INTERNATIONAL RESEARCH JOURNAL OF PHARMACY
www.irjponline.com
ISSN 2230 – 8407

Research Article

CONTENT OF SOME HEAVY METALS IN COMPOUND FISH FEEDS IN NORTHERN NIGERIA

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Article Received on: 11/09/16 Revised on: 13/10/16 Approved for publication: 08/11/16

DOI: 10.7897/2230-8407.0711122

ABSTRACT

This study was carried out to determine the concentrations of zinc, copper, nickel, arsenic and lead in four brands of compound fish feeds (Aqua® , Multi® , Top® and Vital®) obtained in Northern zones (North Central, North West And North East) of Nigeria. Five samples of each of the brands were respectively collected from five different distributors in each of the three zones. The composite samples were prepared by the standard dry ashing method and the concentrations of heavy metals were determined using Atomic Absorption Spectrophotometry (AAS). The results obtained revealed that Vital® feed contained mean concentrations of 11.326 mg/kg and 6.501mg/kg for zinc and copper respectively, higher than the other brands. The concentrations of these essential elements in the feeds were lower than the standard permissible limits. Multi® feed contained the highest mean concentrations of nickel (0.653mg/kg) and arsenic (0.072mg/kg) while Aqua® feed had the highest mean concentration of lead (2.690 mg/kg). There were no significant differences ($p<0.05$) in concentrations of the heavy metals in all the brands of fish feeds sampled within and across the three zones. Overall,the concentrations of copper, zinc, lead, arsenic and nikel found in the four compound fish feeds were below the permissible limits stipulated by the European Union. Despite these findings, more stringent measures are recomended to avoid contamination of the feeds with lead and arsenic, which are known public health risks.

KEY WORDS: Heavy metals, Fish, Compound feeds, Northern Nigeria

INTRODUCTION

The demand for fish and animal products are markedly increasing due to population growth, particularly in the developing world.[1] Concerted efforts are being made by various levels of governments and individuals to address the problem of malnutrition and food shortage in general.[2] Some of such efforts are the intensive fish farming, poultry, piggery, etc. Fish is one of the major sources of protein and the major solution to the dietary shortage for the increasing world population, especially in the developing countries of Africa, Asia and South America[3,4] . However, fish consumption is a major avenue for pathogen and heavy metal exposure to man.[5] Fish are produced from capture and culture (aquaculture) fisheries. While capture fisheries decreased from 95.6 tons in year 2000 to 89.7 million tons in 2008, aquaculture fisheries rose from 35.5 million tons in 2000 to 52.5 million tons in 2008.[6]

One of the measures to boast fish farming is the production of fish feeds.[2] Compound fish feeds usually contained ingredients such as vegetable, proteins, cereal grains, vitamins and minerals in the forms of granules or pellets. These feeds provide the required nutrition for efficient growth of fish. Considering the importance of fish to humans, any contamination of fish feeds can greatly affect both the fish and their consumers. Studies[7,8] demontrated that fish feeds contain significant amount of contaminants including heavy metals; many of which can bio-accumulate and bio-concentrate in fish. The finding of a study[9] to assess eleven types of fish and shellfish obtained from commercial fish farms revealed varying proportion of contamination with heavy metals such as arsenic, lead, cadmium, chromium and mercury.

Heavy metals occur in aquatic systems from natural sources and anthropogenic activities. The pollution of aquatic environment by heavy metals affects aquatic organisms and poses considerable environmental risks and concerns.[10] Heavy metal pollutants compared with other types of aquatic pollutants, are less visible but their effects on the ecosystem and humans are very extensive due to their toxicity and ability to accumulate in the aquatic organisms.[11] Some metals, including chromium, lead, cadmium, arsine and mercury are known to be toxic even at low concentrations.[12] While others, such as copper, iron, zinc, manganese and cobalt, are known to be essential elements and play important roles in biological metabolism at very low concentrations, these elements either in excess or in deficit can disturb biochemical functions in both humans and animals.[13] Heavy metals, unlike organic pollutants, cannot be chemically degraded or biodegrade by microorganisms. They tend to accumulate in tissues and organs of aquatic organisms after entering into aquatic environment.[7] Unlike energy which tends to deplete and disperse at each trophic level, heavy metals concentrate with each trophic level in the food chain.[14] The finding of another study[15] revealed that concentration of heavy metal is enhanced rather than dissipated with progression along the trophic levels in the ecosystem, a process referred to as bioaccumulation.

