FACTORS AFFECTING FEED INTAKE IN CULTURED FISH SPECIES: A REVIEW

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ABSTRACT

Feed expense constitutes the bulk of the whole cost of production in any intensive aquaculture setup in Nigeria. Consequently, feed and feeding stratagems are of paramount interest for feed utilization as well as profit maximization. However, the paucity of documents on the factors affecting feed intake in cultured fish is negatively influencing the efficiency of fish production from aquaculture. Hence, the major factors influencing feed intake by cultured fish are discussed. These factors include management practices, environment conditions, feed quality, inherent genetic factor and physiological condition of the fish. The review would help to increase basic knowledge on the nutrition (with emphasis on feed intake) of aquaculture species for improved management and productivity.

Keywords: Nutrition, Aquaculture environment, Fish metabolism, Feed management, Feed quality, Feed intake

INTRODUCTION

Aquaculture is one of the fastest growing food production sectors. Fish feed and feeding is an important component of aquaculture as feed account for approximately sixty percent of the variable production cost in intensive aquaculture systems in Nigeria (Ayinla, 2007). Feeding is an important life function which involves hunting, processing and evaluation of food materials (Kasumyan and Doving, 2003). Optimal feeding scheme enhance growth, pond water quality, survival, size uniformity, help in minimizing wastage and eventually upsurge production (Dwyer *et al*., 2002; Isyagi *et al*., 2009). Growth potential differs across fish species and it is highly dependent on some factors. Furthermore, the degree to which growth potential is realized is highly dependent on feed intake and on how well the feed has been adjusted to the nutritional needs of the fish. Hence, the profitability of an aquaculture venture depends largely on the adoption of correct feeding strategy. Feed satisfies the nutrient requirements of fish when there is consideration for size of fish, right pellet size for effortless consumption and low wastage, correct quantity and right feeding time.

The uniqueness in feeding fish comparatively with domestic animals has led to the observation of numerous problems (Bureau and Cho, 1999). For instance, for the case of land animal, excess feed can be retrieved when the animal is satisfied. However, this practice is somewhat impracticable in fish farming. This results in wastage of valuable feed nutrients, poor fish growth and a high possibility of water quality deterioration which could culminate in fish mortality and reduced profitability. The quality of the feed can influence its intake by the fed fish and management of water quality variables (Thorpe and Cho, 1995; Talbot *et al*., 1999; White, 2013).

The knowledge on feed intake is a prerequisite for an understanding on nutrient utilization of diet and by reference an ingredient. Feed intake by fish is often reported both as an amount (g fish^{-1}) and rate (g fish^{-1} day). However, accurate assessment of feed intake by fish is one of the most difficult aspects of aquaculture nutrition research (Glencross *et al*., 2007). There is dearth of information on the factors affecting feed intake in cultured fish in Nigeria, and this is negatively influencing the efficiency of fish production from aquaculture. Hence, the major factors influencing feed intake by cultured fish in Nigeria is discussed in this review. The review would help to increase basic knowledge on fish nutrition with emphasis on feed intake of cultured fin-fish species.

MATERIALS AND METHODS

A comprehensive internet and library search of literatures on feed intake in cultured fish species was undertaken using Google Search and other search engines. Literatures recovered were analyzed in pros and relevant tables cited by authors adopted.

RESULTS AND DISCUSSION

Factors that Affect Feed Intake in Cultured Fish: Quantitatively, the most important factors regulating the amount of feed consumed by fishes depends on the species, suitability of the feed, culture environment, stressors (such as pollutants in water), handling and social interactions (NRC, 1987). Although the spectrum of these factors is very broad, the focus of this review will be on management, environment, feed and the inherent genetic factors.

Role of Management and Environmental Factors on Feed Intake: Management and environment play important role in controlling feed intake and feed efficiency. Environmental and management factors in relation to feeding condition and physico-chemical quality of rearing medium have a marked impact on the feed intake of the fish as they can affect the fish physiological condition, capable of creating all sort of stress and neuro-endocrinological imbalance (Wynne *et al*., 2005). Fish feeding is one of the enormous tasks that fish farmers are faced with, if the fish must grow. It is important to consider the relationship between feeding and water quality as they affect each other during the cause of management (Ani *et al*., 2013). A host of management and environmental factors affecting feed intake by fish are considered under the following sub-headings.

