



## The Nigerian Aqua-feed Industry: Potentials for Commercial Feed Production

\*Udo, I. U. and Dickson, B. F.

Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo, Nigeria.

---

Received February 6, 2017

Accepted July 21, 2017

---

### ABSTRACT

Nigeria is blessed with over 12.5 million hectares of water surface which a good percentage could be put to use for aquaculture and development. The animal and aquatic feed (aqua feed) industry, which can be accessed to provide raw materials/expertise within the country and the capacity within the existing infrastructure to manufacture the desired aqua feeds is reviewed. Raw materials available for the manufacture of Aqua feeds within the country and those replacing them are also stressed. Nutritionists on the other hand have fixed almost all the nutrient requirements of African catfish. Evaluation of the suitability of the unconventional ingredient for inclusion into aqua feed has been carried out. Feed formulators have also moved from manual formulation to least-cost formulation. The Federal Government has removed import duties on all forms of agricultural equipment as part of measures to diversify the country's economy while custom duties are imposed on selected agricultural produce used in aqua feed production in Nigeria in order to encourage local production. This is leveraged by support through different loan schemes to farmers. Nigeria is estimated to rake in over N800 billion from the sector as consumption is increasing daily when an enabling environment is provided for commercial aqua feed production.

**Key words:** Keywords: Aqua feed, ingredient, nutrient, nutritionist, commercialization

---

### INTRODUCTION

Nigeria is among the largest fish consumers in the world with over 1.5 million tonnes of fish consumed annually, yet its domestic fish catch is estimated at 450,000 metric tonnes per year (Ezenwa and Anyanwu, 2003; Jim, 2003). According to FDF, (2008), with the estimated population of about 174 million people, the demand for fish stood at 2055 tonnes, supply from aquaculture stood at 671.493 tonnes while deficit increased from 1404.067 in 2014 to 1444.752 tonnes in 2015. This shows a serious gap between demand and supply of fish. According to Ita *et al.* (1985), Nigeria is blessed with over 12.5 million hectares of water surface which a good percentage could be turned to gold mines if the right feeds could be produced to meet aquaculture and cage culture development. Production of high quality feed is one of the persistent bottlenecks holding back great rapid expansion of aquaculture in Nigeria. According to Fagbenro *et al.* (2003) and Isyaki *et al.* (2009) feed cost constitutes about 40 and 60 percent of the operational cost in aquaculture. This has hindered many investors from investing in aquaculture. Among the constraints faced by Aqua feed producers in Nigeria, high cost and scarcity of feed ingredients, particularly the protein source tops the list. In Nigeria, the Aqua feed industry is dominated by few large commercial feed industries usually based in Europe, Asia or America who run local franchised industries.

Currently in Nigeria emphasis has been placed on encouraging indigenous feed enterprises that make use of local ingredient in formulating feeds for the fish industry. The task of meeting the increasing demand for Aqua feed can best be realized through increased availability of indigenous feed production. Indigenous Feed Enterprises are seen as an honest approach because of ease of availability of raw materials, and access by fish farmers. A number of strategies have been adopted such as pricing policies, input subsidies, production credit and liberalization by governments and individuals to increase the output of these Aqua feed enterprises, yet their performance is low in terms of meeting the needs of the fish industry. High cost of feed ingredients caused by indirect devaluation of the Naira and competition

---

\*Correspondence email: [dorime\\_2004@yahoo.com](mailto:dorime_2004@yahoo.com), Tel: +2348038097510

for by man and livestock is top among the factors responsible, followed by lack of manpower. Interestingly, the request for the products of the enterprises is daily on the increase (EDR, 2014). There are few sources of commercial aqua feed in Nigeria as only specialized animal millers engaged in aqua feed production in, demand, as such majority of aqua feed produced (69.75 per cent) are fan-made (Fagbenro *et al.*, 2003). A commercial feed mill in Nigeria will be the catalyst in rebuilding and developing efficient aquaculture production. The commercial feed mill will also serve as a center for animal husbandry training, while simultaneously supporting commercial poultry and dairy production, sheep and beef fattening feedlots and meat processing units. Commercial Feed Milling started in Nigeria in 1963 and has gone through various levels of modernization in terms of equipment and structural reforms. The Industry however, has not met up with local demand. A review of the current status of the Nigerian aqua feed industry showed that the industry is growing rapidly in recent years and has the potentials for both self-sustainability and commercial production (Udo and Umanah 2017). This work has therefore reviewed information on the potentials of Aqua feeds industry toward the expansion of commercial feed production.

