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ASSESSMENT OF ORGANOCHORINE PESTICIDE RESIDUES IN SMOKED FISH SPECIES FROM GALADIMA MARKET, KANO – NIGERIA

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ABSTRACT

The aim of this study was to determine the levels of organochlorine pesticides residues in muscle, skin and bone of dried smoked fish species namely Clarias gariepinus, Heterotis niloticus, Oreochromis niloticus and Bagrus bayad. Samples were collected from Galadima market in Kano, Kanao State. Nigeria. Extraction of the fish samples and de-fattening of the fish extract were performed using standard procedures. Analysis of the fish samples for pesticide residues were carried out using Shimaduzu GC/MS. Large differences in the levels of pesticide residues were observed between tissues within each fish. The skin of Clarias gariepinus with 48.8µg/g showed the highest concentrations while Heterotis niloticus with 0.4µg/g shows the lowest. The highest pesticide therefore be concluded that the concentrations of organochlorine pesticide in the four dried smoked fish species studied did exceed the permissible limits set by FAO AND WHO.

Keywords: Smoked Fish, Galadima Market, Kano, Organochlorine; Pesticide; Residues;

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INTRODUCTION

Contamination of surface water by pesticides derived from agrochemicals input has become a serious problem world-wide (Grzegorz *et al.*, 2012). Pesticides disrupt ecological balance affecting non-target organisms including fish (Lekei *et al.*, 2014). Pesticides produce several biochemical and physiological responses when they enter to an organisms which may be acclimation to the organisms or may lead to toxicity (Fatima *et al.*, 2015). Fish samples can be considered as one of the most significant indicators in fresh water systems for the estimation of pesticides pollution level (Amoako *et al*., 2012).

Most pesticides are resistant to physical, chemical and biological degradation and accumulate in both aquatic and terrestrial food webs (Valiyaveettil *et al.*, 2010). Pesticides are use in agriculture to maintain high production efficiency and there is constant demand for stable crop production to support the growing human population. The contamination of the environment, food and animals feed by pesticides has become a topical issued of considerable concern in many part of the world, and led many researchers to investigate their occurrence, distribution and concentration in several ecosystems (Saleem *et al.*, 2009). Chlorinated organic pesticide are very stable in both fresh and salt water and are resistant to photo degradation. (Shokrzadeh, 2009). They will disappear from the water with secondary mechanism such as absorption on sediment, biological breakdown by microflora and fauna and absorption by fish through gills, skin and feeding. They are poorly hydrolyzed and slowly biodegrade in environment. (Akan *et al.*, 2014). Over 98 % of sprayed insecticides and 95 % herbicides reach a destination other than their target species, including non- target species, air, water and soil (Vivekanandhan and Duraisamy, 2012). The use of pesticides introduces some risks to the environment, the degree of risk depending upon the pesticide persistence, mobility, non-target toxicity and volume of use (Akan *et al*., 2013). The toxicity level of a pesticide also depends on the deadliness of the chemical, the length of exposure, the health status of the recipient and the route of entry into the body.

Organochlorine pesticides contribute acute and chronic health effects, including cancer, neurological damage, birth defects, tremors, headache, dermal irritation, respiratory problems and dizziness (Toppari, 2002). Animal studies by Garry (1996) have also shown the potential for reproductive and developmental effects and disruption of normal hormone function. Long-term exposure to sub lethal levels of OCPs and their metabolites through various pathways in the aquatic environment may cause far reaching ecological damage and health problems to man. Residues of these toxic chemicals found in water, sediments and aquatic biota pose a risk to aquatic organisms, predators and humans. In view of the forgoing, this research aimed as assessing the concentrations of pesticide residues in fish species sold at Galadima market, Kano.

MATERIALS AND METHODS

Study Area

The study area was Galadima market located in Kano metropolis, housing almost a quarter of the State population (4 million) (NPC, 2021). The market specializes for smoked fish, bush meat and animals by products selling in addition to palm oil and other raw commodities. The market is located in Fagge local Government (12°0'24"N, 8°31'45"E).