Feeding Frequency: Feeding frequency refers to the number of times in a day that fish are fed in culture system (Riche and Garling, 2003). The interval between meals will depend on the returns to appetite. This is because fish will continue to eat available food subject to the available space in the stomach and the duration it takes to empty the stomach content. The speed at which the stomach empties depends on prevailing temperature and other water quality variables, weight of the fish and quantity of feed consumed. Feeding frequency affects the quantity of feed consumed in a day and it is a very essential considerations in fish feed management as a result of its influence on growth, survival, survival, feed conversion, water quality as well as profit maximization (Jobling, 1995; Goddard, 1995; Ali *et al*., 2005; Davies *et al*., 2006; Ndome *et al*., 2011; Jamabo *et al*., 2015).

Determination of optimum feeding frequency for maximum growth and survival of fish is a function of species, size, environmental condition, diet and knowledge of the previous feeding (De Silva and Anderson, 1995; Lee *et al*., 2000). Smaller fish have a high energy demand in comparison to their older counterparts. Therefore, it is important that they eat continuously to satisfy the energy demand for growth and maturation. The high energy demand is as a result of energy requirement for rapid growth and development, higher metabolic rates and their small stomach size. Fry and fingerlings can be fed up to 8 times a day (Kaushik, 2013). Frequent feeding can be labour intensive; an option is to feed fry regularly with automatic feeders. Automatic feeders should be checked regularly in order to avoid over feeding which can result in deterioration of water quality (Riche and Garling, 2003). Furthermore, juveniles need to be fed more frequently than adults, but lower than fry and fingerlings because they have higher metabolic rates and their stomachs are too small to hold all the feed they require for a day. Fish from 400 g can be fed once a day, because of their comparative large sized stomach which can hold enough food for the whole day. Usually, there is a positive relationship between growth and feed conversion ratio with frequency of feeding (Craig and Helfrich, 2002; Ashley-dejo *et al*., 2014). Although, these increase will only continue up to a given limit (Wang *et al*., 1998; Bascinar *et al*., 2007; Aderolu *et al*., 2010). Jamabo *et al*. (2015) have reported that fingerlings of *C. gariepinus* fed four times a day performed better than those fed once, twice or thrice a day. However, for hybrids of catfish, fingerlings fed two times daily performed better in terms of growth, survival and nutrient utilization (Li *et al*., 2006; Obe and Omodara, 2014).

Feed Distribution and Duration of Feeding: Feeding can be done by hand or with automatic feeders. The automatic feeders are available in different designs and can be adjusted to deliver specific amounts of feed at set intervals (Gatlin, 2010). Depending on the type of feed, size of the culture medium and the distribution method, feed may be applied on the entire pond area (e.g. when hand feeding finely ground dry feedstuffs in small ponds) or at selected feeding places (e.g. when feeding sinking feedstuffs in large ponds). Feeding the entire pond area is advantageous because it makes the food available over a wide area, thus reducing competition among the fish. Feeding at selected places ease monitoring on food acceptance and intake. Feeding fish requires a high level of experience and patience. Therefore, the longer the time spent on the cultured fish during feeding, better the chance of feed consumption and utilization. Feeding fish in a hurry may lead underfeeding or overfeeding, while some of the feed may even not be accessible to the fish, thus resulting in feed wastage. It has been observed in small research ponds that healthy fish would be satisfied within duration of 30 minutes (Li *et al*., 2006).

