FEED INGREDIENTS AND ANTINUTRIENTS FACTOR

DR. SARVENDRA KUMAR

COLLEGE OF FISHERIES KISHANGANJ

Introduction

- There is a shift from traditional culture practice to intensive aquaculture systems to increase aquaculture productivity.
- Major challenge to increase production of culture system is availability of quality feed.
- There is a growing concern over availability, environmental sustainability and the cost of feed ingredients used in aqua feeds.
- Currently, most countries involved in intensive culture import a major proportion of their feed ingredients such as fish meal, corn gluten and soybean meal, soybean oil, rapeseed oil, linseed oil, and animal fat for aquafeed manufacture.

- Extensive research undertaken in many countries has established the dietary levels of many plant protein and lipid sources that fish can utilize efficiently.
- There number of plant ingredients available which can be used in aquafeed but occurrence of anti-nutritional factors or toxicants in plant-derived ingredients limit the use, these ANF can adversely affect digestion, absorption and physiological utilization of nutrients.
- By applying proper corrective measure the activity of ANF should be removed or reduce.

- Utilization of the Non conventional feed ingredients is the best option for preparation of feed to fulfil the demand.
- These include all types of feedstuffs from animal (silkworm, maggot, termite, grub, earthworm, snail, tadpoles 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, visceral, feathers, fish silage, bone, blood).
- **Utilization of nonconventional feedstuffs** (NCFS) of plant origin had been limited use due to presence of **alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponin, momosine, cyanoglycosides** to mention a few despite their nutrient values and low cost implications
- NCFRs are credited for being non competitive in terms of human consumption, very cheap to purchase,

Some common conventional feed stuff

- The feed industry is, currently mainly depends on conventional feed ingredients. This increases the cost, scarcity and ultimately increased the cost of feed.
- **Groundnut cake:** **Contains CP (crude protein)- 46-48%** but lacks the essential amino acid, lysine. Contain ANF mycotoxin called aflatoxin.
- **Rice products:** These are mainly used as an energy source in the diet. It is rich in fat and fibre with limited use in fish feed. **It contains 9% CP** and **13.2% fibre**.
- **Wheat bran:** good source of energy for warm water fishes & it has good binding properties. It **contains 10.80% CP.**
- **Soybean meal:** This ***most commonly used in the feed industry contain 51% CP.*** It has a balanced amino acid profile and can replace a substantial part of fishmeal. presence of trypsin inhibitor.

- **Cotton seed cake:** ***Contain 37-41% CP, but deficient in lysine.*** The use of cotton seed cake in fish feed is common in China & Japan. **Rich in ANF gossypol & cyclopropenoic acid.** Generally used in cat fish feed at a level of 10-15%.
- **Mustard cake:** 23.6% -CP is quite balanced and although it contain a significant amount of fibre. **Lysine is deficient in the mustard cake.** ***ANF glucosinolate & erucic acid are present.***
- **Palm kernel meal:** This contains a fairly high quantity of crude fiber. **The crude protein is 17%.**
- **Brewers dried yeast:** This is a by-product of the brewery industry. It contains sufficient quantity of crude protein (50% CP) but limited in amino acids, methionine and cystine.

- **Brewers dried grain:** 27% CP The crude fiber content is high and therefore in limited use.
- **Maize:** The energy content is high. This limits use in fish
- **Fish meal:** Apart from its high protein content, fishmeal also acts as an attractant. Fishmeal is produced either from the trash obtained from trawling or fish waste from the canning industry. The percentage protein depends on the source of fish product and method used in producing the fishmeal. **Fish meal contain 55-70% CP.**

Some unconventional feed stuff

- Unconventional fish feeds are potential feed ingredients, which have not been used in fish feed production for the reasons that:
  - They are not well known or understood
  - No effective study of the method of production with a view to commercializing them
  - They are not readily available
  - They can be toxic or poisonous

- The ingredients those not generally used in fish feed preparations referred to as unconventional feed ingredients, not available in the market as conventional feed ingredients. They contain high quality nutrients that can compare favourably with conventional feed types. They are expected to be cheaper than conventional feed ingredients.
- **These may be of animal or plant source origin**