Sample collection was carried out at Galadima market in Yankura, Kano, Nigeria. The market is the largest fish market in Kano metropolis receiving smoked fish and fish products from Chad, Maiduguri, Adamawa, Yobe and Jigawa State. It is a centre of major trans-Saharan commercial fish businesses.

Sample Collection

Smoked fish sample will be purchased randomly from the fish seller at the market which includes *Clarias gariepinus, Oreochromis niloticus, Heterotis niloticus* and *Bagus bayad.* The fish samples were collected in a clean polythene bag, labelled and transported to the central laboratory, Bayero University, Kano

Fish Samples Extraction

Extraction of the fish parts was carried out according to the procedure adopted by Sulaiman *et al.* (2020). The bench was cleaned with soap and water and rinsed with acetone. Foil paper was spread on the bench. The fish sample was place on top and thawing allowed to take place. The scale on the fish sample was removed using sterile surgical blade. The sample code was noted and recorded. Dissection of the fish sample was done to isolate the liver, gills, and muscles. Fish tissue sample was homogenized using a motar and pestle. Approximately 20g of the properly chopped fish samples was further mixed with 10g of anhydrous sodium sulphate. This extraction was done using soxhlet apparatus for eight hour using acetone as a solvent.

Samples Extract Clean-up

Clean-up was carried out by measuring ten gram (10g) portion of deactivated silica gel into a 10 mm glass chromatographic column followed by addition of 3 g of anhydrous sodium sulfate. 10 ml of the 1:1 (v/v) ethyl acetate/dichloromethane mixture were used to wet and rinse the column. The extract residue transferred into the column and the extract vial rinsed (three times) with 2 ml ethyl acetate. The column were eluted with 80 ml portion of ethyl acetate/dichloromethane at a rate of 5 ml/ min into a conical flask as fraction one. The column were eluted again with 50 ml portion of ethyl acetate/dichloromethane for the second elution and added to the first extract. All the fractions of each sample were concentrated to dryness using a rotary evaporator at 40 °C. Each residue were dissolved and collected in 2 ml ethyl acetate for gas chromatograph analysis.

De-fattening of the Fish Sample Extracts

The process of de-fattening was conducted by measuring Fifty (50) ml of 1:1 (v/v) hexane/acetonitrile solution was added to 2 ml pesticide extracted from the fish samples in a 100 ml separator funnel. The separator funnels were shaken gently for 3 min while releasing the gas pressure. The separator funnels were allowed to stand for 20 min to allow for phase separation of the organic solvents. The acetonitrile fractions containing the pesticides were collected into a 50 ml beaker while the fat containing hexane solvent phase was discarded. The acetonitrile solvent extract obtained were further cleaned-up using 25 ml of the pure hexane. The acetonitrile fraction were concentrated with rotary evaporator at 40 °C and the

content of the flask dissolve and collected with 2 ml of ethyl acetate into a 2 ml vial. The vial containing the pesticides extracts were stored in the refrigerator at 4 °C for GCMS analysis.

Determination of Pesticide Residue Levels using GC/MS

The analysis of fish samples for pesticides compounds was conducted at National Research Institute for Chemical Technology Basawa Zaria, Kaduna state (NARICT). The SHIMADZU GC/MS (GC-17A), equipped with fluorescence detector was used for the chromatographic separation and wad achieved by using a 35% diphenyl, 65% dimethyl polysiloxane column. The oven was programmed as follows: initial temperature 40°C, 1.5min, to 150°C, 15.0 min, 5 °C/min to200°C, 7.5min, 25°C/min to 290°C with a final hold time of 12 min and a constant column flow rate of 1 ml/min. The detection of pesticides was performed using the GC-ion trap MS with optional MSn mode. The scanning mode offer enhances selectivity over either full scan or selected ion monitoring (SIM). At the elution time of each pesticide using selected ion monitoring, the ratio of the intensity of matrix ions increase exponentially versus that of the pesticide ions as the concentration of the pesticide approach the detection limit, decrease the accuracy at lower levels. The GC-ion trap MS was operated in MS mode and perform tandem MS function by injecting ions into the ion trap and destabilizing matrix ions, isolating only the pesticide ions. The retention time, peak area and peak height of the sample was compared with those of the standards for quantization.