### **Existing animal feed industry**

It is generally held that the development of commercial aqua feed requires an established commercial livestock feed manufacturing sector. Of particular importance is the level of infrastructure within the industry. While it is evident that some aqua feeds require specialist manufacturing techniques (e.g. high energy/lipid formulations), the majority of the processing (milling, extrusion, etc.) can be undertaken using conventional animal feed manufacturing technologies. Thus, the presence of existing infrastructure and in particular of spare manufacturing capacity is a key indicator of a country's capacity to produce aqua feeds in a commercial scale. Indeed, the development of a country's aqua feed industry is intrinsically linked to their livestock feed manufacturing capacity.

Nigeria had the highest number of animal feed manufacturers (620) in the Sub-Saharan, producing approximately 3.8 million tonnes of feed in 2000. The large number of feed mills can be attributed to the dominance of the sector by small-scale operators (59 percent of all feed mills produces between 0.5 - 5 tonnes/hour) (Fagbenro and Adebayo, 2005). Nevertheless, in 2000, the country's installed capacity was estimated at 7.25 million tonnes - this represents a production efficiency of only 52 percent. New global ranking of animal feed has moved Nigeria from number 51 to 40 in the world, a significant progress from its previous ranking of number 51 out of 130 leading animal feed countries in the world (Alltech, 2015).

### **Existing Aqua feed industry**

Inventories show that there were 215 aqua feed producers in Nigeria as at 2004 (Table 1). Current search shows that in terms of Catfish feed companies, Lagos has the highest, while Anambra, Kwara, and Nasarawa have the lowest. For aqua feed company, Lagos has the highest, while Kaduna has the lowest (USAID 2010). Feed masters Limited (Nigeria) has an aqua feed production in Illorin with a capacity of 10 tons per hour of pelleted feed giving an annual capacity of some 13,000 tons of fish feeds. Chi farms Nigeria in Ibadan produces floating feeds and Guinea feeds company in Edo State produced pelleted fish feeds.

### **Production capacity**

According to Shipton and Hecht, (2005) only 10,760 tonnes of aqua feeds were produced in Nigeria before 2000. This showed gross underutilization of the feed milling capacity, which suggested that if there was sufficient demand, there was enough capacity installed to increase aqua feeds production. In 2000, the Nigerian aquaculture industry used an estimated 35 570 tonnes of feed representing a negligible proportion (< 1 percent) of the national feed production (Fagbenro and Adebayo, 2005). Of the total of 5,300,000 metric tonnes of feed produced in 2015, aqua feed production stood at 647,750 metric tonnes, contributing 12 percent, second to poultry production. This suggests an annual growth rate of about 10 percent. Therefore, Nigeria would have the potential to produce sufficient aqua feeds using existing production capacity.

### Link between aqua feed and poultry production

The production of animal feeds in Nigeria is about 5.3 million tons annually (Alltech, 2016). Twelve percent of the total production is for aqua feeds while 80 percent is for poultry meat and egg production. Poultry feed is exclusively produced locally (no import of poultry feed in Nigeria). In contrast, aqua feeds manufacturers are very limited in number in comparison to the number of fish farmers and, as such, the aquaculture industry is very reliant on the imports of quality fish feeds. Aqua feeds companies are just beginning to learn about the size of the local fish farming industry. Given the dominance of the poultry sector in animal feeds, the fish feed industry can be volatile. If there is a sudden increase in the price of poultry, demand will shift and will most likely lead to re-orientation of feed manufacturers from the production of fish feed to poultry feed. However, there is an increasing recognition in the feed industry that fish farming is promising and feed manufacturers have started taking more risks to enter the fish feed market. Vital Feed produces both feed types and is present in Edo state and Akwa Ibom State. Top Feeds, a local manufacturer of poultry feed has entered the fish feed market in Nigeria. At the production level, commercial farms involved in both poultry and fish production can make economies of scale by reducing the costs of inputs, such as fertilizer and feeds. Animal excreta can also be used as organic manure in fish ponds.

