NUTRITIVE VALUE AND MICROBIAL LOAD OF SOME LOCALLY-MADE SINKING FISH FEEDS IN NIGERIA

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ABSTRACT

Proximate composition, microbe identification and counts of four commercially branded local sinking fish feed in Nigeria were studied to ascertain the authenticity of the nutrient compositions and assess the microbial load. The proximate composition of feeds was analysed according to standard procedures. The spread plate method was used to determine the bacteria count. Fungi were isolated using the dilution plate technique. Analysed values of the feeds were; crude protein (28.4 - 35.2%), ash (5 - 9%), lipid (5.8 - 12%) and crude fibre (2.1 to 4.6%) respectively. The analysed moisture content for Brand EZ and Brand CZ feeds were 92% and 94.8% while their labelled values were 89% and 92% respectively, and no values were disclosed for moisture content of other feeds. Isolated and identified bacteria were Bacillus cereus, Bacillus subtilis, Klebsiella pneumonia, Salmonella typhi and Escherichia coli. Percentage frequency occurrence revealed the prevalence of Bacillus subtilis, Klebsiella pneumonia and Bacillus cereus. Fungi identified were Fusarium spp, Penicillium spp, Aspergillus flavus, and Mucor spp, but the count in the feeds studied is below the microbial international standard for animals. Based on these findings, the feed quality of the various brands might not meet up the nutritional requirements of young fish, however, the microbial load could not precipitate any severe negative effects on the health status of the cultured fish.

Keywords: feed contamination; locally-made sinking fish feeds; microbial quality; nutrient composition.

INTRODUCTION

The growing demand for fish as a source of protein in Nigeria has motivated the development of aquaculture both at the commercial and subsistence levels. However, the cost of feeding which falls within the range of 60-80% of the total cost of raising fish throughout the production cycle (Adekunle *et al*., 2012; Orire and Sadiku, 2014), still remains a major constraint in the expansion of pisciculture. Most available commercial fish feeds are imported and very expensive. Hence, to reduce the production cost, fish farmers opt for affordable locally produced fish feeds without being sure of the proximate composition, processing methods and safety of the feeds. Several fish feed manufacturers have thus emerged in Nigeria selling feed with little or no information on the formulation and nutrient composition (Mustapha *et al*., 2014).

Furthermore, most locally produced sinking fish could not meet the nutrient requirements for optimum fish growth and development (Mustapha *et al.,* 2014). Because the manufacturers made use of published values to determine the nutrient composition of their feed ingredients, rather than carrying out laboratory analyses of these components. The attendant effects include the production of poor-quality feed, which is a great economic loss for both the

fish farmers and the aquaculture industry (Mustapha *et al*., 2014).

It is a well-known fact that the growth and body composition of fish species are affected by dietary protein and energy levels, but beyond that, a good quality feed should contain essential nutrients in the right proportion, palatable, digestible and durable for optimum fish growth (Edwin *et al*., 2001; Mustapha *et al*., 2014).

Also, microbes can decrease feed value quality through nutrient degradation and the production of toxins that are harmful to fish health (Ubiebi, 2017). Bacteria and fungi contamination have been implicated as limiting factors to the development of aquaculture (Austin and Austin, 1999). Contamination of fish feed by *Salmonella*, *E. coli* and other bacteria strains have been reported (Ciceron *et al*., 2008; Kaarine, 2010).

Very few studies have actually looked at the nutrient composition and quality of sinking feed locally produced in Nigeria. Ekanem *et al*. (2012) compared the growth performance and feed utilization of *Clarias gariepinus* fed on local sinking feed and an imported floating feed, while Mustapha *et al*. (2014) compared the effect of local and foreign commercial feeds on the growth and survival of *Clarias gariepinus* juveniles. They found, that the growth and feed utilisation of *C. gariepinus* fed local feed were significantly lower than the group fed imported feed. Probable reasons for the present poor performance of local feed as shown by previous studies could be attributed to the lack of Government legislation, surveillance and control over the components and quality of the feeds produced locally (Ayubu and Iorkohol, 2013), in addition to the dearth of laboratory information on the nutritional and microbial load of these feeds.