Feeding Rate: Growth strongly depends on the amount of feed supplying all the essential nutrients and energy, maximum growth rate is attained by feeding fish at satiation level (Kaushik, 2013). When access to feed is restricted or the ration size is reduced, increased size heterogeneity due to social hierarchies appears within the group (Houlihan *et al*., 2001). Feeding rates is also in part a function of fish size and water temperature (Riche and Garling, 2003; Craig and Helfrich, 2002). About 5 % body weight has been found to be sufficient for maximum growth for a number of fish species at the fingerlings and juveniles stages of life (Table 1) (Yuan *et al*., 2010; Ashley-dejo *et al*., 2014).

Although, data has showed that feeding the fish to satiation produced better yield compared to a restricted feeding rate (Li *et al*., 2006). Underfeeding reduces feeding efficiency (Bureau *et al.,* 2006), growth (Gaylord *et al*., 2001), increases competition (McCarthy *et al.,* 1992) and damage of fin (Hatlen *et al*., 2006). Furthermore, overfeeding also reduces feeding efficiency (Talbot *et al*., 1999) and increases feed wastage (Thorpe and Cho, 1995), which in return can impact the environment and prompt environmental degradation (Cho and Bureau, 1998). However, there is need to understand the implications of these factors in different fish species and in their stages of development. Commercial fish farmers must address each of these factors when designing environmental friendly and economically sustainable feed management strategies. Feeding rates of fish is also influenced by feeding time of the day, season, and water quality such as temperature, dissolved oxygen levels, and other variables.

Feeding Time: Each fish species can have an endogenous feeding rhythm controlled by the central nervous system and the entraining endocrine factors, governed by environmental cues (especially photoperiod). Much work has been undertaken to understand the feeding rhythms in farmed fish (Kadri *et al*., 1997; Madrid *et al*., 2001; Kaushik, 2013).

Table 1: Feeding rates and feed utilization parameters of *Clarias gariepinus* fed with different % body weight

Treatment	3%	4%	5%	6%	7%
Initial weight (g)	3.40 ± 0.04^c	3.10 ± 0.03^b	3.30 ± 0.03^a	2.90 ± 0.03^b	3.13 ± 0.02^d
Weight gain (g)	52.83 ± 1.28^c	60.54 ± 0.58^b	76.53 ± 0.37^a	62.17 ± 2.42^b	48.48 ± 2.23^d
Specific growth rate	3.34 ± 0.03^c	3.60 ± 0.02^b	3.80 ± 0.01^a	3.69 ± 0.07^b	3.34 ± 0.05^c
Feed intake (g)	57.30 ± 0.01^c	71.06 ± 0.02^b	87.51 ± 0.02^b	93.97 ± 0.01^a	101.70 ± 0.02^a

Mean values (mean ± S.E) in the same row with different superscript are significantly different (p<0.05), Adapted from Ashley-dejo et al. (2015).

The timing of a single meal can influence feed intake and consequently results in growth and nutrient utilization (Kaushik, 2013). Feeding Atlantic salmon in sea cages in the afternoon hours of the day is not advisable as a result of lowest dissolved oxygen levels (Figure 1) (Kadri *et al*., 1997).

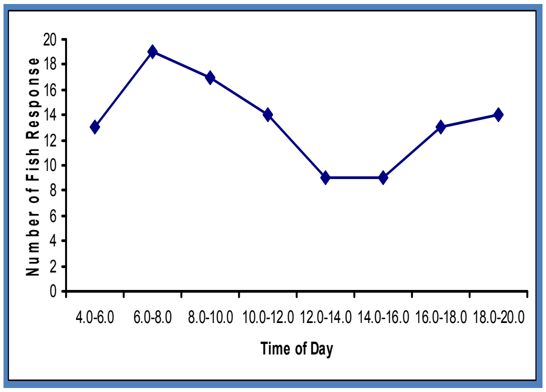

Figure 1: Variation in the number of post-smolt salmon responding to pellets (delivered by a feeder) in relation to the time of day. Adapted from Kadri *et al*. (1997)

On the contrary, fishes in Recirculatory Aquaculture Systems (RAS) can be fed nearly anytime as a result of constant supply of oxygen (Craig and Helfrich, 2002). Most fish farmers commence feeding in the morning as soon as dissolve oxygen level of the water starts to increase. Although, significant differences were not observed in weight among fish fed to satiation at 8:30 am, 4:00 pm, and 8:00 pm (Li *et al*., 2006).