Animal source

- These are ingredients from any living thing, they may be aquatic origin or terrestrial origin. Examples include shrimp waste, crab meal, blood meal tadpole meal; fly larvae, earthworm meal, toad meal, and animal wastes such as cow dung, pig and poultry droppings.
- **Crab meal, crab waste: S**hell portion of the crab after the edible meat portion has been removed is then dried and ground and the resultant product is referred to as crab meal. It contains 27 % CP. Crab shells are high in chitin, which is a nitrogen containing compound that has a structure similar to cellulose. Crab meal is important source of carotenoid pigments.
- **Fish Protein Concentrate (FPC), Fish Hydrolyzed :** Can be prepared from any type of fish or fishery waste. It is prepared from fish by extracting out the oil, screening or settling out the bones and drying. FPC is higher in protein *85% to 95 % and lower in ash content than fish meal.
- Fish Hydrolyzed is similar to Fish Protein Concentrate, except that the oil and water has not been removed. The fish protein is sometimes enzymatically hydrolyzed, using a combination of enzymes and acids, so that the bone can be more easily removed. The particle size of the Fish Protein Concentrate is smaller than fish meal and more uniform in colour and texture.

- **Fish ensiling:** Production of fish silage is a viable alternative to fish meal, especially in location where small amount of fishery waste or by-catch is produced. Prepared from the fishery waste can be easy and economical methods of preserving fishery waste, so that it can be fed at a later time. This can be especially useful when only small amounts of fishery waste are available. **It contains 56% CP.**
- **Poultry by-product meal:** Poultry processing generates a lot of wastes such as offal, blood and heads of birds. These wastes can be processed to form poultry by-product meal. The protein content is high with a balanced amino acid profile. It can be partially replace fishmeal without any adverse effect on the fish. The quantity and proportion in which these conventional feedstuffs are used depend on its nutrient composition, presence of antinutritional substances, palatability and cost

- **Tadpole meal:** Frogs and toads laid eggs are in stagnant pools or any body of water and later hatch into tadpoles.
- Because of the period of life cycle spent in water, tadpoles can be cultured like fish and harvested before they can metamorphose.
- The harvested tadpoles can be processed by oven drying or smoking over a kiln. For immediate use, they can be feed whole to adult fish or pulverized and added to other feed ingredients.
- It contained 50% crude protein.
- **House fly larvae (Musia domestica):** The nutrient quality analysis of processed larvae is Moisture 8%, protein 45%, fat 15%, Ash 8% and chitin 25%.

- **Animal wastes:** Faeces from animals, particularly cow dung, piggery and poultry droppings can be used as pond organic fertilizers for the stimulation of plankton growth. However, these are also used as a direct source of food to fish. As direct food for fish; faeces collected early in the morning without contamination by pig urine, are dropped into a marked area of the pond as food for the fish. Some fish culturist use as oven dried or sun dried during and added to other ingredients in fish feed. Such droppings are known to contain **nearly 30% crude protein content.**
- **Earthworm meal: C**ommercially produced by, heaping animal, human wastes or refuge in a land with enough moisture in the soil or swamps. Suitable pairs of earthworms are introduced. These would breed with the detritus serving as source of nutrients to them. Harvesting can be done after six months. Processing is either by oven drying, smoking over a kiln or pulversing with a grinder. The best known use of earthworm today, is as feed for ornamental fishes and fish bait. **It contains 52-56% CP.**

- **Toad meal (Bufo regularis):** Toads in the tropics are seen in moist or damp areas in the forests, house surroundings etc. They breed by laying large number of eggs in pools of water during the rains, which hatch into tadpoles. The tadpoles metamorphose into toads. Therefore, it is possible to breed toads on a commercial scale and processed by oven drying. Some fish culturist, kill toads and put directly into the fishpond. When the toads go putrid, the catfishes feed on it. Putrefaction or fermentation removes the poison in the toad skin. It **contains 52-56% CP.**
- **Blood meal:** Cow blood is available in slaughterhouses on daily basis. This can be obtained freely. Processing is, by boiling the blood followed by dry in an oven or smoke over or Sundry. The bulk of commercial blood meal is processed during the dry season.
- **Blood meal is high in protein content (85%). It is a supplemental source of lysine but low in methionine.**

Meat and Bone meal: Is an excellent source of supplemental protein and has a well-balanced amino acid profile.