Hence, based on the paucity of empirical data on the nutrient content of locally produced sinking fish feed, there is a need for more research in the area of proximate composition and microbial safety of these feeds for sustainable aquaculture production in Nigeria.

MATERIALS AND METHODS

Sample Collection

Four commercially branded local sinking feeds with varying pellet sizes were purchased from various fish feed markets in Lagos state; 'Brand AZ' (2mm and 6mm); 'Brand BZ' (4.5mm and 8mm); 'Brand CZ' (4mm and 8mm); and 'Brand EZ' (3mm and 8mm) to cover all the spectra of sizes available in the market. They were stored in zip lock bags under aesthetic conditions and stored at -20 ^{0}C till further analyses.

Analytical methods: The proximate composition of different local sinking fish feeds were analysed according to the Association of Official Analytical Chemists (AOAC, 2005). The analyses of crude protein (CP), ether extract (EE), crude fibre (CF), dry matter (DM) and ash content of samples were carried out in triplicates. Brief descriptions of the analytical procedures are stated below:

1 g of feed sample was hydrolysed with 15 mL conc. H_2SO_4 containing two copper catalyst tablets in a heat block at 420 °C for 2 h. After cooling, H_2O was added to the hydrolysates before neutralization and titration. The amount of total nitrogen in the sample was multiplied with both the conversion factor of 6.25 and a species-specific conversion factor of 5.6 for fish and shrimp.

The ether extract in the sample was quantified using petroleum ether. Aliquots of 2 g were packed in cartridges made of qualitative filter paper and underwent extraction for 3 h at a drip rate of 5–6 drops/s. After this period, the cups were dried at 105 °C for 30 min and weighed. The ether extract mass was quantified as weight gain of the cup after extraction and solvent recovery.

The sample was allowed to boil with 1.25% dilute H_2SO_4, washed with water, and further boiled with 1.25% dilute NaOH, and the remaining residue after digestion was taken as crude fibre. The dry matter content of the feed sample was evaluated from the free moisture content. The latter was measured as weight loss of the sample after drying in an oven at 105 °C. The dry matter residue was placed in a muffle at 550 ± 10 °C until a white residue (the ash) was obtained and weighed.

Microbial analysis

Fungi isolation and identification

Fungi were isolated using the dilution plate technique. One gram of each sample was mixed with 9.0ml of sterile distilled water, and serial dilution was carried out to 10^{-4} dilutions. Three different aliquots of dilutions were inoculated into sterile Petri dishes in duplicates with the aid of a micropipette fitted with sterile tips. Potato Dextrose Agar (Lab M) was poured into the inoculated plates and rocked (swirled) to ensure even distribution of the agar solution and allowed to set. The inoculated plates were incubated at 28^{o}C for 3-5days (Nevalainen *et al*., 2014). The developed colonies were counted in triplicates using a colony counter. Fungal isolates were identified from their macroscopic and microscopic characteristics according to Samson *et al*. (2010).

Isolation and enumeration of total heterotrophic and faecal coliform bacteria

Bacterial isolation was carried out using the standard pour plate technique described by Fawole and Oso (2007). One gram of each crushed feed sample was homogenized in 9ml of sterile physiological saline after which serial dilution was carried out to 10^{-4} dilutions. One ml of the solution was inoculated into sterile Petri dishes after which freshly prepared Nutrient agar, MacConkey agar, and Eosine Methylene Blue were poured aseptically into the inoculated plates. The plates were swirled to ensure even distribution of the inoculum and then allowed to set. The plates were incubated at 37^{o}C for 24hrs. The standard streaking method was employed for the isolation of pure cultures. The discrete colonies were streaked on sterile, nutrient agar plates with the aid of a sterile inoculating loop. The inoculated plates were incubated at 37^{0}C for 18-24hrs. Pure cultures were observed for cultural characteristics and cellular morphology (under x100 oil immersion objective) as well as prepared for preliminary identification and biochemical tests (Dubey and Maheshwari, 2014).