Statistical Analysis

Data collected were subjected to one-way analysis of variance (ANOVA) using IBM SPSS version 20.0 software. It was used to determine whether pesticide residues varied significantly between fish species and fish parts. Probability of $p<0.05$ were considered statistically significant.

RESULTS AND DISCUSSION

Figure 1 shows the GC-MS results of the mean concentrations of some organochlorine pesticides (Dichlorodiphenyltrichloroehane, Hexachlorohexane, Endosulfan, Aldrin, Dieldrin, Chlordane, Heptachlor, Lindane, Hexachlorobenxene, Cypermethrin) residue in the muscle, bone and skin of *Clarias gariepinus* in the month of October from Galadima market. The concentration of these pesticides in the muscles of *C. gariepinus* range from 39.07μg/g to 1.1μg/g, 32.09μg/g to 0.47μg/g skin and 13.57μg/g to 1.5μg/g bone in the month of October, 2021.

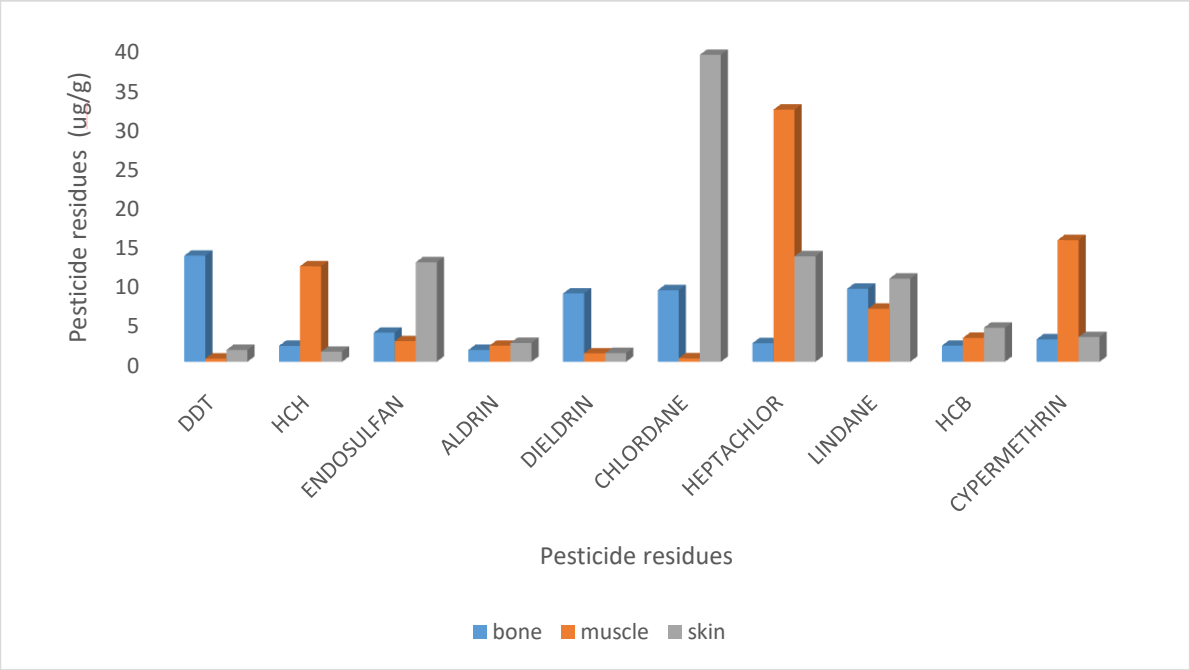

Figure 1: Mean Concentrations of Some Organochlorine Pesticide Residues in different organs of dried *C. gariepinus* from Galadima market, Kano

Figure 2 shows GC-MS results of the mean concentrations of some organochlorine pesticides (Dichlorodiphenyltrichloroehane, Hexachlorohexane, Endosulfan, Aldrin, Dieldrin, Chlordane, Heptachlor, Lindane, Hexachlorobenxene, Cypermethrin) residue in the muscle, bone and skin of *Heterotisniloticus* in the month of October from Galadima market. The concentration of pesticides in the muscle of H.niloticus range from 9.6μg/g to 0.4μg/g, 16.54μg/g to 1.83μg/g skin and 4.33μg/g to 2.22μg/g bone in the month of October, 2021.

