



Aluminium and Zinc Concentrations in Raw and Roasted Fishes Wrapped with Foil consumed in Keffi Town, Nigeria

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ABSTRACT

Aluminum (Al) and Zinc (Zn) levels was compared in three commonly eaten fishes; African cat fish (*Herterobranchus longifilis*), tilapia fish (*Tilapia niloticus*) and cat fish (*Synodontis clarias*) to ascertain leaching from foil wrappers leading to toxicity. The fishes were washed, wrapped in aluminum foil and stored in the refrigerator (4°C) for 1.5 hr, some were roasted in the oven at about 150°C. The fishes were chopped (fresh and roasted) and then homogenized into slurry. The slurry were transferred into test tubes, centrifuged at 3000 G for 10 minutes and clear supernatant were collected aseptically and labeled (A^{1,2,3}, B^{1,2,3} and C^{1,2,3}). The condiments used were weighed about 800 g/850 – 1200 g per fish, grinded into slurry, with a blender. The slurry was further centrifuged at 3000 G for 10 minutes and the clear supernatant aseptically collected into clean test tubes (D^{1,2,3}) and analyzed. Three cone shaped foil (E^{1,2,3}) holding 10 ml of distilled water were allowed to stand for 3 hrs and carefully placed in an oven and heated (120°C) for 1.5 hr, was cooled and then analyzed using an Atomic Absorption Spectrophotometer (Varian AA240). The results obtained showed significant (p<0.05) increase in Al and Zn levels, possibly due to temperature and pH factors. The Al and Zn levels in the fish slurries was (0.127 ± 0.02 - 0.146 ± 0.03 mg/g) and (0.148 ± 0.03 – 0.180 ± 0.03 mg/g), respectively. These were extremely below WHO recommended value of 1mg/day and 15 mg/day for Al and Zn respectively. This study contradicts the media hype about toxic amount of Al and Zn leached into roasted fish in foil wrappers. Hence, the amount of Al and Zn in the tested species of fish are below the acceptable WHO value and thus, not poisonous.

Keywords: Aluminium, Zinc, Foil wrapper, toxicity, fishes, slurry

INTRODUCTION

The art of getting food materials prepared for consumption has evolved like other things, which man has been known with since primitive times. The typical African way of food preparation moved from the crude roasting of meat, tubers, some cereals like corn, directly over hot coal to the use of earthenware, and then metal wares in the form of pots frying pans etc. The usage of these wares was observed to be responsible for one ailments or the other as a result of elemental leach into the foods prepared in them, when consumed. These surely would depend on the metallic element used to manufacture the wares, notably among such element are Al, Zn, Fe, Pb, Cu and these elements falls in the class of “heavy metals” (HMs) makes it even worrisome (Lamberti and Escher, 2007; Veríssimo *et al.*, 2006).

These HMs are acknowledged to have many adverse health effects and possibly last for a long period of time. HMs have the capability of binding with protein sites which are not made for them by displacing original metals from their natural binding sites causing malfunctioning of cells and ultimately toxicity (Flora *et al.*, 2008). Oxidative deterioration of biological macromolecules is primarily due to binding of heavy metals to the DNA and nuclear proteins (Flora *et al.*, 2008). Although these metals are considered to be toxic to human in excess, they also play crucial biological roles in plants and animals. They serve as co-factors for

certain enzymes involved in metabolism and cell growth indicating their biochemical importance.

One material now used locally instead of the cooking pot, is the foil wrapper, which its manufacturers say contains aluminium (Al) and zinc (Zn) elements. The foil wrapper was presumably used for the following reasons; its aesthetic appearance, its light weight and reusability, It has an excellent thermal conductivity, It is not seen to physically affect food appearance or quality, the food taste is unaffected, since the foil is known to be noncorrosive, It serves as a very good material which prevents escape of moisture from the food material during cooking, thereby has a positive impact on taste, food additives such as oils, ingredients, flavours are retained and enhances taste.

The increase rate of diseases of the kidneys, lungs and several others in and around Keffi community has made many people to suspect change in attitude especially the use of foil wrappers as one of the likely predisposers of these ailments (Izah *et al.*, 2016). The anxiety on the use of foil wrappers used for cooking appeared several times in the social media, which got many talking.