Biochemical Characterization and Identification of Bacteria Isolates

Cellular and biochemical identification of the pure cultures was carried out using standard techniques described by De Vos *et al*. (2009). These include Gram staining, catalase, oxidase, motility, urease, citrate, coagulase, indole, hydrogen sulphide production, and gas production.

Gram staining

Each Colony was Gram stained using the Gram staining kit (Crystal violet, Lugol's

Iodine, Ethanol and Safranin). After Gram staining, the slides were allowed to dry for about 14 hrs and differentiated into Gram-positive and Gram-negative bacteria based on the ability of the bacteria cell wall to retain the crystal violet stain when viewed under the microscope.

Catalase test

A drop of 3 % hydrogen peroxide was placed on the centre of a slide and a sterile wire loop was used to pick a small portion of the microorganism to be identified from the nutrient agar plate into the hydrogen peroxide for immediate gas bubble formation. Quick Gas bubble or foaming indicates the presence of *B. subtilis* (Olutiola *et al*., 1991).

Coagulase test

A drop of physiological saline was placed on two separate slides. A colony of the test organism was emulsified in each drop to make a suspension. A drop of plasma was added and mixed gently with the suspension. The ability of the microorganism to coagulate indicated the presence of *Staphylococcus aureus* (Olutiola *et al*., 1991).

Motility test

A loopful of growth was inoculated into peptone water broth and incubated overnight. A wet preparation from the peptone water culture was prepared and examined under a microscope at a ×40 objective lens. The dating movement of the organism indicates the presence of *E. coli* (Olutiola *et al.*, 1991).

Citrate utilization test

A slant of citrate agar was aseptically inoculated with the organisms to be identified using a sterile wire loop. The inoculated citrate agar slant was incubated at 37°C for 24hrs and observed for colour change daily for up to 4 days. Blue colouration indicates the presence of *K. pneumonia* (Olutiola *et al*., 1991).

Indole reaction test

The micro-organisms to be identified were inoculated into tryptone broth for 48h at 37°C, and 5 drops of Kovac's reagent were then added. A deep red colour indicates the presence of *B. cereus* (Olutiola *et al*., 1991).

Sugar fermentation test

Peptone water (7.5g) was weighed and diluted to 500ml with distilled water after which a few pinches of phenol red were added. 9ml of broth was distributed into test tubes with Durham tubes inverted into each tube. The tubes were sterilized at 121°C (at 15 pounds pressure for 15min. One % (w/v) aqueous solution of Glucose, Sucrose, Lactose, and Mannitol was prepared separately and sterilized. One ml of 1 % of the sugar solution was added aseptically using a sterile pipette into each of the test tubes containing 9ml broth. The test organisms were inoculated into each set of test tubes. Non-inoculated test tubes served as control. Incubation was done at 35°C for 5 days. A change in the initial colour of the solution indicates acid production, and gas in the inverted Durham tubes indicates gas production. After which 5 drops of Kovac's reagent were then added and deep red colour indicates the presence of sugar fermenting microbes (Olutiola *et al.*, 1991).

Oxidase test

A drop of freshly prepared oxidase reagent was added onto a strip of filter paper. A little of the test organism was rubbed into it. A colour change into deep blue in 5s indicates the presence of *K. pneumonia* (Olutiola *et al.*, 1991).

Hydrogen Sulphide Production

With the use of a straight wire loop, a discrete colony was picked and streaked on the slant containing Kligier Iron agar. The culture was incubated at 37 ^{o}C for 24 hours and observed for colour changes. Black colouration shows the presence of *S. typhi* due to the reaction between hydrogen sulphide (H_2S) and iron (Fe) to give a black colouration of iron sulphide (FeS_2) (Olutiola *et al.*, 1991).

Gas Production

With the use of a straight wire loop, a discrete colony was picked and streaked on the slant containing Kligier Iron agar. The culture was incubated at 37 ^{o}C for 24 hours and observed for colour changes. The formation of space or visible gas in form of bubbles or cracking of agar indicates the presence of gas-producing microbes (Olutiola *et al.*, 1991).

Statistical Analysis

Results were tested for statistical significance using one-way analysis of variance (ANOVA) followed by paired sample T-tests using the statistical package, SPSS 16.0. $P<0.05$ was considered statistically significant.

