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Proximate and mineral composition of dried catfish (*Clarias gariepinus*) in Ilorin metropolis, Kwara State, Nigeria

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ABSTRACT

The proximate and mineral composition of dried catfish (*Clarias gariepinus*) obtained from four different markets (Idi-Ape, Ipata, Unity and Ojatutun) in Ilorin metropolis, Kwara State, Nigeria were analyzed and compared with catfish smoked with Nigerian Stored Products Research Institute (NSPRI) smoking Kiln following standard methods. The samples collected were Idi-Ape (A, B, C), Ipata (A, B, C), Unity (A, B, C) and Ojatutun (A, B, C). The highest protein content (64.23±0.03%) was recorded in Unity B sample while the least protein content (42.76%) was recorded in Unity A which also had highest moisture content (44.57±0.33%). Also, NSPRI processed fish had the highest fat content and Ipata B had highest ash content (16.64±0.47%). The results of the mineral composition of the various dried catfish samples showed that the highest concentration of arsenic was detected in Ipata C sample and the concentration (1.64±0.01PPM) was significantly (p=0.05) higher than other samples. The concentration of cadmium was highest in Unity A sample (0.036±0.01PPM). Different concentrations of other minerals such as copper, manganese, lead, zinc, iron, calcium, sodium potassium, aluminium and magnesium were also detected. The presence of heavy metals (arsenic, cadmium, and lead) may be due to the contamination of the water used in breeding the fish. Considering the health risk of these heavy metals, care should be taken to reduce fish contamination. Relevant agencies should train fish farmers on proper siting of fishpond and management to reduce the risk of heavy metal contamination.

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1. Introduction

Fish is extensively acceptable because of its high palatability, low cholesterol, tender flesh, and aroma in cooking. It is the primary source of animal protein and have other essential nutrients needed in human diets (Pradeepkiran 2019). In Nigeria, fish is a major food item contributing a total of 40% dietary protein requirements (Solomon and Oluchi 2018). Also, fish provide 16% of the animal protein consumed by the world's population (Tidwell and Allan 2001). Fish plays a critical function in food security, poverty reduction and wealth creation (Chan *et al*., 2019). The nutritional and medicinal values of fish products depend on their protein, oil, minerals, and vitamins. Fish proteins have high biological values because they are characterized by the presence of essential amino acids in good proportions. It is a good source of vitamins and minerals. Fish oil is often marketed for utilization as part of diet or in dietary supplements. Also, fish oils have been used as cosmetic preparation for protecting, moisturising, and lubricating the skin (Njinkoue *et al*., 2016).

Due to the highly perishable nature of fish, proper handling and processing of fish is important both for the fishing industry and for the consumers. Improvement of the processing and handling of fish in terms of quality, results in increased economic activity and employment (Getu *et al*., 2015). Postharvest fish loss is the fish that is either discarded or sold at low price due to quality deterioration. This causes low availability of fish and fish products to consumers, loss of income for fishers, processors, and traders. Postharvest fish loss take place during pre-processing, processing, storage, and transportation. The loss could be physical, economical, or nutritional (Kumolu-Johnson and Ndimele 2011). Poor handling practices lead to microbial contamination and insect infestation which eventually shortened the shelf life of fish. Various traditional methods are engaged to preserve and process fish for consumption and storage. These includes drying, smoking, salting, frying, and fermenting. Sun drying is the simplest and most economical method of fish preservation, but it has many limitations which includes; long period of drying during cloudy weather, inefficient drying and low quality of products. Sun dried fish is prone to insect infestation and microbial contamination (Patterson *et al*., 2018). In most Countries in Africa, smoking is the most widely practiced method. Fish smoking prolongs shelf life, enhances flavour, and increases utilization (Adeyeye and Oyewole 2016). Fish smoking are usually carried out using open fire, mud oven, cut-up barrels, and kilns. Traditional fish smoking kilns most times are poorly constructed and lack mechanisms for the control of smoke and heat production which in turn affect the efficiency of smoking and the quality of the smoked fish (Olopade *et al*., 2013). This study was there aimed at investigating the proximate and mineral analysis of smoked fish samples in some markets in Ilorin, Kwara State, Nigeria. Ilorin was chosen as a location for this study because the town has big markets where fish handlers market their fish.