The foil wrapper is presently used in many households and commercial eateries within Nigeria for packaging, storing and cooking in styles (Kashtock, 2009). One of such styles is the grilling or roasting of fish, a practice in hotels, eateries and drinking joints, which many say came about with the raised awareness about several diseases that are attributed to the high consumption of red meat (*suya* or *tsire*) traditional

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grilled or roasted meat or home prepared meat (Osseo-Asare, 2005).

The elements contained in foil wrapper Al, is widely distributed in the lithosphere, food is the main route by which the normal daily intake of Al occurs in humans (Rajwanshi *et al.*, 1997; Mohammad *et al.*, 2011). Al content of food additives, from cans and some cooking utensils are also known to be additional routes of Al exposures (Aguilar *et al.*, 2008; Mohammad *et al.*, 2011). Some studies opined that, the raise in level of Al in food is influenced by several factors such as temperature, presence of sugar, salt, organic acids, duration of heating and pH-value among others (Anyasi *et al.*, 2017; Stahl *et al.*, 2017). The other component of the foil wrapper Zn is considered to be comparatively non-toxic, mostly if taken orally. However, manifestation of overt toxicity symptoms like vomiting, lethargy, nausea and epigastric pain will occur with extremely high Zn intakes (Fosmire, 1990).

Zn is found in organs, tissues, bones, fluids, and cells, with an average total of about 2 to 3 g (Brown *et al.*, 2001; Marie *et al.*, 2001). It plays significant roles in a number of enzyme actions in the living systems as well as being essential for many physiological functions. Optimum amounts of Zn in the animal body have been ascribed to normal immunity and form part of essential enzymes used for maintaining animals' health and promotion of fertility (Sikiru, 2016).

Zn toxicity and its role in human nutrition and well-being have come under investigation. Reports indicated the role of Zn toxicity causes of Cu deficiency, significant changes in the immune system and alterations in blood lipids (Pluhator *et al.*, 1996).

Fish is an important part of the human diet and no doubt, numerous studies have been carried out on heavy metal accumulation in different fish species (Ebrahimpour and Mushrifah, 2010; Hashim *et al.*, 2014). In Nigeria, fish is usually wrapped with foil during preparation especially roasting and during preservation. Most of the foils are made of Al alloy, with Zn, Cu, Mg etc. It is popularly acclaimed that under certain environmental stress; heavy metals in the foil might leech and accumulate up to a toxic concentration in the fishes. This phenomena may be responsible for

physiological damage if consumed. This study therefore evaluated the concentrations of Al and Zn in commercial fishes wrapped with foil, prepared and consumed in Keffi town, Nigeria in order to assess the possible risk involved in the consumption of such fish.

MATERIALS AND METHODS

Sample Collection

Three species of fresh fish African cat fish (*Herterobranchus longifilis*), tilapia fish (*Tilapia niloticus*) and cat fish (*Synodontis clarias*) were purchased from main market in Keffi town, Nasarawa State, Nigeria and were divided into three groups (A, B and C). Each group consisted of three (3) fishes of the same species as replicates.

Sample Preparation

The fresh fishes of the three species were washed, wrapped in separate aluminum foil and stored in the refrigerator (4°C) for 1 hour 30 minutes while three (3) of the fresh fishes of the three species were roasted in the oven with the wrapped foil for 1 hour 30 minutes at a temperature of about 150°C, while the fish used for the control was frozen at 4°C. At the end of the freezing and roasting time, a sharp knife was used to chop the fishes (fresh and roasted, separately) and then each homogenized into a slurry. The fish slurry of different species (fresh and roasted) were transferred into test tubes, centrifuged at 3000g for 10 minutes and clear supernatant collected aseptically and labeled (**A**^{1, 2, 3}, **B**^{1, 2, 3} and **C**^{1, 2, 3}). The labeled samples were kept in the refrigerator until when needed for further analysis.

The various condiments and ingredients used by the fish sellers namely, tomatoes (*Solanum lycopersicum*), Bell Pepper (*Capsicum annum*), Black pepper (*Piper nigrum*), salt, maggi seasoning cubes, onion (*Allium cepa*), potatoes (*Solanum tuberosum*), lemon (*Citrus limon*) juice, ginger (*Zingiber officinale*), garlic (*Allium sativum*), cloves (*Syzygium aromaticum*) and vegetable oil, were measured according to the advice of the local fish sellers. Each weighed about 1200 g per fish.