RESULTS

Proximate Composition of four commercially branded local feeds

The results of comparison between the labelled and analysed values of proximate composition of AZ sinking local feed are shown in figure 1. The labelled values for crude protein and the ether extract for the 2mm (45 and 10% respectively) and 6mm (40 and 12% respectively) were below the analysed values for 2mm (29.9 and 5.2%) and 6mm (28.4 and 6.82%) feeds. The percentage ash content of the feed (5%) was lower than the laboratory analysed values (5.8, 5.6%) for both 2mm and 6mm respectively. The dry matter values from the manufacturer were not indicated while the values from the laboratory analysis were 91.8% (2mm) and 91.5% (6mm).

Results for BZ sinking local 4.5 and 8mm feed are shown in figure 2. All the proximate compositions claimed by the producer were actually higher than the values obtained from the laboratory except for crude fibre which has a lower value than the laboratory value. Manufacturer labelled values for CP were 45 and 40 % while analysed values were 35.3 and 32.1% for 4.5 and 8mm respectively. The labelled values for ash content were 9 and 8.5% while analysed values were 5.5 and 4.7 %. Laboratory analysed values for ether extract were 7.6 and 6. 1 % which was also lower than the manufacturer's claimed values of 10 and 8% respectively. Dry matter values from the manufacturer were not stated, however, the laboratory analysed values were 94.8 and 93.5% respectively.

The CZ feed (4mm), labelled values for crude protein, ash and ether extract (41, 40 and 8% respectively) were higher than the analysed values (30.5, 26.1; 5.5% respectively). Similarly, the CZ feed (8mm), labelled values for crude protein, ash and ether extract (8; 10, 9% respectively) were higher than the analysed values (5.2; 7.5, 5.1% respectively). Also, the manufacturer's crude fibre values for both the 4 and 8mm feed were not given, but the analysed values from the laboratory for both feed sizes were 3.7 and 3.8% respectively (figure 3).

The EZ feed, at both 4mm and 8mm according to the manufacturer had 41 and

39.1% crude protein respectively, these values were higher than the analysed values of 28.4 and 25.7% respectively. The analysed values for ether extract 4mm feed (6.32%) and 8mm feed (5.7%) were in a close range with the manufacturer's labelled values (6.9%, 5.8% respectively). On the other hand, the crude fibre contents of the analysed values (3.4% and 3.9% respectively) were above the manufacturer acclaimed values of 3% each for 4mm and 8mm feed (figure 4).

Microbial Load

The level of bacteria load across sizes compared using the T-test is shown in Table 1. In AZ Feed, TCC and TFC are not significantly different across sizes but TBC is significantly different. Also, in the BZ feed, TCC, TBC and TFC are not significantly different across sizes. The same trend was observed in CZ and EZ feed.

The most common bacteria across all brands and sizes studied were rated according to percentage frequency and the summary is given in Table 2. The most frequent organisms are *Klebsiella pneumonia, Bacillus substilis and Bacillus cereus*.

Biochemical characterization of species obtained from the locally made fish feed is shown in Table 3. Five (5) different bacteria were identified in AZ Feed, two (2) in BZ feed and four (4) in CZ and EZ respectively. Across different brands *Bacillus substilis, Bacillus cereus, and Escherichia coli* were common.

The summary of bacteria loads identified in locally made sinking fish feed is shown in Table 4. *Klebsiella pneumonia, Bacillus subtilis, Escherichia coli, Bacillus cereus* and *Salmonella typhi* were identified.

Fungi load in the fish feeds cut across all the sampled feed are more in the bigger size feed compared to the smaller across same feed type and identified specie are *Aspergillus flavus, Fusarium spp, Penicillium spp* and *Mucor spp* as shown in Table 5.