2. Materials and Method

2.1 Collection and smoking of fish for analysis

Fresh catfish was collected from a fishpond at Asa-dam area, Ilorin Kwara State, Nigeria. The fresh fish sample was coded "NSPRI F". The fish was processed and smoked following hygienic protocol with Nigerian Stored Products Research Institute (NSPRI) smoking kiln. Charcoal was used as a source of energy. The smoked fish was coded "NSPRI D" and stored for further analysis.

2.2 Collection of fish samples from markets in Ilorin metropolis

Dried catfish were randomly sampled from three traders at each market. The markets that were sampled were: Ipata, Idi-Ape, Unity and Ojatutun. The samples were coded Ipata (A, B, C); Idi-Ape (A, B, C), Unity (A, B, C), Ojatutun (A, B, C). The samples were taken to the laboratory for further analysis.

2.3 Proximate composition of the catfish samples

Proximate analysis of the catfish samples was carried out following standard procedures (AOAC 2019). Moisture content was determined using hot air oven by drying the sample at 105^0C until a constant weight was obtained. Fat content was determined by Soxhlet extraction method, protein content by Kjeldahl's method, ash content was determined by ashing in the furnace. Total carbohydrate was determined by subtracting the sum of moisture, protein, fat, and ash from 100.

2.4 Mineral analysis of the catfish samples

One gram (1g) of each fish homogenized sample was weighed into a crucible and heated at 600 ^{0}C for three hours in a muffle furnace. The ash obtained was dissolved in 5 mL of 10% hydrochloric acid. The solution was filtered and transferred into a 100 mL volumetric flask. The volume was adjusted to 100 mL with distilled water. The solution was analysed for minerals of interest using Buck Scientific ACCUSYS 211 Atomic Absorption Spectrophotometer (AAS) at the Central Research Laboratory, Tanke, Ilorin, Kwara State, Nigeria. The minerals that were analysed for were As, Cd, Ca, Fe, Mn, Cu, Zn, Na, K, Al, Mg and Pb.

2.5 Statistical Analysis

Data were subjected to analysis of variance (ANOVA) and tested for significance difference among treatments by new Duncan's Multiple Range F-Test (DMRT) at ($P < 0.05$) using SPSS software package version 20.0.0 (IBM SPSS Statistics 2011, IBM Corporation Armonk NY USA).

3. Results and Discussion

3.1 Result of the proximate composition of the catfish samples

The results of the proximate analysis are shown in figure one to five. The highest protein content (64.23±0.03%) was recorded in Unity B market sample while the least protein content (42.76±0.48%) was recorded in Unity A market sample which also had significantly (p=0.05) higher moisture content (44.57±0.33%) than other samples. The moisture content of Unity A market sample was higher than the safe moisture level for the storage of dried fish, which will invariably reduce the shelf life of the dried fish. To ensure the storage of dry fish that is safe from moulds and bacteria infestation, the moisture level must be less than thirty percent (Idah and Nwankwo 2013). Shearer (1994) reported that the protein content of fish is determined by the size of fish but this claim was not confirmed in this study. Also, NSPRI processed fish (NSPRI D) had the highest fat content (29.30±0.26%) and Unity A market sample had the least fat content (7.10±0.88%). The fat content of fish depends on factors such as specie, size, age, season, geographical location and feeding habit (Abdulkadir *et al*., 2010; Vsetickova *et al*., 2020). Ipata B market had highest ash content (16.65±0.47%) while the lowest (4.62±0.19%) was reported for Unity A. Chukwu and Shaba (2009), reported 28.92%, 53.10%, 21.20%, 3.92%, 1.71% and 2.78% for moisture, protein, fat, ash, fibre and carbohydrate respectively. They also reported that the proximate composition of dried catfish is influenced by the method of drying.