Table 1: Percentage of ingredients used

S/N	INGREDIENTS	Percentage inclusion (%)
1	Tomatoes (<i>Solanum lycopersicum</i>)	30
2	Bell Pepper (<i>Capsicum annum</i>)	4
3	Black pepper (<i>Piper nigrum</i>)	6
4	Salt	2
5	Maggi seasoning cubes	3
6	Onion (<i>Allium cepa</i>)	10
7	Potatoes (<i>Solanum tuberosum</i>)	30
8	Lemon (<i>Citrus limon</i>) juice	1
9	Ginger (<i>Zingiber officinale</i>)	3
10	Garlic (<i>Allium sativum</i>)	3
11	Cloves (<i>Syzygium aromaticum</i>)	3
12	Vegetable oil	5

Since there was no special difference in the condiments, three species of fishes were grinded thoroughly into slurry, using a kitchen blender (the Saisho 3-in-1 Grinder and Blender). The slurry was further centrifuged at 3000 g for 10 minutes and the clear supernatant aseptically collected into

clean test tubes (**D**^{1, 2, 3}) and sealed, before refrigeration until needed for further analysis.

Three foil wrappers were shaped into cones (**E**^{1, 2, 3}) to hold about 10 ml of distilled water, about 7cm in width. Each was carefully sealed after loading it with the required amount of

water and allowed to stand for 6 hrs and then carefully placed in an oven and heated (120 °C) for an hour, after which it was brought out and allowed to cool. The water contained in the cones were transferred into clean bottles and sealed. These samples were kept in the refrigerator at 4 °C, until needed for further analysis.

Quantitative Analysis of Aluminum and Zinc

Quantitative analyses to determine the concentration of Al and Zn in the samples was performed using Varian AA240 Atomic Absorption Spectrophotometer (AAS) according to the method of APHA (2005) (Made in USA). All evaluations were carried out in triplicate.

Statistical Analysis

Table 2: Mean values for Al and Zn concentrations in fresh (unheated) samples of fish, ingredients/condiment and distilled water.

Group	Al(mg/g)	Zn(mg/g)
A	0.135 ± 0.01 ^{a,c}	0.107 ± 0.03 ^{a,d}
B	0.098 ± 0.03 ^{a,b}	0.271 ± 0.03 ^{a,c}
C	0.130 ± 0.01 ^{a,c}	0.109 ± 0.02 ^{b,d}
D	0.132 ± 0.00 ^{a,d}	0.128 ± 0.05 ^{a,c}
E	0.140 ± 0.01 ^{a,b}	0.123 ± 0.03 ^{a,d}
WHO limit	≤ 1.00	≤ 15.00

Results are expressed in Means ± SD (n = 3) Mean values with different letters as superscripts down the columns are considered significant at p < 0.05

Group A = *Herterobranchus longifilis*, Group B = *Oriochromis niloticus*, Group C = *Synodontis clarias*, Group D = Ingredients/condiments, Group E = Distilled water

Results were expressed as arithmetic means ± standard deviation (SD). Statistical analysis was performed using SPSS version 17.0 (SPSS Inc, Chicago). The elemental concentrations of the fresh and roasted fish, with the heated distilled water and ingredient samples were analyzed using one-way ANOVA at p < 0.05.

RESULTS AND DISCUSSION

The result on the Al and Zn concentrations in fresh (unheated) samples of fish, ingredients/condiment and distilled water is presented in Table 2. The result revealed that the concentration of Al and Zn in fresh (unheated) samples ranges from 0.098 ± 0.03 - 0.135 ± 0.01 and 0.107 ± 0.03 - 0.271 ± 0.03 respectively are below WHO acceptable value.

Al and Zn concentrations in roasted (heated) samples of fish, ingredients/condiment and distilled water is indicated in Table 3. The concentration of Al and Zn in roasted (heated) samples ranges from 0.110 ± 0.02- 0.176 ± 0.06 and 0.130 ± 0.01 - 0.160 ± 0.03 respectively which are below WHO acceptable value.

Table 3: Mean values for Al and Zn concentrations in roasted (heated) samples of fish, ingredients/condiment and distilled water.