DISCUSSION

Economically-productive fish farming relies upon a sufficient supply of low-cost feeds with high nutritional quality and very low microbial components (Al Mahmud *et al*., 2012). Thus, fish feed quality plays a crucial role in the value chain of aquaculture production as it implies the quality control of raw materials, which is vital for the feed safety, and economic gain and ensured optimal growth for farmed fish under different conditions (Thorarinsdottir *et al*., 2011). The nutrient composition and microbial quality of feed are great factors that determine the growth, reproduction and health status of cultured fish species. Protein is very essential and the most critical nutrient that affects the growth performance of cultured fish species (Deng *et al*., 2011). From the laboratory analysis of locally made commercial fish feed, it was observed that most of the analysed data on the crude protein was lower compared to the values on the label. Probable reasons for the lower actual values of commercial feed crude protein content could be deliberate sabotage attempt by the manufacturer in order to maximize their own profit, or the proximate composition of the raw materials are far less than the book value and it could also result from poor quality of raw materials used. Other reasons could be that manufacturers get feed proximate composition only by calculation and not by chemical analyses.

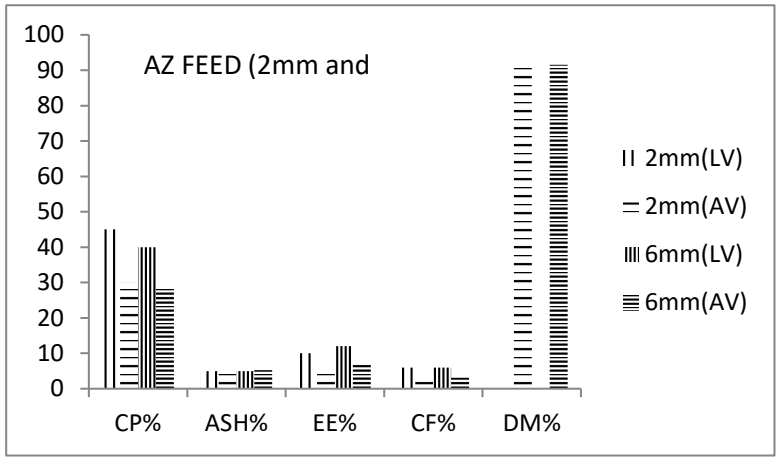

Figure 1: Comparison between labelled value (LV) and analysed value (AV) of AZ feeds (2mm and 6mm).

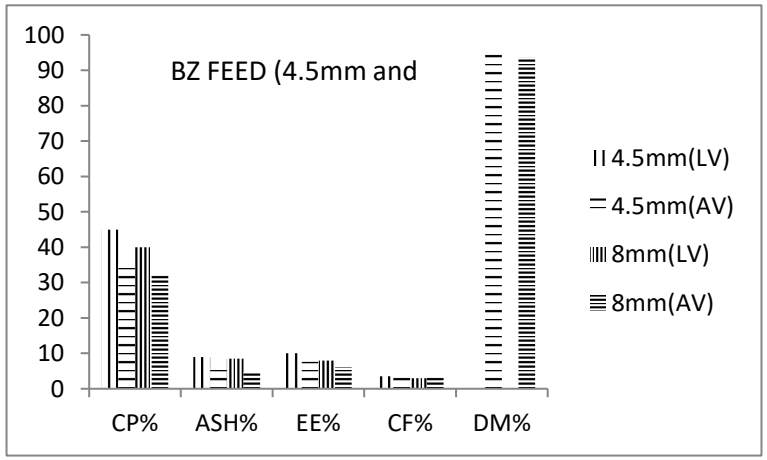

Figure 2: Comparison between labelled value (LV) and analysed value (AV) of BZ feeds (4.5mm and 8mm).

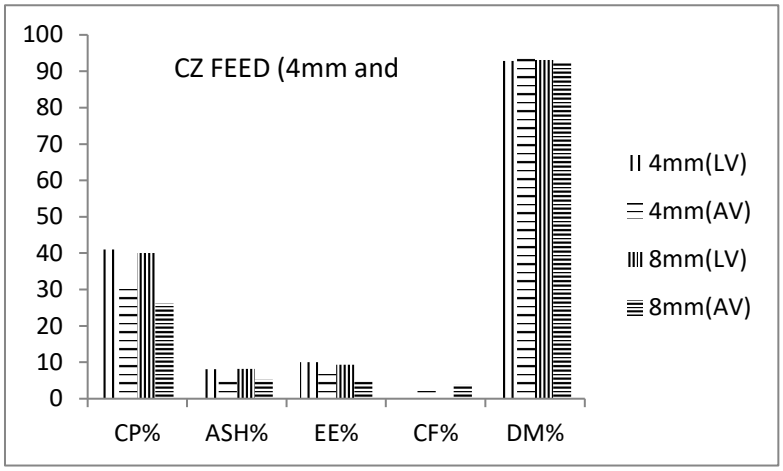

Figure 3: Comparison between labelled value (LV) and analysed value (AV) of CZ feeds (4mm and 8mm).