### Availability of suitable feed ingredients

The major ingredients required for commercial aqua feed production are presented in Table 2. The availability and costs of suitable feed ingredients are a prerequisite to the development of a viable aqua feed industry. Conventional aqua feed formulations rely heavily on fish meal to provide much of the dietary protein. Nigeria imports fish meal - and in some cases - at prohibitively high prices.

### Fishmeal

Of the estimated 65253 tonnes of fishmeal available in Nigeria in 2000, 13.4 percent was sourced from local production, and the remaining was imported - predominantly from Norway and Denmark (Shipton and Hecht 2005). The cost and availability of local and imported fishmeal available in Nigeria are presented in Table 3. Aqua feed formulators have recently been more active in looking at alternatives to lower the proportion of fishmeal (FM) in their formulas (Spinelli, 1980). This has become a hot topic in China, for example. Alternate sources of protein that are being evaluated or have potential as partial or whole replacement for fish meal in aquaculture diets are presented in Table 4.

Table 1: Summary of Inventories on Aquatic Resources, Fish Farms and Feed Producers in Nigeria (AIEP 2004)

No.	Geopolitical Zones and States			
	South –East Zone			
1	Abia	4	40	2
2	Anambra	5	181	3
3	Ebonyi	17	12	7
4	Enugu	22	4	4
5	Imo	9	40	16
	Subtotal	57	114	32
	South-South Zone			
1	Akwa Ibom	16	98	4
2	Bayelsa	52	86	-
3	Cross River	17	199	-
4	Delta	30	420	6
5	Edo	6	136	-
6	Rivers	22	89	8
	Subtotal	147	1028	18
	South – West Zone			
1	Ogun	24	173	35
2	Ekiti	6	31	2

Table 1 Cont'd

3	Lagos	-	153	16
4	Ondo	8	15	3
5	Osun	7	300	26
6	Oyo	29	234	9
Subtotal		74	906	91
North – Central				
1	Abuja	15	29	1
2	Benue	45	198	5
3	Kogi	35	32	-
4	Kwara	21	121	18
5	Plateau	85	18	9
6	Nassarawa	16	16	2
7	Niger	35	29	1
Subtotal		252	443	36
North-East Zone				
1	Adamawa	16	4	-
2	Bauchi	49	-	-
3	Borno	18	12	-
4	Gombe	44	9	1
5	Taraba	83	8	1
6	Yobe	20	13	1
Subtotal		230	46	3
North – West Zone				
1	Jigawa	15	4	1
2	Kaduna	20	10	9
3	Kano	17	10	1
4	Katsina	40	7	16
5	Kebbi	30	56	-
6	Sokoto	15	9	1
7	Zamfara	40	9	7
Subtotal		177	105	35
Grand total		937	2643	215

Table 2. Major ingredients required for commercial aqua feed production in Nigeria

Ingredient	Quantity (kg) required per tonne		
	Catfish feeds (40 percent protein)		Tilapia feed (30 percent protein)
	Grower	Broodstock	
Fishmeal (65 percent cp)	250	250	150
Soybean meal (45 percent cp)	350	350	450
Maize	150	100	250
Blood meal (85 percent cp)	100	100	-
Fish oil	60	90	40
Vegetable oil	40	60	60
Vitamin/mineral premix	30	30	30
Binder	20	20	20

Source: Shipton and Hecht (2005).

### Soybean meal

The Nigerian formal soybean processing sector has an installed capacity exceeding 700,000 tons per annum with the main products being soybean oil and the high protein cake that is usually used as an ingredient in poultry feed. Annual production is estimated at around 550,000 tons. The processing firms estimate based on what they are able to procure that annual production is around 350,000 tons.