- Digestibility of the protein fraction is normally quite high, ranging from 81 to 87%.
- Provides not only a well-balanced protein source, but also a highly available source of calcium and phosphorus.
- it contain 50% CP, Its protein quality is inferior than to fish meal. It is good source of mineral (35% ash). MBM is deficient in methionine.

- **Silkworm pupae meal:** is a protein-rich feed ingredient with a high nutritional value. Its crude protein content ranges from 50% DM to more than 80% DM (for defatted meal). The lysine (6-7% of the protein) and methionine (2-3% of the protein) content are particularly high.

Plant sources

- The plant sources of fish diets however include, leaf protein, leaf meal, aquatic macrophytes, cultivable pulses such as Mucuna bean, yam beans, bread beans, winged beans or any legume ornamental that can yield pods with seeds.
- **Leaf protein:** Leaves are abounding in the tropics growing freely without cultivation. All contain diverse levels of protein, which can produce an inexhaustible and inexpensive source of nutrient for fish. Examples of plants with nutritionally valued leaves are cassava (*Manihot esculenta*), pawpaw (*Carica papaya*), pineapple (*Ananas comosus*), Groundnut (*Arachis. hypogea*), soya bean (*Glycine max)* and plantain (*Musa paradisica*).
- A number of techniques have been evolved for extracting protein from leaves. The crushing of leaves into a solution with trichloroacetic acid is a useful method. The mixture is allowed to settle in separating flax for a period of 12 h. The bottom slurry is protein obtained by decanting and drying.
- **leaf protein concentrate containing up to 15-50% crude protein.**

- **Aquatic macrophytes:** These are common aquatic plants found growing on water surface.
- These include, rooted flowering plants like grasses and sedges that are commonly seen along the rim of fresh water bodies, rotted flowering plants with submerged leaves like ceratophyllum, and with floating leaves like the water lilies (nymphaea) and free floating plants such as duckweed, water lettuce, water hyacinth and salvinia
- Utilization of *Azolla pinnata as* a potential fish feed component in the diet of *Oreochromis niloticus*.
- **Unconventional pulses:** example- Mucuna beans, broad beans, sword beans, winged beans, yam beans etc. Their protein content range from 18-20%, fat 3-10%, carbohydrate 50-60%, making them easily gelatinisable.
- The toxic substances in them are hydrogen cyanide and trypsin inhibitors.
- These can be removed by applying heat during processing. Processing is by toasting, boiling, steam cooking and drying.

Anti-nutritional factors (ANF)

- There are number of compounds in the feed ingredients which significantly reduce the nutrition value of the feed. Nature has endowed many plants with the capacity to synthesize a chemical substance (antimetabolites) that are known to exert deleterious effect when ingested by animals. These substances are produced by plants for self defence. These substances become antinutritional factor when present in feed stuff & influence metabolic pathways.
- ANF produces subleathal effect such as reduced growth, poor feed conversion, hormonal changes & occasional organ damage. ANF has been defining as substances which interfere with food utilization, affect the health & production of animals.

- Good quality of feed ingredients for commercial feed preparation should be free from ANF. Autoclaving, extrusion cooking & infrared cooking or micronization is effective method to remove or reduce the level of ANF. In case of oil cake which are rich in aflotoxin can be destroyed by ammoniation & monomethylation.

Anti-nutritional factors and their corrective measures:-

ANF Groups	ANF Classes	Feed Ingredients	Harmful Effects	Corrective measures
Protein Inhibitor	Protease inhibitor (Trypsin and Chymotripsin)	Most legumes, soyabean meal	Inhibit proteolytic enzyme. Pancreatic hypertrophy. Increase the requirements of sulphur containing aa.	Heat treatment
	Lectins/Haematoggulatinins (Ricin, Abrin and Modeccin)	Most legumes seed	Agglutination of vertebrate RBC. Reduce the absorption of nutrient in the gut	Moist heating
	Toxic amino acid Mimosine	Ipil-ipil	Enlargement of thyroid gland.	Drying & ensiling
	Food allergens (beta-glycine, beta-conglycine)	Soyabean meal	Gastro intestinal hyposensitivity reaction & digestive disturbance	Heating