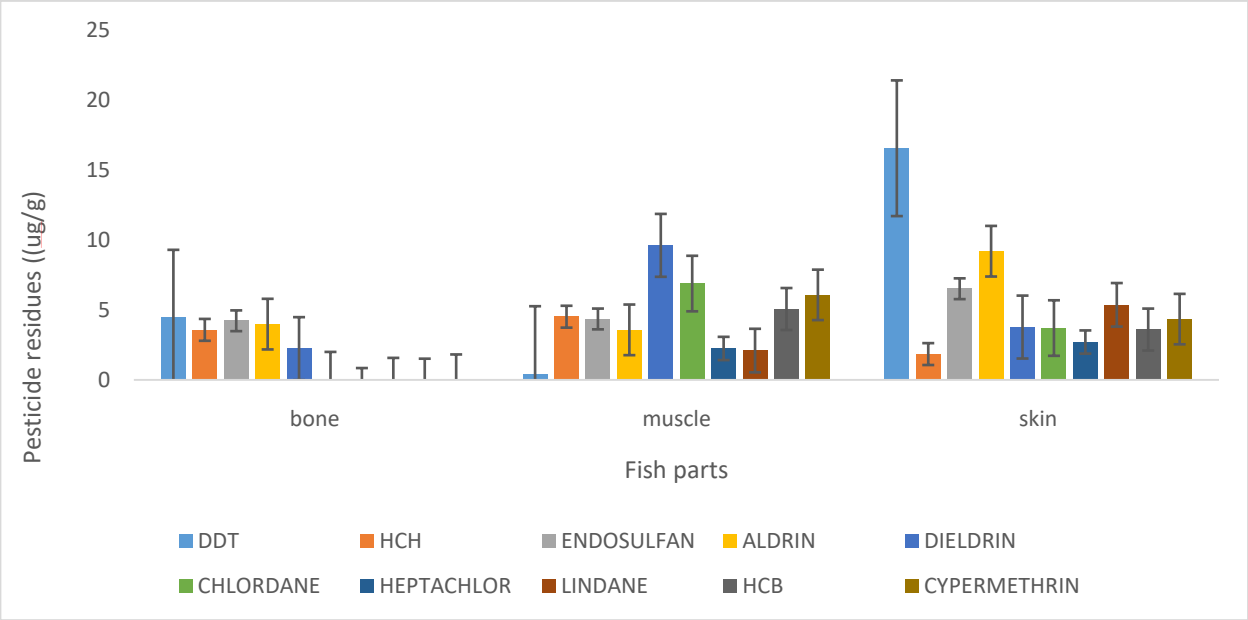

Figure 2: Mean Concentrations of Some Organochlorine Pesticide Residues in different organs of dried *H. niloticus* from Galadima market, Kano

Figure 3 also shows GC-MS results of the mean concentrations of some organochlorine pesticides (Dichlorodiphenyltrichloroehane, Hexachlorohexane, Endosulfan, Aldrin, Dieldrin, Chlordane, Heptachlor, Lindane, Hexachlorobenxene, Cypermethrin) residue in the muscle, bone and skin of *Oreochromis niloticus* in the month of October from Galadima market. The concentration of pesticides in the muscle of *O. niloticus* range from 2.55μg/g to 0.55μg/g , 4.2μg/g to 1.4μg/g skin and 3.8μg/g to 0.56μg/g bone in the month of October, 2021.