Table 3. Fishmeal availability in Nigeria

Production designation		Quantity (tonnes)	Price (US\$/tonne)	Availability
Local production	Commercial	8 050	650	low
	Artisanal	710	530	low
Imports	65 percent cp.	44 386	870	low
	72 percent cp.	12 107	1 350	scarce

Source: Shipton and Hecht (2005).

The 200,000 tons difference is probably because large quantities of soybean are eaten at home by the families that produce the crop and also large numbers of small scale processors make Awara with soybean every morning for sale. There is a substantial deficit between domestic requirements and production (FMARD, 2014). Although soybean production has increased from 160000 m tons in 1995 to 550,000 mm tons in 2010 there is still a national demand gap of 200, 000 m tons being met through importation.

### Maize

Production figures (FAOSTAT, 2011) show that the area planted to maize in Nigeria has increased from 438,000 ha in 1981 to 3,335,860 ha in 2009 with associated increase in production from 720,000 tons to 7,338,840 tons during the same period. Grain yield has also increased from 1.6 t/ha in 1981 to 2.0 t/ha in 2009. However, the slow turnover of maize varieties and hybrids on farm, coupled with limited availability of good quality improved seed, fertilizer and other inputs have minimized the potential yield gains recorded on farm in Nigeria.

### Blood meal

Large quantities of animal blood are currently being wasted in abattoirs throughout the country. Apart from the environmental problems and health hazards this creates, it is an economic waste as the blood could be used to produce the needed blood meal at a very low cost (Okuneye and Banwo 1990).

### Oils

The cost and availability of local and imported oils are presented in Table 4. Their availability is inconsistent, and hence prices remain unstable.

Table 4. Local and imported oils availability in Nigeria

Product	Price (US\$/litre)	Availability
Fish oil (imported)	3.75	scarce
Palm oil	1.15	adequate
Groundnut oil	1.70	adequate
Soybean oil	1.45	adequate
Coconut oil	2.30	scarce
Corn oil	1.35	scarce
Olive oil (imported)	1.10	scarce
Mixed vegetable oil	1.10	low

Source: Shipton and Hecht (2005).

### Feed additives

All the feed additives currently available in Nigeria are imported from Western Europe and the United States. Table 5 presents the cost and availability of some of the principal feed additives available in Nigeria.

### Unconventional feed ingredients

These are potential feed ingredients which have hitherto 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 and they can be toxic or poisonous

(Abowei and Ekubo, 2011). They are of plant or animal origin (Roberts, 1989). Unconventional ingredients that are commercialized and frequently used in fish feeds are presented in Table 6.

Table 5. Feed additive availability in Nigeria

Product	Price(US\$/kg)	Availability
Layers premix	4.50 - 6.00	Adequate
Growers premix	4.50	Adequate
Broiler finisher premix	5.50	Adequate
Bone meal	0.36	Adequate
Oyster shell	0.08	Adequate
Sodium chloride	0.15	Adequate
Lysine	5.20	Low
Methionine	5.50	Low

Source: Shipton and Hecht (2005).

Table 6: Commercialized alternate sources of fishmeal for aqua feeds industry

Vegetable	Animal
Soy meal	Poultry by-products
Rapeseed meal	Feather meal
Sunflower meal	Shrimp and crab meal
Oat groats	Blood flour
Cottonseed meal	Fish silage
Wheat middlings	Meat meal
Protein (range), %	
15-50	50-85

Source: Spinelli (1980).

Unconventional ingredients that have not yet been commercialized, but included in fish diets with good results include: single cell protein, microalgae, recycled waste, yeast, phytoplankton, bacteria, and higher plants with protein content ranging from 4 – 85 per cent (Spinelli, 1980).

### Single cell protein

Single cell protein (SCP) includes microalgae, bacteria and yeast and are alternative to conventional protein sources that are frequently used as feed ingredients for fish due to their nutritional value (Anupama, 2000). SCP serves as alternative protein source for aqua-feeds among other important in aquaculture (Bharti *et al.*, 2014). SCP from bacteria and yeast contain relatively high nucleic acid content in the form of RNA. The large amounts of RNA in microorganisms promote rapid protein synthesis (Adedayo *et al.*, 2011). These authors reported that rapid protein synthesis and short multiplication times are key factors related to high protein content in single-cell microbes. High nucleotide content in Aqua-feeds improves hepatic function and lipid metabolism in fish. Single cell proteins are now becoming well accepted in fishmeal replacement strategies.