Ani *et al*. (2013) have recommended that catfish should be fed twice daily; morning hours (07.30 - 08.30 am) and evening hours (17.00 to 18.00 pm) for a better performance and feed utilization. However, the prevailing physical and chemical characteristics do alter optimum feeding level for desirable behaviour in ponds. Other factors such as stocking density, stocking integration and aggression, feed composition, feeds size, fish type and feed preparation should also be considered in determining best time of the day to feed catfish.

Colour of Fish Holding Facility: Rearing conditions of farmed fish species may negatively affect feeding activity, health, welfare and growth, especially, when culture conditions are stressful (Strand *et al*., 2007). Therefore, design and setup of optimal species-specific culture conditions are of prime importance for successful aquaculture operations.

In visual feeders, feeding success of fish depends on the contrast between the feed and background colour (Üstündağ and Ferit, 2015). Maximizing the contrast between the feed and the background would facilitate feed detection by fish and thereby improve feeding success under culture conditions (Banan *et al*., 2011). Improved visual detection of feed item is associated with a number of factors. This includes light intensity and background colour of rearing units (El-Sayed and El-Ghobashy, 2011). Therefore, choice of proper background colour in rearing system would improve growth and survival rates in farmed fish through promotion of feed acceptability. Improper background colour may induce external stress to the fish under culture as it affects their behaviour and metabolism (Strand *et al*., 2007; Barcellos *et al*., 2009; El-Sayed and El-Ghobashy, 2011) and it results to poor growth and low survival (Rabbani and Zeng, 2005; Yasharian *et al*., 2005; Pena *et al*., 2005). Although, background colour of fish receptacle did not influence feed intake in fry of *Clarias gariepinus* (Ekokotu and Nwachi, 2014).

Water Quality: Water quality condition of a culture system and the health status of the fish under culture are the twin most important primary causes of poor feed consumption. This is because; the response of pond fish to feed can be used to ascertain the health condition of the fish. In the light of these, the aquaculturist should therefore ensure sustained water of good quality for the fish under culture. Important water quality variables influencing feed intake are considered below.

Temperature: The prevailing water temperature is listed among the most important variables affecting vital functions in fish (Kasumyan and Doving, 2003). Growth rate, feed intake, feed conversion efficiency (FCE), and stomach evacuation rate were significantly influenced by temperature (Handeland *et al*., 2008).

A study on the effect of varied feeding level and water temperature on feed utilization by Azevedo *et al*. (1998) revealed that there is a positive relationship between feed consumption and water temperature. There is a dramatic increase in feed intake with increasing temperature (Martinez-Palacios *et al*., 1996; Koskela *et al*., 1997). Although, increasing water temperature above the optimal temperature of a species results in the reduction in feeding behaviour (Walberg, 2011; Md Mizanur *et al*., 2014). The basic factor affecting feed efficiency of fish in a complete diet is feed wastage (Bureau and Cho, 1999). Conventionally, when approaching the upper thermal tolerance limit for growth, a progressive decline in feed intake is observed. During the early hours of the day or after a rain and its attendant lowered water temperature, fish are not likely to feed optimally. It is therefore recommended to halt feeding at temperatures beyond optimum levels as warm water fish perform better at temperatures between 25 – 32 ^{o}C (Boyd and Lichtkoppler, 1979).