The aim of this study was to determine the content of zinc, copper, nickel, lead and arsenic in compound fish feeds obtained in Northern zones of Nigeria.

MATERIALS AND METHOD

Sampling

Four brands of compound fish feeds (Aqua®, Multi®, Top® and Vital®) sold commercially were sampled from five major distributors of the compound fish feeds in each of the three zones (North central, North west and North east) of Northern Nigeria.

Sample preparation

The five samples of each brand of fish feed in each zone of Northern Nigeria were mixed together to give four composite samples per zone. The samples were dried in the shade, then grounded and passed through a 0.25-mm mesh sieve. Each composite sample (0.5 g) was used for digestion.

Quality Assurance for Metal Analysis

30 ml of prepared multi-element standard solution wasused to spike each of the 0.5g-composite sample into a 100 cm^3 Kjeldhal digestion flask; 5ml of concentrated nitric acid (HNO_3) was added followed by 1 ml each of concentrated sulphuric acid (H_2SO_4) and perchloric acid ($HClO_4$). The flask was heated in the fume cupboard until dense white fumes were observed. The flask was cooled, and the content was made up to the 100ml-mark with deionized distilled water and transferred into plastic bottles. The percentage recovery for each metal was calculated following Atomic Absorption Spectroscopic analysis.[16]

Determination of Heavy Metals

The sample solutions were then analyzed for zinc, copper, lead, chromium and nickel at required wavelengths using GBC Atomic Absorption Spectrophotometer, model number ICE 3000 AA from Advanced Chemistry Laboratory, Sheda, Abuja.

Statistical analysis

The mean concentrations of metals in the four brands of fish feeds were compared within and across the zones using student t-test and the level of significant difference at $p<0.05$. [17]

RESULTS AND DISCUSSION

Table 1: **Mean percentage recovery (n=3) for Zn, Cu, Ni, Pb and As in fish feeds samples**

Metals	Percentage recovery (%)±SD
Zn	95.24±1.36
Cu	98.57±0.81
Ni	92.08±2.00
Pb	92.66±1.15
As	95.13±0.58

The results of the analysis of the heavy metals in the spiked samples are shown in table 1. The mean percentage recoveries for the metals were in the range of 92.08 to 98.57% demonstrating accuracy of the analytical method.

Table 2: Mean concentrations in mg/kg of zinc, copper, nickel, lead and arsenic in different brands of fish feeds sampled in North Central, North West and North East, Nigeria

Fish Feeds	Zone	Zn	Cu	Ni	Pb	As
	NC	8.224±1.91	6.301±1.08	0.181±0.69	2.160±0.69	0.015±0.02
Aqua®	NW	8.416±1.87	5.120±1.81	0.551±0.05	3.128±0.35	0.023±0.04
	NE	8.322±0.46	5.867±3.13	0.323±0.21	2.781±0.81	0.017±0.08
	Mean±SD	8.321±7.55	5.763±2.45	0.355±0.21	2.690±0.73	0.018±0.01
	NC	8.679±2.02	5.909±1.46	0.522±0.06	2.615±0.14	0.077±0.02
Multi®	NW	9.320±0.04	6.321±2.07	0.342±0.44	2.113±0.08	0.106±0.91
	NE	8.525±1.06	6.667±3.21	1.084±0.96	2.651±0.22	0.032±0.07
	Mean±SD	8.841±3.26	6.302±0.08	0.653±0.22	2.460±0.03	0.072±0.01
	NC	8.664±1.50	6.121±1.65	0.713±0.13	2.081±0.54	0.011±0.02
Top®	NW	10.211±4.67	6.772±3.06	0.631±0.55	2.324±0.42	0.025±0.01
	NE	9.127±0.96	6.361±0.91	0.552±0.08	1.856±0.83	0.038±0.02
	Mean±SD	9.334±3.06	6.418±1.81	0.632±0.31	2.087±1.57	0.025±0.01
	NC	12.661±3.59	6.565±2.00	0.617±0.07	2.611±0.58	0.017±0.01
Vital®	NW	10.872±1.41	6.329±0.05	0.321±0.11	2.087±1.62	0.022±0.01
	NE	10.553±0.55	6.610±3.22	0.211±0.05	1.733±1.30	0.026±0.02
	Mean±SD	11.362±2.89	6.501±1.50	0.383±0.14	2.144±0.84	0.022±0.01
MPL [E.U.(2003a)] 500.0 100.0 1.05.0 0.5						
MPL -Maximum Permissible Limit; E.U –European Union; NC- North Central; NW-North West; NE- North East						