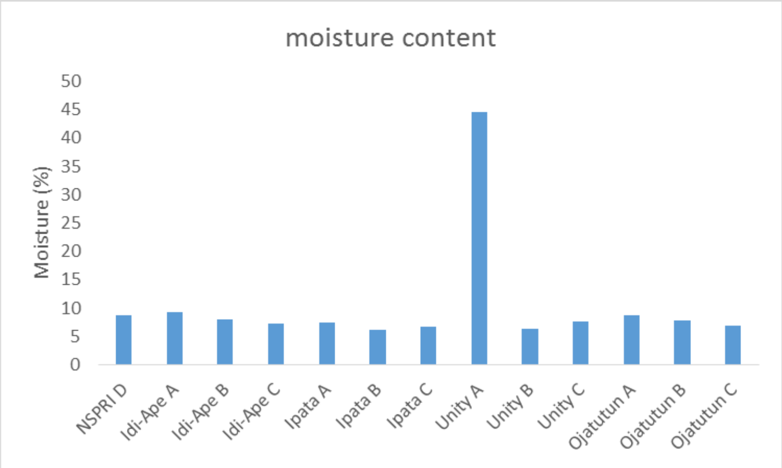

Fig. 1: Moisture content of the fish samples. Each bar represents mean of triplicate readings.

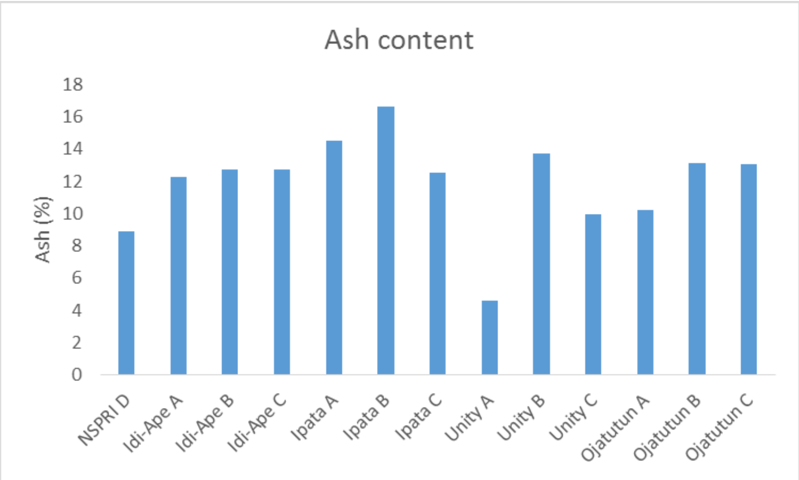

Fig. 2: Ash content of the fish samples. Each bar represents mean of triplicate readings.

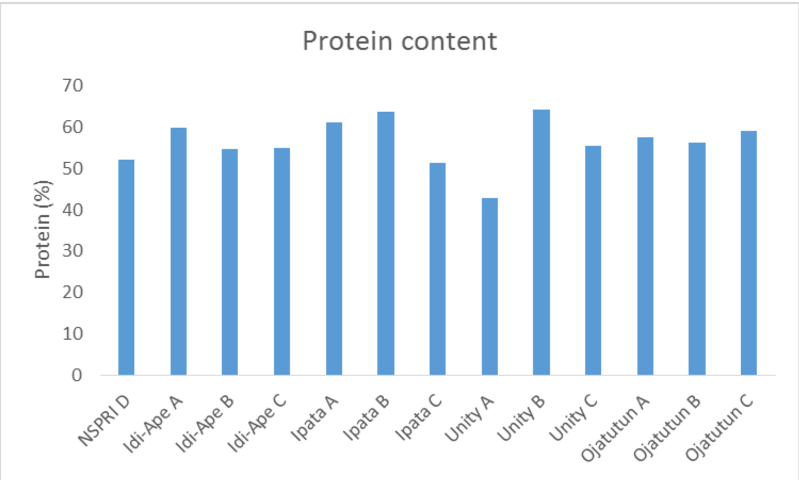

Fig. 3: Protein content of the fish samples. Each bar represents mean of triplicate readings.