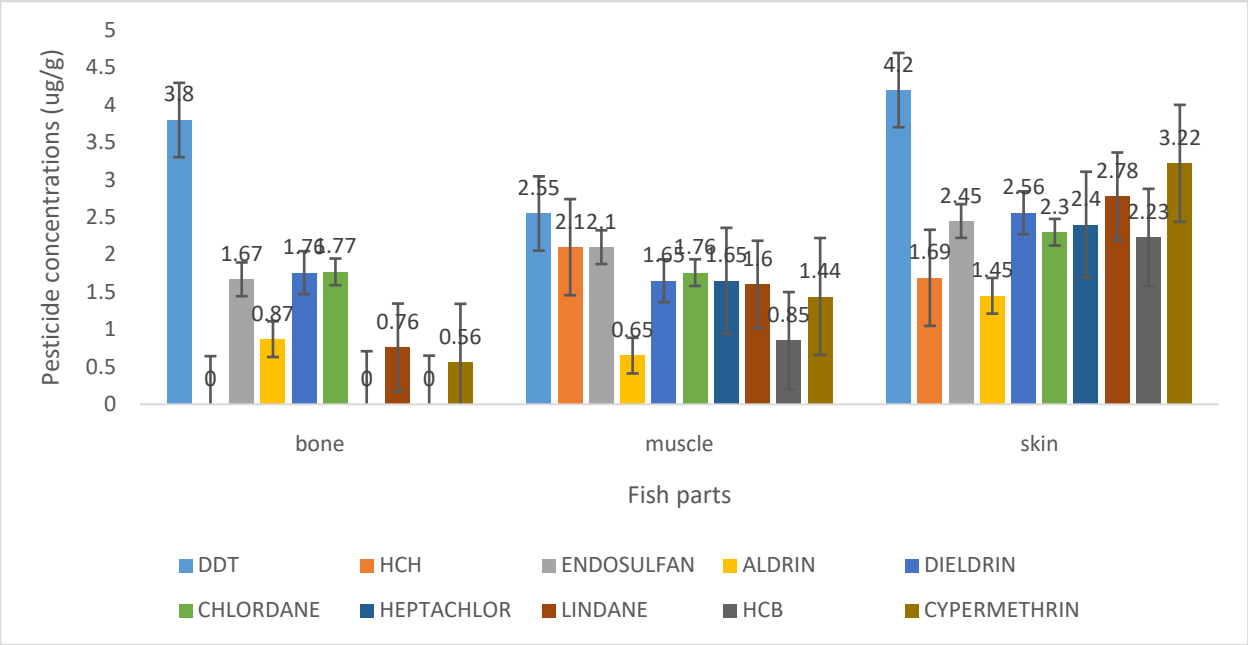

Figure 3: Mean Concentrations of Some Organochlorine Pesticide Residues in different organs of dried *O. niloticus* from Galadima market, Kano October, 2021

Figure 4 showed GC-MS result of the mean concentrations of some organochlorine pesticides (Dichlorodiphenyltrichloroehane, Hexachlorohexane, Endosulfan, Aldrin, Dieldrin, Chlordane, Heptachlor, Lindane, Hexachlorobenxene, Cypermethrin) residue in the muscle, bone and skin of *Bagus bayad* in the month of October from Galadima market. The concentration of pesticides in the muscle of B. bayad range from 2.76μg/g to 0.65μg/g, 4.53μg/g to 0.76μg/g skin and 2.98μg/g to 0.78μg/g bone in the month of October, 2021