Among unconventional protein sources, SCP of microbial origin appear to be a promising substitute for fishmeal, which can replace up to 25-50% fish meal (Selvakumar *et al.*, 2013). SCPs are playing a greater role in the evolution of aquaculture diets. With excellent nutrient profiles and capacity to be mass produced SCPs have been added to aquaculture diets as partial replacement for fishmeal Coutteau and Lavens (1989), Olvera-Novoa *et al.* (2002), Li and Gatlin (2003) and for Highly Unsaturated Fatty Acids (HUFA). The nutrient composition of the main group of microorganisms used for single cell protein production is presented in Table 7. The cost and availability of fish meal as well as the replacers either within the country or imported are cost effective and available in sufficient quantities to support feed production targets.

Table 7. Nutrient composition (as percent dry weight) of the main group of microorganisms used for single cell protein production

Nutrients	Microorganisms			
	Fungi	Algae	Yeast	Bacteria
Protein	30-45	40-60	45-55	50-65
Fat	2-8	7-20	2-6	1-3
Ash	9-14	8-10	5-10	3-7
Nucleic acids	7-10	3-8	6-12	8-12

Source: Miller and Litsky (1976)

### Algae

About 30 percent of the world's algae production are used for animal feed production, primarily in aquaculture. Companies are examining opportunities to provide a high quality, sustainable alternative to fish oil through heterotrophic microalgae production. Microalgae are grown under strictly controlled conditions without producing any environmental pollutants. The Marine Ingredients Organization (IFFO) sees microalgae as the most promising and sustainable alternative sources of EPA and DHA in fish oil. Algal oils are now being commercialized as sustainable alternative sources of fish oils (Tsappis, 2014).

### Human resources

The availability of suitably trained personnel is an important consideration. The skills that are required to develop an aqua feed industry are varied and are inevitably sourced from a number of disciplines. For example, trained personnel are required to run and service the manufacturing plants. Fortunately, Nigeria has an existing livestock feed manufacturing industry, therefore, these skills are available locally. Nigeria already has large skills bases that have been developed in their extensive governmental, NGO, university and research institutions. Trained quality control and management personnel are available. In the area of aquaculture nutrition, before now, feed for African catfish (*Clarias gariepinus*) had been formulated based on the nutrient requirement of Channel catfish (*Ictalurus punctata*), but now nutritionists have fixed almost all the nutrient requirements of African catfish (NRC, 2011). They have also evaluated the suitability of the unconventional ingredient for inclusion into aqua feed (Fagbenro *et al.*, 2010; Udo and Umoren, 2011; Udo and John 2015). Feed formulators have also moved from manual formulation to a least - cost formulation by linear programming Udo *et al.* (2011a), Stochastic programming Udo *et al.* (2011b), etc. these have helped in the formulation of not only least-cost diets/feed for the indigenous feed mills, but also addressing nutrients and price variability in fish diet formulation.

### Legislation and taxation

Legislation and taxation issues are important considerations that have clear economic implications for all commercial enterprises. Nigeria is not a member of COMESA (Common Market for Eastern and Southern Africa), and as a result does not enjoy barriers-free trade. The Federal Government has removed import duties on all forms of agricultural equipment as part of measures to diversify the country's economy (CBN, 2016).

Table 8: Custom duties on selected agricultural produce used in aqua feed production in Nigeria

CET Code	Description	SU	ID	VAT	LVY	EXC
0305.1000.00	Fishmeal	-	10	-	-	-
1201.1000.00	Soya beans Seed	-	5	5	-	-
1201.9000.00	Soya beans (excluding seeds)	-	10	5	-	-
1005.1000.00	Maize (corn) Seed	-	5	-	-	-
1102.2000.00	Maize (corn) flour	-	20	-	-	-
0210.2000.00	Blood meal	-	35	5	-	-

Source: Abdi *et al.* (2009). Key: SU=System Unit, ID=Import Duty, VAT=Value Added Tax, LVY=Levy, EXC=Excise Duty

Custom duties are imposed on selected agricultural produce used in aqua feed production in Nigeria in order to encourage local production (Table 8).