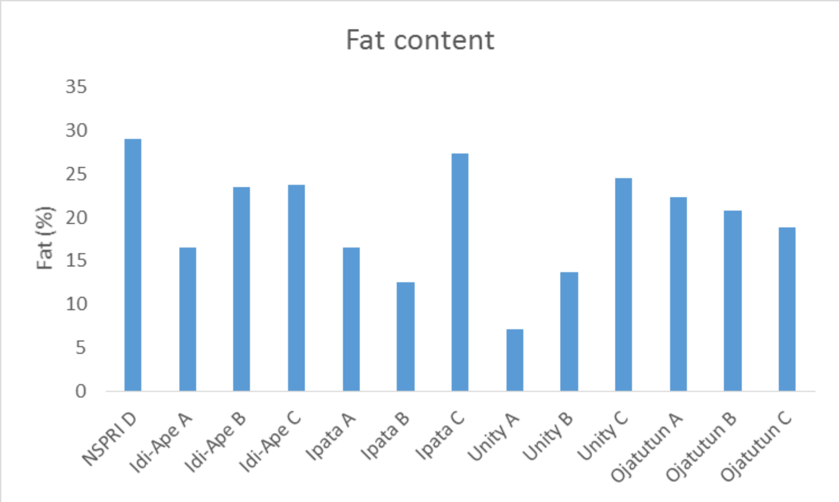

Fig. 4: Fat content of the fish samples. Each bar represents mean of triplicate readings.

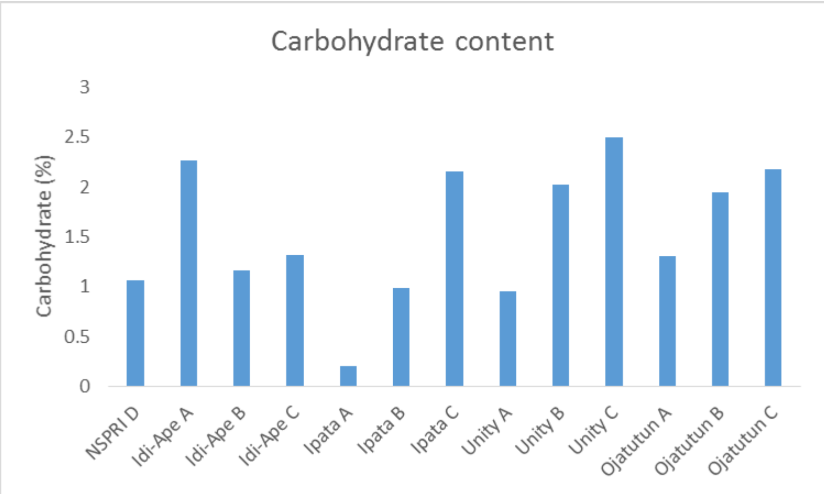

Fig. 5: Carbohydrate content of the fish samples. Each bar represents mean of triplicate readings.

3.2 Results of mineral analysis of the dried catfish samples

The results of the mineral composition of the various dried catfish samples showed that the highest concentration of arsenic was detected in Ipata C sample and the concentration (1.64±0.01) was significantly (p=0.05) higher than other samples followed by Ojatutun A (1.15±0.01). Arsenic is a toxic element that can cause weakness, headache, vascular system disorder and gastrointestinal disease (Saha *et al*., 1999). The report of Khan *et al*. (2003), indicated that exposure to arsenic can cause different cancers such as liver, lung, skin, bladder and kidney cancers. The concentration of cadmium was highest in Unity A sample (0.036±0.01). Cadmium is a metallic element found naturally in low concentrations, usually combined with zinc and lead as sulfide ores. Dispersion into the environment occurs through cadmium containing phosphate fertilizers and inappropriate disposal of electronic waste. Exposure to cadmium can lead to lungs and kidney diseases (Nordberg *et al*., 2018). NSPRI D recorded the highest concentration of copper (0.11±0.01). Copper is a vital catalyst for iron absorption. It is required for adequate growth, cardiovascular functioning, neuroendocrine function, and lung elasticity.

Deficiency of Copper may cause osteoporosis and anaemia (Myint *et al*., 2018). There was no significant difference (p=0.05) in the concentration of manganese in all the samples. Manganese is a part of pyruvate carboxylase and superoxide dismutase, it helps in the metabolism of protein (Aziz *et al*., 2016). Lead was detected in Ojatutun A and Ipata A samples only. Lead is the most important toxic heavy metal in the environment. Its important properties like softness, malleability, ductility, poor conductivity, and resistance to corrosion encourages the use of lead. Long term exposure to lead has been reported to cause anaemia and high blood pressure (Wani *et al*., 2015). NSPRI D had highest concentration of zinc. Zinc is a major component of many enzymes. It plays a significant function in alcohol dehydrogenase, ribonucleic polymerases, alkaline phosphatase, and carbonic anhydrase. Deficiency of Zinc during pregnancy may lead to developmental disorder in offspring. Zinc deficiency can also cause coronary disease (Karpiuk *et al*., 2016).