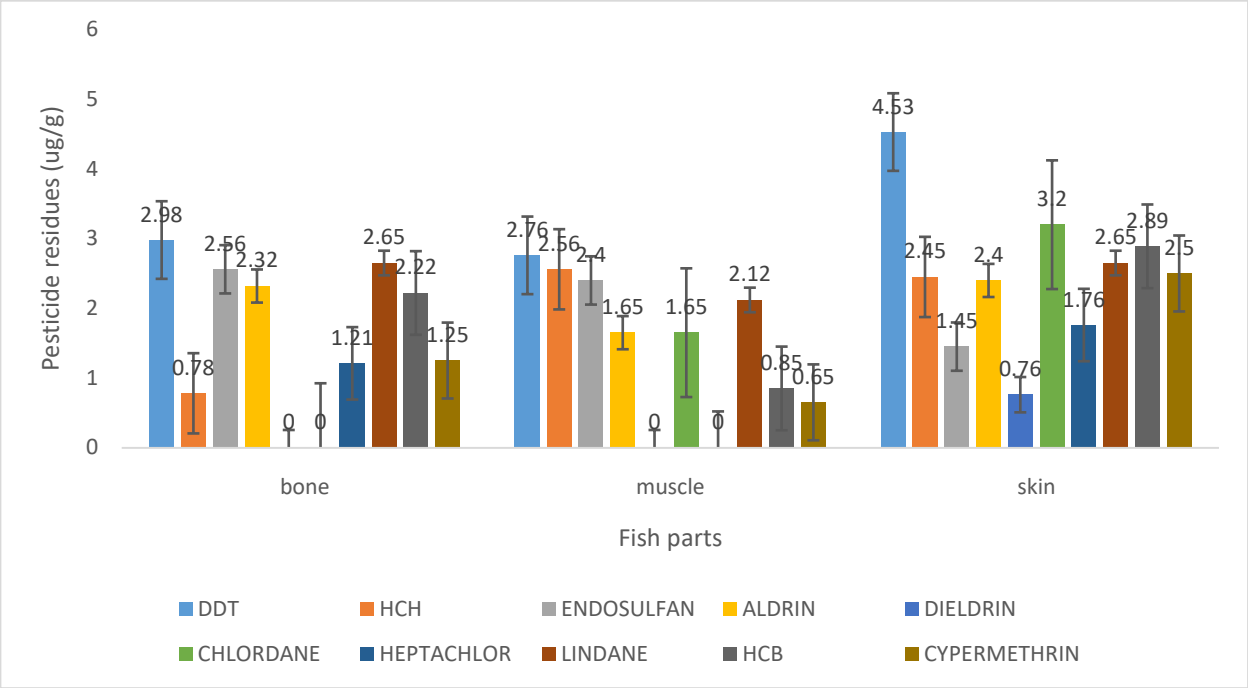

Figure 4: Mean Concentrations of Some Organochlorine Pesticide Residues in different organs of dried *Bagrus bayad* from Galadima market, Kano October, 2021

Figure 5 shows the GC-MS results of the mean concentrations of some organochlorine pesticides (Dichlorodiphenyltrichloroehane, Endosulfan, Lindane, lambda-cyhalothrin Chlordane, Heptachlor, Lindane, Cypermethrin, Chlrpyrifos residue in the muscle, bone and skin of the four dried smoked fish species in the month of November from Galadima market. The highest concentration of pesticides was in *O. niloticus* and lowest was in *H. niloticus*in the month of November, 2021.

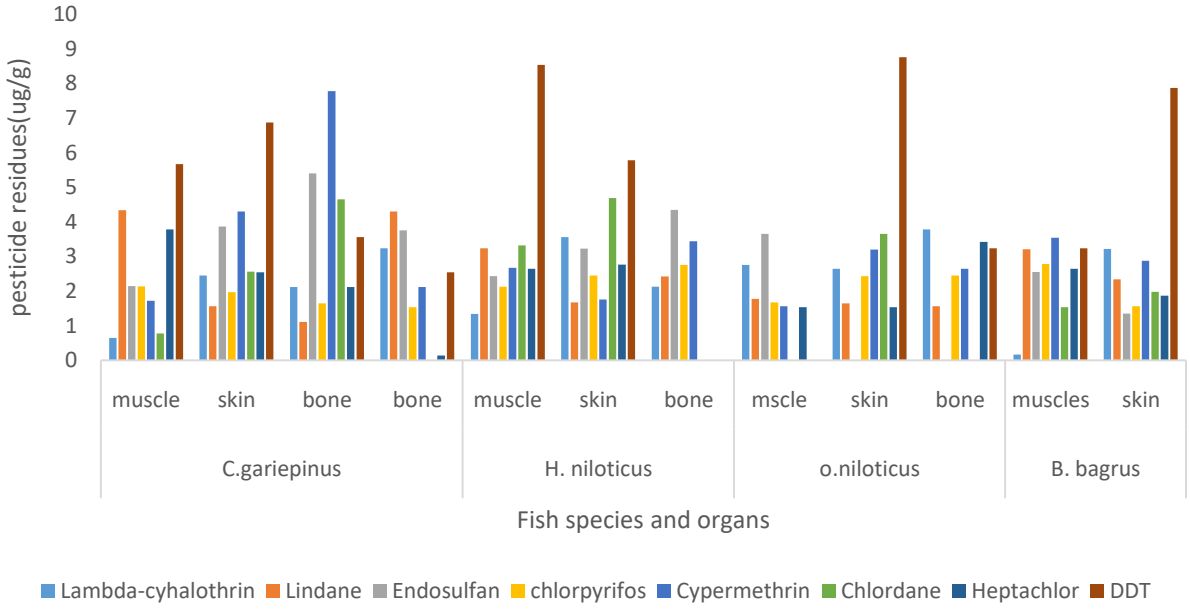

Figure 5: Mean Concentrations of Some Organochlorine Pesticide Residues in different organs of dried fish species from Galadima market, Kano November 2021