The Nigerian Customs Service (NCS) increased duties in line with the Central Bank of Nigeria's (CBN) new flexible exchange rate policy which has the Naira officially trading at ₦315 to \$1. The policy implemented on August 1<sup>st</sup> 2016 saw a 43 percent increase in Customs duties that cost the country 3,000,000 jobs, as many operators considered relocating to neighbouring countries with friendlier policies. This was the second time in two months that the NCS has increased its duties. The first occurred on July 1, 2016 when the customs directed that the dollar rate used for calculating import duty be increased from ₦197 to ₦286 to a dollar. Again, effective August 1, the calculations increased to ₦315 to a dollar. An additional 3 million unemployed people to the 22.45 in the unemployment pool is a grim prospect for Nigeria. In addition to seeing a seventh consecutive rise in the unemployment rate, cash strapped Nigerians can expect further increases in the prices of consumer goods, as companies pass rising costs on to consumers. However, the Federal Government of Nigeria is giving support to farmers which is aimed at accelerating local production of these products. This is a step towards self-sufficiency.

### Supports to Farmers

#### Central bank of Nigeria loan

The Central Bank of Nigeria (CBN) has approved the disbursement of about ₦75 billion as loan to farmers in the 36 states and the Federal Capital Territory (FCT) under the Nigerian Incentive-Based Risk Sharing in Agricultural Lending (NIRSAL). The CBN (CBN, 2016) is also funding Agricultural Credit Guarantee Scheme (ACGS).

#### The Federal Government youth empowerment programme

The Federal Government of Nigeria (FGN) had flagged off Dry Season Farming, Launches ₦20 billion CBN Loan in Kebbi State (CBN, 2016; FMARD, 2016). Youth Initiative for Sustainable Agriculture (YISA) is one of the laudable projects by the FGN. Achievements of YISA include: (i) Intensification of efforts in the production of High-yield wheat Foundation Seeds. The Organization received Breeder seeds of the high-yield Norman BourlagWheat Variety (with 5-6 tons/ha capacity) from the Lake Chad Research Institute (LCRI) for multiplication in the 2015/2016 Dry Season production scheme in Kadawa, Kano State and Bakilori Irrigation Facility in Talata Marfara, Zamfara State: (ii) Benefits from Federal Government of Nigeria Mechanize Equipment Intervention support of Wheat Farmers. (iii) Partners with CEED to Create Opportunities for Rural Youths (CORY). (iv) Partners with the Lake Chad Research Institute (LCRI) on Youth Empowerment through Local Production of Wheat (v) Trains 100 Youths and Women on Fish Value Chain in Benue State. Other supports by the FGN includes: Growth Enhancement Scheme (GES), Youth in Agriculture Scheme and Commercial Agriculture Development Project (CADP).

### Conclusion

Although aquaculture started far back in the 80's, one of the hindrances to aquaculture development in Nigeria is the unavailability of commercial aqua feeds. However, the country with its growing population and increasing demand for fish needed an ever-growing feed industry to match the fish production rate. In the livestock industry, Nigeria has improved drastically in animal feeds and livestock production. Nigeria is now rated as one of the world's largest emerging animal feeds producers in the world with a better opportunity to penetrate the International animal feeds export market. In the past few years, the Nigerian aqua feed industry has grown rapidly, next to poultry in terms of feed production rate. Therefore, the Nigerian aqua feed industry has the potentials for commercial feed production.

### REFERENCES

- Abdi, A., Flake, L. and Nzeke, U. (2009). Federal Government of Nigeria, Federal Ministry of Finance, Nigerian Custom Service (NCS). CET tariff - act no. 4. *Annual Export guide*. USDA foreign agricultural service, No. 19010.