ANF Groups	ANF Classes	Feed Ingredients	Harmful Effects	Corrective measures
Glycosides	Goiterogens	Crucifers plants, rape seed & mustard seed	Bind with iodine reduce growth	Additional supplements of iodine.
	Cyanogens	Cassava, linseed, chick pea & pigeon pea	Reduce oxygen carrying capacity & inactivate cytochrome oxidase	Drying reduce the enzyme responsible for converting the toxic compound.
	Saponins	Soyabean meal, groundnut, lupin, sunflower, alfa-alfa	Interference with the absorption of lipid, cholesterol, bile acid & vit. A & B. Lower the surface tension & haemolysed red blood cells	Extraction with hot water or ethanol
	Estrogens	Crucifers plants, rape seed & mustard seed		Additional supplements of iodine.
		Wheat, rice, chick pea, alfa-alfa, soyabean, groundnut, lupin	Poduce elevated zinc in the liver & bones. Increase the deposition of calcium, phosphorous & manganese in the bone	Heating

ANF Groups	ANF Classes	Feed Ingredients	Harmful Effects	Corrective measures
Phenols	Gossypol	Cotton seed	Liver & kidney abnormality. Reduction in heamocrit, haemoglobin & plasma protein levels. Formation of indigestible gossypol-protein complex. Make complex with iron	Cooked with small amount of calcium and iron salts.
	Tannin	Mustard oil cake, sorghum, sal seed meal, mango seed kernel	Bind with enzymes or binds with feed components like protein or minerals. Reduce the absorption of vit B_{12}	Soaking & cooking. Supplementation of methyl doner such as choline & methionine.
Microbial toxin	**Aflatoxin, Cyclopiazonic acid, Fusarium, Orchratotoxin, Slaframine & Citrinin**	**Oil seeds & maize**	**Carcinogenic, neurotoxic, liver toxic, poor growth, inhibit enzyme activity & decrease immune responsiveness**	**Monomethylation & ammonization**

ANF Groups	ANF Classes	Feed Ingredients	Harmful Effects	Corrective measures
Anti vitamins	Lipoxidase/ Antivitamin A	Raw soyabean	Destroy Vit. A	Heating
	Antivitamin D	Raw soyabean	Destroy Vit. D	
	Antivitamin B_6	Linseed	Destroy Vit. B_6	
	Antivitamin B_3	Maize & wheat bran	Destroy Vit. B_3	

ANF Groups	ANF Classes	Feed Ingredients	Harmful Effects	Corrective measures
Anti enzymes	Cholinesterase inhibitor	Potato	Inhibit enzyme activity	Heating
	Alpha amylase inhibitor	Wheat, oats & rye	Destroy Vit. D	
	Arginase inhibitor	Sunflower seed	Destroy Vit. B_6	

ANF Groups	ANF Classes	Feed Ingredients	Harmful Effects	Corrective measures
Miscellaneous	Phytic acid	Leaf meal …….	Act as demineralise phytate bound with minerals P, Ca, Zn, Mg, Fe Cu and make unavailable	Aquous extraction & autoclaving. Supplementation of phytase enzyme.
	Oxalates	Leaves of plant ingredients	Bind with calcium and make insoluble	Supplementation of calcium
	Alkaloids (Vicine, Convicine, Caffeine & Nicotine	Found in plant	Interfere with nerve functioning	
	Oligosaccharide & non starch polysaccharide	Grains, legumes & cereals	Binding to bile acid. Obstructing action against digestive enzyme.	Steam cooking
	Oxycarotenoid (zeaxanthin, luetin)	Corn gluten meal	Give yellow colour to white muscle	Bleaching
	Cyclopropene (Sterculic acid, Malvalic acid)	Cotton seed oil meal.	Inhibition of desaturase	Lipid extraction
	Erucic acid	Rape seed	Cardiac toxic & necrosis of muscle	Lipid extraction

ANF Groups	ANF Classes	Feed Ingredients	Harmful Effects	Corrective measures
Animal products origin	Thaiminase	Raw fish more specifically fresh water fishes	Hydrolyze thiamine	Deactivated by heating
	Histamine	Fish meal due to improper storage	Food poisoning	Proper storage
	Gizzerosine	Fish meal	Gizzard erosion	Do not heat fish meal more than 90 ^{0}C
	Peroxidised lipid	Raw material	Free radical, toxic compound	Proper storage, supplementation of antioxidants
	Avidine	Raw egg white	Bind with biotin and inactivate	Heating
	Prion (pathogen)	Meat & Bone meal	Bovine spongiform encephalopathy (BSE)	Proper heating