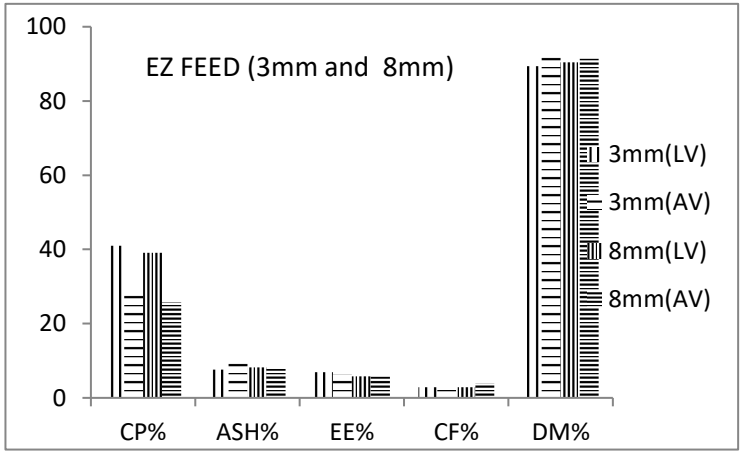

Figure 4: Comparison between labelled value (LV) and analysed value (AV) of EZ feeds (3mm and 8mm).

Table 1: Levels of bacteria load in local fish feed across sizes of different brands

BRANDS	SIZES	TBC x 10^5	TCC x 10^5	TFC x 10^5
AZ	2mm	0.08 ± 0.01^{a}	0.04 ± 0.01	0 ± 0.0
	6mm	0.44 ± 0.03^{a}	0.04 ± 0.01^{a}	0 ± 0.0
EZ	3mm	0.14 ± 0.06^{a}	0.08 ± 0.02^{a}	0.04 ± 0.01^{a}
	6mm	2.82 ± 1.56^{b}	0.02 ± 0.01^{a}	0 ± 0.0
CZ	4mm	1.45 ± 0.08^{ab}	0.33 ± 0.04^{b}	0 ± 0.0
	8mm	1.82 ± 0.05^{b}	0.40 ± 0.01^{b}	0.13 ± 0.06^{a}
BZ	4.5mm	2.40 ± 0.04^{c}	0 ± 0.0	0 ± 0.0
	8mm	0.32 ± 0.13^{a}	0.03 ± 0.01^{a}	0 ± 0.0

Values with different superscripts along the same column for same feed type are significantly different ($P<0.05$), TBC= Total Bacteria Counts x 10^5 $Cfug^{-1}m^{-1}$, TCC= Total Coliform Counts x 10^5 $Cfug^{-1}m^{-1}$ TFC= Total Faecal Counts x 10^5 $Cfug^{-1}m^{-1}$

Table 2: Percentage frequency occurrence of bacteria isolates from brands of fish feed

BRAND	SIZE	*Bacillius subtilis*	*Bacillius cereus*	*Klebsiella pneumonia*	*Escherichia coli*	*Salmonella typhii*
AZ	2mm	+	-	+	+	-
	6mm	-	+	-	-	+
BZ	4.5mm	-	+	-	-	-
	8mm	-	+	+	-	-
CZ	4mm	+	-	+	-	-
	8mm	-	+	+	+	-
EZ	3mm	+	-	-	+	+
	8mm	+	-	+	-	-
Total		4/8(50%)	4/8(50%)	5/8(62.5%)	3/8(37.5%)	2/8(25%)

Table 3: Biochemical characterization of bacterial species obtained from different fish feed samples