- Abowei, J. F. N. and Ekubo, A. T. (2011). A Review of Conventional and Unconventional Feeds in Fish Nutrition. *British Journal of Pharmacology and Toxicology* 2(4):179-191.
- Adedayo, M. R., Ajiboye, E. A., Akintunde, J. K. and Odaibo, A. (2011). Single cell proteins: as nutritional enhancer. *Advances in Applied Science Research* 2(5):396-409.
- Alltech (2016). Alltech Global feed survey 2016. <http://www.alltech.com/feedsurvey>.
- Anupama, P. (2000). Value-added food: Single cell protein. *Biotechnol. Advances*, 18:459-479.
- Bharti, V., Pandey, P. K. and Koushlesh, S. K. (2014). Single Cell Proteins: A Novel Approach in Aquaculture Systems. *World Aquaculture* 62-63. Available on: [www.was.org](http://www.was.org).
- CBN (2016). 2015 Statistical Bulletin: Domestic Production, Consumption and Prices. Central Bank of Nigeria Annual Statistical Bulletin <https://www.cbn.gov.ng/Out/2016/SD/2015%20Statistical%20Bulletin>
- Coutteau, P. and Lavens, P. (1989). The use of yeast as a single-cell protein in aquacultural diets. *Artemia Reference Centre, Med. Fac. Landbouww. Rijksuniv. Gent.*, 54:1583-1592.
- Economic Development Research (2014). Analysis of Fish Feed Market in Delta State. Economic Development Research No 7. PIND Foundation 63Pp.
- Ezenwa, B. and Anyanwu, P. E. (2003). Water Recirculatory System Technology as a Major Tool for Increased Fish Production by Private Fish Farmers. *Proceeding of the 18th Annual conference of the Fisheries Society of Nigeria (FISON) Owerri, 18 -12 December 2003* Owerri, Nigeria, 33-37.
- Fagbenro O. A., Adeparusi E. O and Jimoh, W. A. (2010) Nutritional evaluation of raw sunflower and sesame seed meal in *Clarias gariepinus*: an assessment by growth performance and nutrient utilization. *African Journal of Agricultural Research*, 5 (22) 3096- 3101.
- Fagbenro, O.A. and Adebayo, O.T. (2005). A review of the animal and aqua feed industries in Nigeria. In: A synthesis of the formulated animal and aqua feed industry in sub-Saharan Africa, 25-36. (John Moel and Matthias Halwart, eds.). CIFA Occasional Paper No.26, FAO, Rome. 61Pp.
- Fagbenro, O. A., Adeparusi, E. O. and Fapohunda, O. O (2003) Feedstuff and dietary substitution for farmed fish in Nigeria. In. *Proceeding of the Joint Fisheries Society of Nigeria/ National Institute for Freshwater Fisheries Research/FAO-National special programme for food Society. National Workshop on Fish Feed Development and feeding practices – Aquaculture* (Eyo, A.A. Ed) held at National Institute for Freshwater Fisheries Research, New Bussa 15th – 19th September 2008, 60 – 72.
- Food and Agriculture Organization Statistics (2011). FAO Statistics Division 2011 (accessed 21/07/2014). Available on: <https://fmard.gov.ng/about/fmard-policies>
- FDF (2008) Federal Department of Fisheries, Fisheries Statistics of Nigeria. Projected human population; fish demand and supply in Nigeria, 2000 – 2015, 56Pp.
- FMARD (Federal Ministry of Agriculture and Rural Development) 2016. Private Sector Driven Agriculture Mechanization Framework. (PSDAMF) and GES Application Strategy for ATA, (CD-ROM) Nigeria. <https://fmard.gov.ng/about/fmard-policies>.
- Isyagi, N., Veverica, K. L., Asiiwme, R. and Daniels, W. H. (2009). *Manual for the commercial production of the African catfish in Uganda*, USAID FISH (Fisheries Investments for sustainable harvest). 222Pp.
- Ita, E. O., Balogun, J. K., Pandogari, A. Ibitoye B. and Sado, E. K. (1985). A preliminary checklist of inland water bodies in Nigeria with special reference to ponds, lakes, reservoirs and major rivers. *Kainji Lake Research Institute Technical Report Series* No.14.
- Jim, M. (2003). Aquaculture Professional Organisations: The Future of Nigeria Aquaculture Industry in the Land. *A paper presented on 18<sup>th</sup> Annual Conference of Fisheries Society of Nigeria (FISON), Owerri, 8<sup>th</sup> -12<sup>th</sup> December, 2003*. 14-15.
- Li, P. and Gatlin, D. M. (2003). Evaluation of brewer's yeast (*Saccharomyces cerevisiae*) as a feed supplement for hybrid striped bass (*Morone chrysops* - *M. saxatilis*). *Aquaculture*, 219:681-692.
- Miller, B. M. and Litsky, W. (1976). *Single Cell Protein in microbiology*. McGraw-Hill Book Co., New York, NY, USA.