Dissolve Oxygen: In the absence of deliberate poisoning, dissolve oxygen (DO) is the single most important and critical water quality parameter for fish in pond culture systems (Boyd and Lichtkoppler, 1979). Reduced oxygen concentration is considered as a foremost factor affecting feed intake in cultured fish species (Morkore and Rorvik 2001; Nordgarden *et al*., 2003). It is common to see fish at the water surface gasping for oxygen in water of poor quality as a last resort for gaseous exchange. Usually, lethargy and fish going off feed may be an indicator of poor oxygen content in the culture system (Ovie and Adeniyi, 1990). Therefore, it is important to determine the concentration of oxygen in the water as a preliminary step during lethargic condition, fish going off feed or mortality before proceeding on medication. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth, vulnerability to diseases and parasitic infestation as well as mortality (Bhatnagar and Garg, 2000). This is as a result of the fact that metabolism is extremely dependent on the concentration of the dissolve oxygen present in the rearing environment. Fish does not assimilate consumed food at low DO (Tom, 1998). A study on the influence of ambient oxygen on feeding and growth in *O. niloticus* (Tsadik and Kutty, 1987) revealed fastest growth rate in tanks with high DO and the slowest growth in the low DO. Dissolved Oxygen level greater than 5 ppm is essential to support good fish production (Bhatnagar and Singh, 2010; Bhatnagar *et al.,* 2004). At dissolved oxygen levels between 3.0 – 5.0 ppm feeding should be slashed when DO level is between 3.0-5.0ppm and stopped when below 3.0 ppm (Riche and Garling, 2003).

Ammonia Concentration: Of the two form of ammonia (unionized ammonia and ionized ammonia) that is present in water, the unionized ammonia is most toxic to fish and other aquatic organisms (Riche and Garling, 2003). Ammonia concentrations in water have a marked and predictable effect on the feed intake. Elevated ammonia level in water leads to a diminution in feed intake in cultured fishes, under otherwise identical environmental condition (Haskell, 1959). The level of ammonia in a culture system is dependent on temperature, feeding type, feeding rate and the size of the fish. Ammonia concentration in the water starts to increase few hours after feeding but peaks at 4 – 6 hours. High temperature as well as increased pH levels favours the un-ionized form of ammonia in a fish production system.

Stress and Pollutants: In a broad context, stress can be considered as a biological response that drives physiological systems outside their normal range. Fishes typically respond to short-term or acute stress by mechanisms designed to maintain physiological function; compensating for the stress for a while, and then when the stress is resolved the fish can return to its previous physiological state (Helfman *et al*., 2009). Also, stress due either to excessive handling, diseases and social interactions do affect fish's appetite. Interest for food reduces when fish are subjected to stress. Furthermore, a long period of starvation may also affect feed intake in cultured fish species. Also, taste receptors of the fish are always exposed to the water and make them susceptible to the pollutant present in the water. Pollutants can also affect the taste receptacle by either destroying the taste bud and/or reduction in the sensitivity of the taste stimuli (Kasumyan and Doving, 2003).

Role of Feed Quality on Feed Intake: Feed quality alludes to the dietary efficiency and objective attribute of a feed which make it suitable for feeding and digestion in the typical fish digestive systems. Efficient feeding levels is attained only when the right supply of energy and essential nutrients is available in the proportions that is adequate to the fish for maintenance and growth (Hepher, 2009). Reception, lusciousness and digestion of feed differ as a result of variation in ingredients (Craig and Helfrich, 2002). For good health and satisfactory growth, a complete feed must meet all the nutritional requirement of the fish (Omitoyin, 2006). Therefore, farmers should determine the quality of the feed because of its tremendous involvement in acceptability, palatability and digestibility. Some of the indicators of feed quality and their corresponding relationship with feed intake in fish are considered below.

Feed Types and Sizes: Commercial fish feed are either extruded (floating) or pressure-pelleted (sinking). Both form of feed can yield adequate growth (Craig and Helfrich, 2002). Sinking pellets are cheaper than the floating pellets, but the use of the former requires a greater degree of management (Ayinla, 2007). The preference of extruded feed to sinking feed lies in the flexibility in the adjustment of feeding rate. This is because; farmers can easily monitor the fish behavioral response to feeding. However, its limitation lies in its high cost of procurement occasioned by high cost of machinery and expertise (Abowei and Ekubo, 2011; Helfrich and Smith, 2001). Generally, better FCR are obtained in the use of floating feed (Adewumi and Olaleye, 2011).

