
- Expressed as a percentage; indicates how much profit has been generated for each dollar of sale.
- Most significant and commonly used is net profit margin, a company's bottom line after all other expenses, including taxes and other costs have been removed from revenue.
- Used by creditors, investors, and businesses as indicators of a company's financial health, management's skill, and growth potential.

iii. Return on Investment (ROI): is a financial metric of profitability that is used extensively to measure the profit or gain an investment can realize. The ROI is a simple ratio of the gain from an investment relative to its cost. It is as useful in evaluating the potential return from a stand-alone investment. It can also be used to compare returns from several investments.

The ROI can be positive or negative. A positive ROI figure means that net returns are good because total returns exceed total costs. On the other hand, negative ROI figure means that the investment produces a loss because total costs exceed total returns. To compute ROI with greater accuracy, total returns and total costs should be considered. It is better to express ROI as percentage because it is easier to comprehend and make deductions from.

Steps in calculating ROI

- Compute all costs and all income
- Sum all the costs to generate total cost of production
- Sum all income to generate total income

- To calculate net income, subtract total cost of production from the total income (total income- total cost of production)
- To calculate ROI, divide net income by total cost of production and multiplied 100 (net income/total cost of production x 100),
- Knowledge of the factors to be considered in cost computing is important to prevent omissions.

Using information in Table 9 below, the ROI is 23.1% and CBR is 1.23 which is greater than 1. This suggests that the NPV of the business cash flows outweighs the NPV of the costs, and the business can be considered.

Table 9: Financial Analysis for Production of 1-ton Catfish Feed Using Local Feed Ingredients in Nigeria

	A	B	C	D	E	F
1		Ingredients	Inclusion rate (%)	Quantity of ingredient (Kg)	Price (#) per Kg	Price of ingredients
2		Maize	35	350	98	34300
3		Soyameal	25	250	130	32500
4		GNC	20	200	120	24000
5		Fishmeal(72%)	5	50	1100	55000
6		Wheat bran	8	80	55	4400
7		Poultry meal	6	60	410	24600
8		Premix	0.5	5	1100	5500
9		Vitamin C	0.2	2	1800	3600
10		Lysine	0.1	1	900	900
11		Methionine	0.1	1	1450	1450
12		Blood meal	0.5	5	250	1250
13		Salt	0.05	0.5	40	20
14		Milling/ Extruding		1000	40	40000
15	**Total cost of production**					**227520**
16	**Income**	**280 per Kg**				**280000**
17	**Net profit**	**Income-total cost of production**				**52480**
18	**ROI (%)**	**(Net profit/Total cost of production) x 100**				**23.06610408**
19	**CBR**	**Income/Total cost of production**				**1.230661041**

5.7. Sourcing for Capital/Grant

A capital-intensive project or business-like fish feed production is usually difficult to start. This is a barrier to entry. Hence ways of overcoming this challenge must be considered.

If business owners do not have the funds to start or improve an existing business, the other available options are seeking for a grant or getting a loan.

There are many ways to secure the funds required to complete a project:

1. Personal fundraising: the first investor in a business should be you. This can be in form of cash, in-kind or with collateral on assets. This signifies to potential investors that you have a long-term commitment for the project you are embarking on.

2. Partnerships: this is an agreement between two or more parties to advance their mutual interest (sharing management and profits). The partners may be individuals, Non-Governmental Organizations, businesses and Community-Based Organizations.

- Check if there are other organizations, either not-for-profit or commercial, that could partner with you in sharing the capital costs of the project.
- Depending on agreement and arrangement, they may join in management (sharing or dividing responsibilities) or they may be passive.
- It is advantageous when the partners are trained and equipped in different fields because it increases the chance of success.

3. Government or public funding: depends on the country and agricultural policies. There may be grants and subsidies by government for low interest loans expected to boost agricultural production. It will be good to check lists of available grants or loans by government either online or at governmental offices in charge of such funding.

***5bi. Leaning Activity*:** *Prepare learning activity that leads to discussion, remembering, memorizing, action*

Learning activity will be prepared that leads to discussion, remembering, memorizing, action on Module 4

5bii.Facilitation Methods

Facilitation methods to be used by facilitators include:

i. Lecture with audio-visuals
ii. Brainstorming on issues raise
iii. Role plays on key issues
iv. Group discussion and feed backs in plenary

5biii. Learning Materials: (W*rite narrations or further illustrations about the contents and indicate/attach further reading material in relation to the given content)*

Module sequential narration will be accomplished in simple non-technical form

***5biv. Output Evaluation with Feedback*:** *(Prepare evaluation questions based on the content/s you covered; either open- or close-ended). Then prepare answers for learners to check their performance.* 10 Questions with Answers should be prepared based on content of this Module

Output Evaluation with Feedback

1. Differentiate between loan and grant

2. Is competition an advantage to fish feed business?

3. What are advantages of branding?

4. Identify barriers to entry.

5. What is the safest form of sourcing fund?

6. Enumerate challenges of personal fund sourcing?

7. What is the advantage of partnership funding?

8. List the disadvantages of partnership funding

9. Direct costs include the following except

(a) Cost of feed stuffs (b) Equipment and machineries (c) Feed cost (d) Rent

10. Indirect costs include except

(a) Cost of feed stuffs (b) Overhead costs from management (c) Electricity (d) Rent