Brand	GRT	GRM	SLA	BUT	H_2S	GAS	MOT	IND	URE	OXI	CIT	CAT	COA	GLU	XYL	GAL	Organisms
AZ	+	GPB					+	-	-	-	-	+		+	-	-	*B. cereus*
	+	GPB					+	-	-	-	+	+		+	+	+	*B. subtilis*
	+	GNB	+	+	-	+	+	+	-	-	-						*E. coli*
	+	GNB	+	+	-	+	-	-	+	-	+						*K. pneumonia*
	+	GNB	-	+	+	+	+	-	-	-	+						*S. typhii*
BZ	+	GPB					+	-	-	-	-	+		+	-	-	*B. Cereus*
	+	GNB	+	+	-	+	-	-	+	-	+			+	+	+	*B. subtilis*
CZ	+	GPB					+	-	-	-	-	+					*E. coli*
	+	GPB					+	-	-	-	+	+					*K. pneumonia*
	+	GNB	+	+	-	+	+	+	-	-	-			+	-	-	*B. Cereus*
	+	GNB	+	+	-	+	-	-	+	-	+						*K. pneumonia*
EZ	+	GPB					+	-	-	-	+	+		+	+	+	*B. subtilis*
	+	GNB	+	+	-	+	+	+	-	-	-						*E. coli*
	+	GNB	+	+	-	+	-	-	+	-	+						*K. pneumonia*
	+	GNB	-	+	+	+	+	-	-	-	+						*S. typhii*

Grt= Growth, Grm= Gram reaction, Sla= Slant, But= But t, Mot= Motility, Ind= Indole, Ure= Urease, Oxi= Oxidase, Cit= Citrate, Cat= Catalase, Coa= Coagulase, Xyl = Xylose, Gal= Galactose. GNB= Gram-negative bacteria, GPB= Gram-positive bacteria

Table 4: Bacteria load across brands and sizes of some locally made feeds

BRANDS	SIZES	ORGANISMS
AZ	2mm	*Escherichia coli, Klebsiella pneumonia, Bacillus subtilis*
BZ	4.5mm	*Bacillus cereus*
	8mm	*Klebsiella pneumonia, Bacillus cereus*
CZ	4mm	*Klebsiella pneumonia, Bacillus subtilis*
	8mm	*Escherichia coli, Klebsiella pneumonia, Bacillus cereus*
EZ	3mm	*Escherichia coli, Klebsiella pneumonia, Bacillus subtilis*
	6mm	*Salmonella typhi, Bacillus subtilis*

Table 5: Fungi load identified in local fish feed

BRAND	TFC	Identified Organism
AZ (2mm)	$5.0X10^3$	*Mucor spp, Aspergillus flavus, Fusarium spp*
BZ (8mm)	$6.0 x10^3$	*Aspergillus flavus, Fusarium spp, Penicillium spp*
CZ (4mm)	$1.63 x 10^3$	*Aspergillus flavus, Penicillium spp.*
(8mm)	$2.0 x 10^4$	*Aspergillus flavus, Fusarium spp, Penicillium spp.*
EZ (3mm)	$4.0x10^3$	*Fusarium spp, Penicillium spp*
(8mm)	$1.8 x 10^4$	*Aspergillus flavus, Penicillium spp.*

The quality of feed could also be ascertained by the ash content which represents all minerals in the feed. However, cultured fish requires a lesser amount of minerals in the feed compared to other livestock, because fish can absorb several minerals directly from the culture medium (water) (Prabu *et al*., 2017). In this study, the analysed ash contents of different local sinking feeds were higher than the declared values except for the 'Brand AZ' feed which was lower.

The analysed ether extracts of the different local sinking feed ranged from 5.3 to 7.6% which is slightly higher than the claimed values. According to Wilson (2000), the recommended ether extract level in catfish feeds should be 6%. Also, Luquet (2000) also stated that a diet containing lipids level of 5-6% is suitable for Tilapia. Lipids are utilized efficiently by fish as an energy source, however, high lipid content in fish feed will cause rancidity in fish feed as well as pollution of the culture medium.