Feed is also presented in a wide variety of sizes ranging from minute particles for small fish to large pellets for big sized specimen (Craig and Helfrich, 2002; Ibiyo, 2016). The use of pelleted and extruded diet in fish farming has resulted in the standardization of rules relating to the size of pellet to be fed to fish of a particular size class. Proposals and endorsement on appropriate size for fish have been based to a large extent on practicability and simplicity rather than experimentation. This is because, particles occupies a significant position in the acceptance or rejection of diet, it is more critical for dry diets than for semi-moist or moist diets (NRC, 1981; 1983). For efficient feeding and feed utilization, Craig and Helfrich (2002) suggested that an adequate pellet size should be approximately 20 – 30 % of the mouth gape for a corresponding size and species. This is to avoid an unproductive habit of feeding too small pellets resulting in energy loss during feed location. On the contrary, feeding too large size of feed will slow down feeding and sometime cause choking to the fish. It is therefore advisable to select the optimum sized feed that the fish can eat conveniently. Information on the average weight of fish and corresponding pellet size preference is presented in Table 2. Ajani *et al*. (2011) have reported higher weight gain in fingerlings of *C. gariepinus* fed with floating pellet against the ones fed with sinking pellet.

Floating pellet float on water and does not disintegrate easily like sinking pellet vis-à-vis their availability to the fish in water. Meanwhile sinking pellets does not float on water and it disintegrates easily thereby becoming unavailable to the fish. A significant increase in ammonia level above the recommendation of Ayodele and Ajani (1998) had also been observed in fish fed with sinking feed, thus indicating that there exists a relationship between feed type and water quality variables.

Table 2: Recommended pellet sizes for cultured fish

Average Weight of Fish (g)	Size of Pellets (mm)
5-10	1.5-2
15-30	2
30-100	3
100-250	4
250-500	4
500-750	4-6
750-1500	6
>1500	6-10

Adapted from Ibiyo (2016)

Feed Flavour: The taste properties of the feed have a high stimulating implication on feed intake and growth (Kasumyan, 1997). Olfaction and gustation are the major chemosensory systems in fish (Kasumyan and Doving, 2003). Previously, palatability describes acceptance to taste or agreement with flavour during consumption. Although, it may be difficult to determine the flavour preference, it is however very feasible to verify deviations in the amount of feed consumed. This is imperative because, despite the digestibility of nutrients and energy composition of a particular individual nutrient, if the ingredient reduces feed intake, it is of limited use in a feed formulation. While there may be stratagems to avert or resolve issues on palatability of feed ingredients using ingredient processing or feeding stimulants, the best practice would be to avoid feeding unpalatable diets (Glencross *et al*., 2007).

Substitution of fish meal with other proteins of plant origin and the addition of certain antibiotics have resulted in the reduction of palatability of fish feed. Although, the inclusion of stimulants in feed formulation has helped in masking deterrent ingredients (Papatryphon and Soares, 2000; Kasumyan and Doving, 2003). Stimulants that caused the greatest response are composed of amino acids, nucleotides, and quaternary amines (NRC, 1987). Proceeds from an experiment carried out by Takeda and Takii (1992) revealed that fish consumed more feed in diets that are highly palatable while early satiation was recorded in diets that were not palatable. Furthermore, fish that were hitherto satisfied after consumption of feed of poor palatability continued to receive more feed and attained another satiation level upon the introduction of feed with high palatability profile.

Anti-Nutritional Factors: Some quantities of anti-nutrients may be introduced into feed during preparation of ingredients and feed formulation. These anti-nutrients may result in the contamination of feed and thereby reduces the acceptability and utilization of the diet (NRC, 1993). Examples of anti-nutritional components in ingredients are gossypol, alkaloids, trypsin inhibitors, phytic acid, hemagglutinating agents, thiaminase, etc. Some of these substances have been proven to cause anorexia when present in feed stuffs while others suppress feed intake (NRC, 1981).