Group	Al(mg/g)	Zn(mg/g)
A	0.134 ± 0.05 ^{a,c}	0.160 ± 0.03 ^{a,b}
B	0.176 ± 0.06 ^{b,c}	0.285 ± 0.04 ^{b,d}
C	0.110 ± 0.02 ^{a,b}	0.208 ± 0.03 ^{b,c}
D	0.165 ± 0.01 ^{a,d}	0.130 ± 0.01 ^{a,c}
E	0.142 ± 0.01 ^{a,d}	0.117 ± 0.03 ^{a,b}
WHO limit (2008)	≤ 1.00	≤ 15.00

Results are expressed in Means ± SD (n = 3) Mean values with different letters as superscripts down the columns are considered significant at p < 0.05

Group A = *Herterobranchus longifilis*, Group B = *Oriochromis niloticus*, Group C = *Synodontis clarias*, Group D = Ingredients/condiments, Group E = Distilled water

The results obtained showed significant (p<0.05) increase in Al and Zn concentrations when comparison was done between the fresh (unheated) and roasted (heated) fishes. Al and Zn leaching may have occurred from the foil wrapper due to factors of temperature as suggested by earlier reports of (Odularu *et al.*, 2013; Tesfaye, 2015). This probably could be why the concentration of Al in fresh fishes are slightly lower than those that were roasted, because the heat applied would trigger a chemical reaction resulting in the break down and mixture of various organic compounds (Krewski *et al.*, 2007; Al Juhaiman, 2015; Inan-Eroglu *et al.*,

2019).The fact still remains that, if Al and Zn exceeds the acceptable limits from daily ingestion of food, cooked in utensils containing these elements, coupled with other sources from the environment, diseases such as loss of memory, damage to central nervous system, dementia, severe trembling, and several other ailments will be observed (Odularu *et al.*, 2013; Jabeen *et al.*, 2016).

From the results, the total mean Al for both the fresh (unheated) and roasted (heated) fish were (0.127 ± 0.01 - 0.145 ± 0.03 mg/g), respectively. This was far below WHO (2008) recommended value of 1mg/day.

The same is the case for Zn, which showed slight dissimilarities in concentration of raw (unheated) and roasted (heated) fishes (0.148 ± 0.03 – 0.180 ± 0.03 mg/g). Previous studies showed that, the maximum Zn levels permitted in commercially processed fish is 5mg/g (Tuzen, 2009), while the WHO level recommended is 15 mg/day (WHO, 2008). Furthermore, the fear about Al and Zn

toxicity from foods consumed in the local community may be said to be baseless because, Al is not bioaccumulated in the living tissues to a significant extent, and therefore not expected to undergo biomagnification in terrestrial food chains (Krewski *et al.*, 2007). Similarly, because of its toxicity to many aquatic organisms, including fish, Al does not bioconcentrate in aquatic organisms to any significant degree (Howells *et al.*, 1990; Mao *et al.*, 2011). Since Al is ubiquitous in the environment, the general population will be exposed to aluminum by the inhalation of ambient air and the ingestion of food and water because Zn is one of the solid minerals that is mined in Nasarawa State, the populace are exposed to these heavy metals (Aliyu *et al.*, 2015). The consumption of foods containing Al additives are a major sources of Al in the diet (Saiyed and Yokel 2005; Bratakos *et al.*, 2012; Stahl *et al.*, 2017). The use of other consumer items such as antiperspirants, cosmetics, internal analgesics (buffered aspirins), anti-ulcerative medications, anti-diarrheals, and antacids that also contain Al compounds will result in exposure to Al (Krewski, 2007; Ingerman *et al.*, 2008).

The intake of Al from food and drinking water is low, especially compared with that consumed by people taking Al-containing medicinal preparations (Shaw and Marler, 2013; Fanni and Faa, 2015). While Al is naturally present in food and water, the greatest contribution to Al in food and water

by far is the Al-containing additives used in water treatment and processing certain types of food such as grain-based products and processed cheese.

CONCLUSION

Foil wrapper used as a packaging material is important for all products that are sensitive to light or oxygen and those that may lose or take up moisture or aroma compounds. To ensure this barrier effect, cracking of the foil during processing must be avoided. Therefore, the use of foil wrapper in food processing is not responsible for the leaching of toxic metals into food and as such not poisonous. The results obtained from these experiments proves that, if there has been any reported case of Al and Zn toxicity in Keffi town, such could have been from other sources and definitely not from eating roasted fishes in foil wrappers.

These results, showed to a large extent, that there is a probability of the Al and Zn which make up the foil wrapper to be inert and may not have leached into the food cooked in it.

CONFLICT OF INTEREST

The authors declared no conflict of interest

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