KEY TERMS

Terms	Meaning
Algae	These are photosynthetic organisms that possess photosynthetic pigments such as chlorophyll. However, they lack true roots, stems and leaves characteristic of vascular plants.
Catabolites	Substances produced by the process of catabolism, which a chemical reaction in organism that consists of breaking down complex molecules into smaller, simpler molecules

	e.g. the breaking down of food into nutrients such as proteins, lipids, carbohydrates, etc..
Cyanogenic glycosides	Natural plant toxins that are present in several plants, most of which are consumed by humans. Cyanide is formed following the hydrolysis of cyanogenic glycosides that occur during crushing of the edible plant material either during consumption or during processing of the food crop. It is an antinutritional factor.
Ethoxyquin (EMQ)	A quinoline-based antioxidant used as a food preservative in certain countries and originally to control scald on pears after harvest (under commercial names such as "Stop-Scald"). It is used as a preservative in some pet foods to slow the development of rancidity of fats. Each country has a regulatory limit in the use of this product.
Feedstuffs	Ingredients grown or developed to make feeds for livestock and fisheries
Feed Conversion Ratio (FCR)	The amount of dry feed it takes to grow a kilogram of fish. For example, if it requires two kilograms of dry feed to grow one kilogram of fish, the FCR would be two. This means that when a feed has a low FCR, it takes less feed to produce one kilogram of fish than it would if the FCR were higher.
Fertilization (reproduction)	The fusion of haploid gametes, egg and sperm, to form the diploid zygote. During spawning season, the male fish seek out the nests of fish eggs that the female has laid. When they find one, they swim over the nest, and fertilize them with their semen. This allows fertilization to take place.
Fingerlings	When fish eggs are hatched into larvae they developed into about the size of fingers and are called fingerlings. They are usually not older than 8 weeks
Fry	Fish not older than 6 weeks
Gossypol	A natural phenol derived from the cotton plant (genus Gossypium). Gossypol is a phenolic aldehyde that permeates cells and acts as an inhibitor for several

	dehydrogenase enzymes. It is a yellow pigment. It is an antinutritional factor.
Lectins	Carbohydrate-binding proteins that are highly specific for sugar groups of other molecules. Lectins have a role in recognition on the cellular and molecular level and play numerous roles in biological recognition phenomena involving cells, carbohydrates, and proteins. It is an antinutritional factor.
Juveniles	Fish not older than 12 weeks; typically, between 25 and 50 mm long
Protease inhibitors	Synthetic drugs that inhibit the action of protease, an enzyme that cleaves two precursor proteins into smaller fragments. These fragments are needed for viral growth, infectivity and replication. It is an antinutritional factor.
Saponins	Phytochemicals which can be found in most vegetables, beans and herbs. It is an antinutritional factor.
Tannins or **Tannoids**	A class of astringent, polyphenolic biomolecules that bind to and precipitate proteins and various other organic compounds including amino acids and alkaloids. It is an antinutritional factor.
Zooplankton	Microscopic animal organisms moving freely in oceans, seas, and bodies of fresh water.

BIBLIOGRAPHY (SOURCES)

Bolorunduro P.I. (2002). Fish Feed Formulation and Feeding Practices in Fish Culture. National Agricultural Extension and Research Liaison Services (NAERLS), Ahmadu Bello University, Zaria, Nigeria, Extension Bulletin No.152, Fish Series No.8

Mohamed Din MS and Subasinghe R. (2017). Basic biosecurity manual for tilapia hatchery technicians in Bangladesh. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Manual: FISH-2017-10.

Schalekamp D., van den Hill K., Huisman Y., (2016) Update A Horizon Scan on Aquaculture 2015: Fish Feed. Brief for GSDR – 2016

https://corporatefinanceinstitute.com/resources/knowledge/strategy/competitive-advantage/

WFC (2009) Producing tilapia feed locally: A low- cost option for small-scale farmers. WorldFish Centre; 8p

ADDITIONAL RESOURCES-FURTHER READING

FAO (2008) Food and Agriculture Organization of the United Nations. Cultured Aquatic Species Information Programme: *Clarias gariepinus* (Burchell, 1822); 13p.

Western Edge (2009) The Tilapia Handbook: A Learning Guide to Farming and Production of Tilapia; 17p

For more information please contact:

WorldFish Nigeria Office, c/o International institute of tropical Agriculture (IITA)

AfricaRice Building IITA HA, Ibadan Nigeria

Telephone: +2348033476184 Email:

Partners:


TANZANIA FISHERIES RESEARCH INSTITUTE
TAASISI YA UTAFITI WA UVUVI
UTAFITI NA UVUVI

ISABU
INSTITUT DES SCIENCES AGRONOMIQUES DU BURUNDI

IRAD