Intrinsic Factors and Feed Intake: A number of intrinsic characteristics of the fish are also instruments for regulating feed intake. The intrinsic factors are usually motivated by genetic composition of the fish, in order word, they are mostly hereditary. The taste bud of the fish and hormones are some of these factors.

Taste Buds: The primary mode of detecting feed in fish is through olfaction or sight. Although, chemo-reception is most important in locating food since sight is frequently poor in fishes especially in turbid water (Hepher, 2009). It is a major determinant on the acceptance or rejection of food (Adron and Mackie, 1978). Fish are able to taste with their snout, mouth, tongue, and throat. A fish's tongue has taste buds just like in human. However, they are unable to retract their tongue. Catfish whiskers called barbells are also loaded with taste buds. This organ is used to feel around in the mud, when something tasty is found, they stop and bite. For fish, the tongue can only move when the lower jaw of the fish moves. The perceived well-defined and species specific flexibility of taste organ in fish species has led to the development of substances aimed at enhancing the palatability of feed (Goh and Tamura, 1980; Kasumyan, 2004).

Hormones: Several hormones in the fish have been shown to affect feed intake in fishes. It is widely recognized that a number of fish species ceases feeding during the reproductive season. Such periods are linked to changes in feeding behaviour and occur in connection with reproductive cycles (NRC, 1987). Fletcher (1984) has suggested that hormones may indirectly influence hunger by affecting the secretion of other hormones or by inducing changes in the levels of various plasma nutrients. For instance, steroid hormones (both androgens and oestrogens) have been shown to either suppress or enhance appetite in fishes while simultaneously altering plasma nutrient (Ince *et al*., 1982).

According to Le Bail and Rœuf (1997), most of the observed effects of hormones on feed intake, may result from four types of mechanisms, with each hormone acting by one or several as follows: (i) hormones could have a direct effect on central nervous system centres, associated with food intake behavior or via vagal afferent neurons; (ii) an indirect effect may occur via the gut which slows gastro-intestinal transit, thus resulting in stomach distention which activates vagal afferent neurons; (iii) indirect effect by acting directly on intermediary metabolism via glucose, free fatty acids or amino acids mobilization or storage; (iv) indirect effect by modifying directly or indirectly secretions of other hormones involved in food intake control. Some of these hormones (CCK, PYY, glucagon, adrenalin) act as short-term factors which regulate meal ingestion and are generally inhibitory factors. On the other hand, other hormones (GH, TH and leptin) require more time to modify food intake behaviour, and appear as stored calorie regulators.

Chua and Teng (1980) have showed that the use of bovine growth hormone in fish (*Epinephelus salmoides*) substantially improve feed intake and increased growth, while it concurrently lowered the production cost.

Physiological Status of the Fish and Feed Intake: Within a given species, feed intake will vary depending upon the physiological status (e.g. during gametogenesis). The rate of feed intake can decrease before and during spawning (Hepher, 2009). It is well established that feed intake per unit body weight decreases with increasing body weight and increases with increasing water temperature within the thermal preferendum zone of a given species. Under stressful conditions such as hypoxia or high ambient ammonia levels, the feed intake are also reduced (Kaushik, 2013). Also, after a period of starvation, fish tend to consume more food than before starvation period. However, there seems to be an adjustment of the food taken in subsequent feeding (Hepher, 2009). Ishiwata (1968) has reported that fish do not take food well immediately after their introduction into a new tank. This may be due to their need to be acclimated to the new environment or to their new food.

Conclusion: Different sizes and species of fish and the diverse environmental and management conditions used in aquaculture require different feeding strategies. Diet characteristics, such as source (living or non-living feed), particle size, texture, density, and palatability, must be carefully considered for size and species of fish. Feed allowance and frequency of feeding are important for growth rate and feed efficiency. Type of feed (floating or sinking) used and method of feeding will depend on the fish, culture system, equipment and personnel available. Design and setup of optimal species-specific culture conditions are of prime importance for successful aquaculture operations. Fish farmers should therefore make use of current research works aiming at optimizing management practices and micro environment for better feed intake and utilization.

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