The highest concentration of iron was reported in Ojatutun B sample. Iron is the main component of haemoglobin and many enzymes that play significant function in the oxygenation of red blood cells. It is needed to improve the immune system and for energy production, its deficiency results in anaemia. Iron deficiency during pregnancy is associated with different adverse conditions such as increased risk of sepsis, maternal mortality, perinatal mortality and low birth weight (Abbaspour *et al*., 2014). Ipata A recorded the highest concentration of calcium. Calcium performs a significant function in the uptake of dietary Vitamin B and activation of lipase. It also helps in the synthesis of neurotransmitter acetylcholine. It lowers blood pressure and helps in building and maintaining bone mass (Olaniyi *et al*., 2018; Wang *et al*., 2008). Almost all the samples recorded high sodium content, but Ipata C had significant ($p=0.05$) higher concentration. Sodium is an essential nutrient involved in the maintenance of normal cellular homeostasis. It regulates fluid and electrolyte balance and blood pressure (Strazzullo and Leclercq 2014). Unity A showed highest concentration of potassium. Potassium helps the kidney to function properly and also, it lowers blood pressure thus reducing the risk of hypertension (Weaver 2013). The concentration of Aluminium was within the range of 0.016 – 0.036 PPM for all the samples. Aluminum is used medically as an adjuvant in vaccines and an agent against pathological hyperhidrosis. It is also used in antiperspirants.

The tolerable weekly intake of aluminium set by the European Food Safety Authority is 1 mg/Kg body weight (Klotz *et al*., 2017). Ipata C recorded the highest concentration of magnesium. Magnesium has several functions in the human body. It acts as a cofactor for more than 600 enzymes, it regulates muscle contraction, neuromuscular conduction, glycemic control, myocardial contraction, blood pressure, energy production and bone development (De Baaij *et al*., 2015). The results showed that the concentration of arsenic and cadmium were higher in the fresh fish (NSPRI F) than the dried product (NSPRI D), this implies that drying may reduce or eliminate these metals in fish. Bawuro *et al*. (2018), reported that factors such as sex, age, size, reproductive cycle, swimming pattern, feeding behaviour and geographical location influence the uptake of metals in fish.

Table 1A: Mineral composition of the dried catfish samples (PPM)

Sample	As	Cd	Cu	Mn	Pb	Zn	Fe
Ojatutun A	1.15±0.01^{d}	0.019±0.01^{d}	0.074±0.01^{e}	0.082±0.01^{a,b}	0.955±0.001^{b}	0.35±0.01^{h}	ND
Ojatutun B	ND	0.024±0.01^{e}	0.064±0.01^{d}	0.028±0.01^{a}	ND	0.28±0.01^{d}	0.46±0.01^{f}
Ojatutun C	ND	0.024±0.01^{e}	0.064±0.01^{d}	0.11±0.01^{a,b}	ND	0.30±0.01^{f}	0.14±0.03^{a,b,c}
Ipata A	ND	0.003±0.01^{a}	0.064±0.01^{d}	0.140±0.01^{a,b}	0.535±0.000^{a}	0.34±0.01^{g}	0.41±0.04^{e,f}
Ipata B	ND	0.012±0.01^{b}	0.034±0.000^{a}	0.096±0.01^{a,b}	ND	0.37±0.01^{i}	0.11±0.12^{a,b}
Ipata C	1.64±0.01^{e}	0.003±0.00^{a}	0.084±0.01^{f}	0.22±0.01^{a,b}	ND	0.28±0.01^{d}	0.40±0.01^{e,f}
Unity A	ND	0.036±0.01^{f}	0.034±0.01^{a}	0.020±0.01^{a}	ND	0.23±0.01^{b}	ND
Unity B	0.39±0.01^{b}	0.003±0.000^{a}	0.073±0.01^{e}	0.10±0.01^{a,b}	ND	0.46±0.01^{l}	0.06±0.00^{a}
Unity C	ND	0.003±0.000^{a}	0.044±0.01^{b}	0.33±0.04^{a,b}	ND	0.29±0.01^{e}	ND
Idi-Ape A	ND	0.020±0.001^{d}	0.054±0.01^{c}	0.11±0.01^{a,b}	ND	0.38±0.01^{k}	0.29±0.19^{d,e}
Idi-Ape B	0.24±0.01^{a}	0.016±0.001^{c}	0.074±0.00^{e}	0.083±0.01^{a,b}	ND	0.27±0.01^{c}	0.28±0.00^{c,d,e}
Idi-Ape C	ND	ND	0.074±0.00^{e}	0.064±0.01^{a}	ND	0.37±0.00^{j}	0.13±0.03^{a,b}
NSPRI F	0.70±0.01^{c}	0.011±0.000^{b}	0.034±0.00^{a}	0.12±0.01^{a}	ND	0.19±0.00^{a}	0.070±0.04^{a}
NSPRI D	ND	ND	0.11±0.01^{g}	0.12±0.01^{a,b}	0.0540±0.00^{a}	0.55±0.00^{m}	0.23±0.02^{b,c,d}