The inclusion of plant materials as ingredients in fish feed serves as a source of dietary fibre. Fibre provides physical bulk to the feeds. Dietary fibre provides additional benefits of better binding and regulates the passage of feed through the alimentary canal. However, De Silva and Anderson (1995) noted that crude fibre content above 8-12% and less than 5% for juveniles were not suitable, as the increase in fibre content would result in a reduction in digestibility of the diets and consequently, leading to retarded growth. The analysed crude fibre content of all the diets under study was within the safe dietary limit for fish.

Most of the local feeds collected did not disclose their moisture content except for Brand EZ and Brand CZ feed. Brand EZ feed declared values lower than the analysed value while Brand CZ feed declared values higher than the analysed values, though both were still within recommended values of between 85 -90% (dry weight). High levels of moisture content in feed can cause peroxidation of

the lipid and degradation of vitamins (NRC, 1981). According to Soorensen (2003), moisture content of 8% and below increases the feed shelf life during storage.

Fish feeds are constantly in contact with environmental organisms and become readily colonized by various microbial species but feed producers seem not worried about the short shelf life of the feeds since they hardly use any anti-oxidants. Poor and careless method of packaging and storage of feed (Ayinla, 2007; Adewumi and Olaleye, 2011) ultimately results in insect and rodent infestations.

Aquafeeds can easily be colonized by microbes, thereby, serving as a carrier of microbial contaminants such as mycotoxins (Maciorowski *et al*., 2007). This may be due to its composition, which provides a favourable environment for the microorganisms' growth (Čabarkapa 2009). Feed materials may be inoculated by a diverse range of microflora during the growing, harvesting, processing, storage and dispersal of the feed (Maciorowski *et al*., 2004; Kabir *et al*., 2014). According to FAO (2007), improper storage of fish feeds together with other environmental factors predispose the fish feeds to microbial spoilage. These microbes can decrease feed value quality through nutrient degradation and the production of toxins that are harmful to fish health (Ubiebi, 2017).

The feed microbial analysis indicates the presence of *B. subtilis, B. cereus, E. coli, K. pneumonia* and *S. typhi*. It is important to note that the presence of some *S. aureus* is very injurious to fish and the environment. *E. coli* is not expected to be a microbe found in fish feed but was reported in Ciceron *et al*. (2008), Nwabueze and Nwabueze (2011) and Kabir *et al* (2014) and this was attributed to unhygienic handling and poor storage of the feed. None of the above authors reported the presence of *Vibrio cholerae* contamination of fish feeds and the same was not reported in the present study.

The presence of other organisms like *Aspergillus flavus, Fusarium, Penicillium spp* and *Bacillus cereus* has been reported in other animal feed like poultry (Rosa *et al* 2005; Arotupin *et al* 2007; Omojasola *et al* 2015) as prevalent contaminants. Although, the total fungi count found in this experiment is far below the values reported by Omojasola *et al* (2015) for various poultry feed. It could be concluded that the total fungi load in all feed samples studied are within the safe bracket and not of any serious health concern.

The observed type and bacterial counts in studied feeds might be attributed to poor quality ingredients used, unhygienic production conditions and poor handling of feed materials and finished feed during manufacturing and sales (Kabir *et al*., 2014).

Studies have shown that bacteria contamination such as *Salmonella* can affect protein sources of both animal and plant origin (Barakat, 2004; PDV, 2007). Members of the Enterobacteriaceae family have been implicated as the major environmental contaminants of feed and their abundance in ingredients such as unprocessed soybean can be as high as 10^6–10^8 cfu/g of ingredient (Veldman *et al*., 1995). Contaminated feed by *E. coli* and *Bacillus* species may pose a health hazard for animals and humans through

contaminated food of animal origin (Magnusson, 2007).

CONCLUSION

In conclusion, based on the findings from this study, the feed quality of the various brands might not meet up the nutritional requirements of young fish, though the microbial load could not precipitate any severe negative effects on the health status of the cultured fish. However, Nigeria Government should take proper initiative in aqua feed quality control for the benefit of the growing aquaculture industry and this will ensure that feeds that have the right nutrient composition and are free from pathogens are sold to fish farmers.

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