The mean concentrations of zinc in all brands of fish feeds sampled were in the range of 8.224 to 12.661 mg/kg (Table 2) . This concentration range was higher than 1.21 – 3.32 mg/kg obtained by Anhwange et al[18] in their analysis of fish feeds in Makurdi metropolis, North Central Nigeria The highest mean concentration was recorded in Vital® fish feeds in North Central Zone. Similarly, the Vital® feeds also has a higher mean concentration of 11.362mg/kg compared to the other brands across the three zones while Aqua® fish feeds had the lowest concentration of 8.321mg/kg. The mean copper concentrations were in a range of 5.120 to 6.772mg/kg (Table 2) and these concentrations were also higher than 2.05mg/kg obtained by Anhwange et al[18]. Vital® fish feeds contained the highest mean concentration of 6.501mg/kg than the other brands of fish feeds sampled. However, there were no significant differences ($p<0.05$) in copper values recorded within and across the three zones.

Zinc and copper are essential trace minerals required for many biological processes, particularly enzyme functions, and they have a positive influence on fish growth and reproduction. In this study, the mean concentrations of zinc (11.362mg/kg) and copper (6.501mg/kg) in all the composite samples were respectively lower than the acceptable concentrations of 500 mg/kg and 100 mg/kg in fish feeds as stipulated by European Union[19]. The lower zinc and copper contents in the commercial fish feeds may neccessitate supplementation of these essential metals for more efficient and productive aquaculture fishery.

The mean concentrations of lead in all brands of fish feeds sampled were in the range of 1.733mg/kg to 3.128mg/kg. Mean value of 2.690mg/kg was obtained in Aqua® feeds which were higher than the other feed types while the Top® fish feeds had the lowest. North East zone had lowest lead concentrations in Top® and Vital® fish feeds while North West for Aqua® feeds recorded the highest concentrations across the zones. However, the values obtained in this study were higher than 0.348-0.375mg/kg obtained by Anhwange et al[18] in analysis of fish feeds. Yaba et al[20] reported that lead toxicity in man causes damage to brain and the central nervous system. Other effects include damage to the gastrointestinal tract (GIT) and urinary tract resulting in bloody urine, neurological disorder.[21]

The mean concentrations of arsenic obtained were in a range of 0.011 to 0.106mg/kg for all the fish feeds sampled. The Multi® fish feeds had comparatively higher mean concentration than the other feed types while the Aqua® fish feeds had the lowest. However, the highest mean concentration of arsenic was recorded in the North West zone. The highest concentrations of 3.128mg/kg and 0.106mg/kg for lead and arsenic respectively were found in all the brands of the feeds. These concentrations were lower than the maximum acceptable limits of 5mg/kg for lead and 1mg/kg for arsenic in fish feeds as stipulated by European Union.[22]

The mean concentrations of nickel in the feeds were in the range of 0.181 to 1.084 mg/kg as shown in the table. The North East zone recorded the highest mean concentration than in the other zones. The Multi® fish feed brand had a higher mean concentration of 0.653mg/kg than the other brands while the Aqua® feeds had the lowest concentration of 0.355mg/kg. There were significant difference($p<0.05$) in nickel concentrations in Multi® and Aqua® feeds. Ololade [13] reported that nickel toxicity includes skin rash, vomiting, headache, chest pain and weakness.

CONCLUSION

The cocentrations of zinc, copper, nickel, lead and arsenic found in the compound fish feeds obtained in Northern Nigeria were within the international permissible limits. Therefore, these feeds are relatively safe for aquaculture production. The lower concentrations of the essential elements (zinc and copper) in the feeds demontrated that supplements were not sufficiently added to the feeds as expected. However, there were varying proportions of lead and arsenic in the feeds sampled in the three zones of Northern Nigeria. Since these metals are undesirable and toxic even at very low concentrations to fish and humans following a long time exposure, adequate measures should always be taken to avoid their contamination with the feeds.

ACKNOWLEDGEMENT

We wish to express our appreciation to technical staff of Advanced Chemistry Laboratory, Sheda, Abuja, Nigeria.

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Cite this article as:

Yahaya Salawu, Sani Ibn Yakubu, Magaji Garba, Musa Usman, Adamu Ibrahim Yakasai. Content of some heavy metals in compound fish feeds in northern Nigeria. Int. Res. J. Pharm. 2016;7(11):19-22 http://dx.doi.org/10.7897/2230-8407.0711122

Source of support: Nil, Conflict of interest: None Declared