- National Research council (2011). *Nutrient requirements of fish and shrimps. Committee on the Nutrient Requirements of Fish and Shrimp*; National Research Council. National Academic Press Wasington DC. USA, 392Pp.
- Okuneye, P. A. and Banwo, P. A. (1990) Bloodmeal, livestock feed and investment opportunities in Nigeria and elsewhere. *Biological waste* 31(2):85-95.
- Olvera-Novoa, M. A., Mart ´nez-Palacios, C. A. and Olivera-Castillo, L. (2002). Utilization of torula yeast (*Candida utilis*) as a protein source in diets for tilapia (*Oreochromis mossambicus* Peters) fry. *Aquacult. Nutr.*, 8:257-264.
- Roberts, R. J. (1989). Nutritional Pathology of Teleosts, In: Roberts R. J., (Ed), Fish Pathology, Balliere Tindall, London, 337-362.
- Selvakumar, D., Jyothi, P. M. and Dhevendaran, K. (2013). Application of Streptomyces as a Single Cell Protein to the Juvenile Fish *Xiphophorus maculatus*. *World Journal of Fish and Marine Sciences* 5 (6):582-586.
- Shipton, T. and Hecht, T. (2005). A synthesis of the formulated animal and aqua-feed industry in sub-Saharan Africa. pp. 1-13. In J. Moehl and M. Halwart, (eds.) A synthesis of the formulated animal and aqua feeds industry in sub-Saharan Africa. *CIFA Occasional Paper. No. 26*. Rome, FAO. 61Pp.
- Spinelli, J. (1980) Unconventional feed ingredients for fish feed. In Fish feed technology. Rome, UNDP/FAO, ADCP/REP/80/11, 187-214.
- Tsappis, A. (2014) Fishmeal and Fish Oil Shortage: Consider algae. In: Advances in Processing and Formulation. *Aquafeed*. an Aquafeed.com publication, 6(2):19-23.
- Udo, I. U. and John, J. F. (2015). Effect of processing methods on the utilization of cassava (*Manihot esculenta* Crantz) leaf meal (CLM) by African catfish (*Clarias gariepinus*). *Livestock Research for Rural Development*, 27 (8). <http://www.lrrd.org>.
- Udo, I. U. and Umoren, U. E., (2011). Nutritional Evaluation of Some Locally Available Ingredients Used for Least-Cost Ration Formulation for African Catfish (*Clarias gariepinus*) in Nigeria. *Asian Journal of Agricultural Research* 5(3):164-175.
- Udo, I. U., Ndome, C. B., Ekanem, S. B. and Asuquo, P. E. (2011a). Application of linear programming technique in least-cost ration formulation for African catfish (*Clarias gariepinus*) in semi-intensive culture system in Nigeria. *Journal of Fisheries and Aquatic Science* 6(4):428-437.
- Udo, I. U., Ndome, C. B., and Asuquo, P. E. (2011b). Use of stochastic programming in least-cost ration formulation for African catfish (*Clarias gariepinus*) in semi-intensive culture system in Nigeria. *Journal of Fisheries and Aquatic Science* 6(4):447-455.
- Udo, I. U. and Umanah, S. I. (2017). Current Status of the Nigerian Aqua Feed Industry: a review. *International Journal of Innovative studies in Aquatic Biology and Fisheries*. 3(1):14-22
- USAID (2010) "Aquaculture Buyer's Guide for Nigeria, United States Agency for International Development. 46Pp.