Values are mean (±S.D) of 3 replicates; Values with the same subscript in the same column are not significantly different at ($p < 0.05$). ND = Not detected

Table 1B: Mineral composition of the dried catfish samples continued (PPM)

Sample	Ca	Na	K	Al	Mg
Ojatutun A	9.66±0.34^{c,d}	2.10±0.21^{a}	0.52±0.05^{d,e}	0.016±0.00^{a}	0.076±0.01^{a}
Ojatutun B	10.02±0.39^{c,d}	12.58±0.04^{c,d}	0.48±0.44^{c,d}	0.033±0.00^{c,d}	0.24±0.00^{h,i}
Ojatutun C	12.30±0.07^{d}	12.15±0.35^{c,d}	0.91±0.01^{i}	0.032±0.00^{c,d}	0.18±0.01^{d,e,f}
Ipata A	16.28±5.7^{e}	11.95±0.42^{c}	0.30±0.02^{b,c}	0.030±0.00^{c}	0.23±0.01^{g,h}
Ipata B	9.29±0.16^{c,d}	9.60±0.14^{b}	0.79±0.02^{g}	0.028±0.00^{b}	0.14±0.01^{b}
Ipata C	10.14±0.03^{c,d}	14.43±1.45^{d}	0.54±0.00^{e}	0.036±0.00^{d}	0.25±0.01^{i}
Unity A	3.83±0.33^{b}	12.65±1.63^{c,d}	1.02±0.04^{j}	0.033±0.00^{c,d}	0.16±0.01^{b,c}
Unity B	7.81±0.03^{c}	12.00±0.82^{c,d}	0.43±0.27^{c}	0.032±0.00^{c,d}	0.17±0.02^{c,d}
Unity C	10.26±0.44^{c,d}	9.23±0.11^{b}	0.27±0.01^{a}	0.028±0.00^{b}	0.13±0.01^{b}
Idi-Ape A	7.74±0.29^{c}	11.98±0.88^{c}	0.34±0.34^{b}	0.032±0.00^{c,d}	0.21±0.02^{e,f,g}
Idi-Ape B	7.95±0.15^{c}	12.40±0.11^{b,c}	0.85±0.12^{h}	0.033±0.00^{c,d}	0.21±0.00^{e,f,g}
Idi-Ape C	8.22±0.28^{c}	12.58±2.44^{b,c}	0.80±0.01^{h}	0.033±0.00^{c,d}	0.19±0.03^{d,e,f}
NSPRI F	0.48±0.03^{a}	13.05±1.41^{b,c}	0.69±0.01^{f}	0.034±0.00^{c,d}	0.18±0.01^{c,d,e}
NSPRI D	7.00±0.18^{b,c}	12.28±2.90^{b,c}	0.43±0.03^{c}	0.032±0.00^{c,d}	0.20±0.00^{e,f,g}

Values are shown Means (±S.D) of 3 replicates; Values with the same subscript in the same column are not significantly different at ($p < 0.05$).

4. Conclusion

All the fish samples had high protein content which showed that the smoking process did not deplete the protein content. Apart from Unity A sample, all the fish samples were dried to safe moisture level which is necessary for shelf-life extension. The results also showed that fish is a rich source of vital minerals. The presence of heavy metals such as arsenic, cadmium and lead may be due to the contamination of the water used in breeding the fish. Considering the health risk of these heavy metals, care should be taken to reduce fish contamination. Relevant agencies should train fish farmers on proper siting of fishpond and management to reduce the risk of heavy metal contamination.

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