The mean concentrations of some organochlorine pesticides (Dichlorodiphenyltrichloroehane, Endosulfan, Lindane, lambda-cyhalothrin, p,p′ − DDE, Heptachlor, Lindane, Cypermethrin, Chlorpyrifos) residue in the muscle, bone and skin of the four dried smoked fish species in the month of December from Galadima market are presented in Figure 4.6. The highest concentration of pesticides was in B. bayad and lowest was in *O. niloticus* in the month of December, 2021.

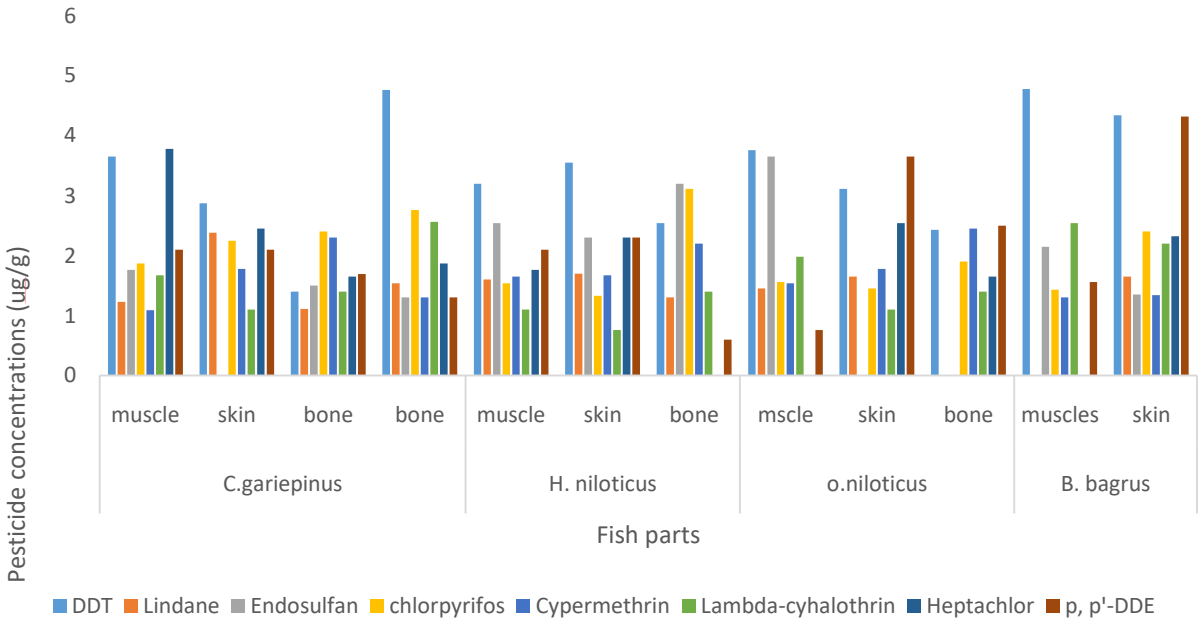

Figure 6: Mean Concentrations of Some Organochlorine Pesticide Residues in different organs of dried fish species from Galadima market, Kano December, 2021

The concentration of the organochlorine pesticide residue were DDT 9.34 µg/g to 3.45µg/g heptachlor 3.78µg/g to 1.87µg/g, chlordane 5.46µg/g to 3.76µg/g, Cypermethrin 8.43µg/g to 2:54µ/g, chlorpyritos 2.76 µg/g to 1.87µg/g, Endosultan 3.76 to 1.76µg/g, Lindane 4.3 µg/g to 2.4 µg/g and Lambda Cyhlothrin 8.56µg/g, 3.65µg/g. This result shows high concentration of OCPs to be greater than their respective MRLs as set by FAO/WHO as shown in Figure 7.

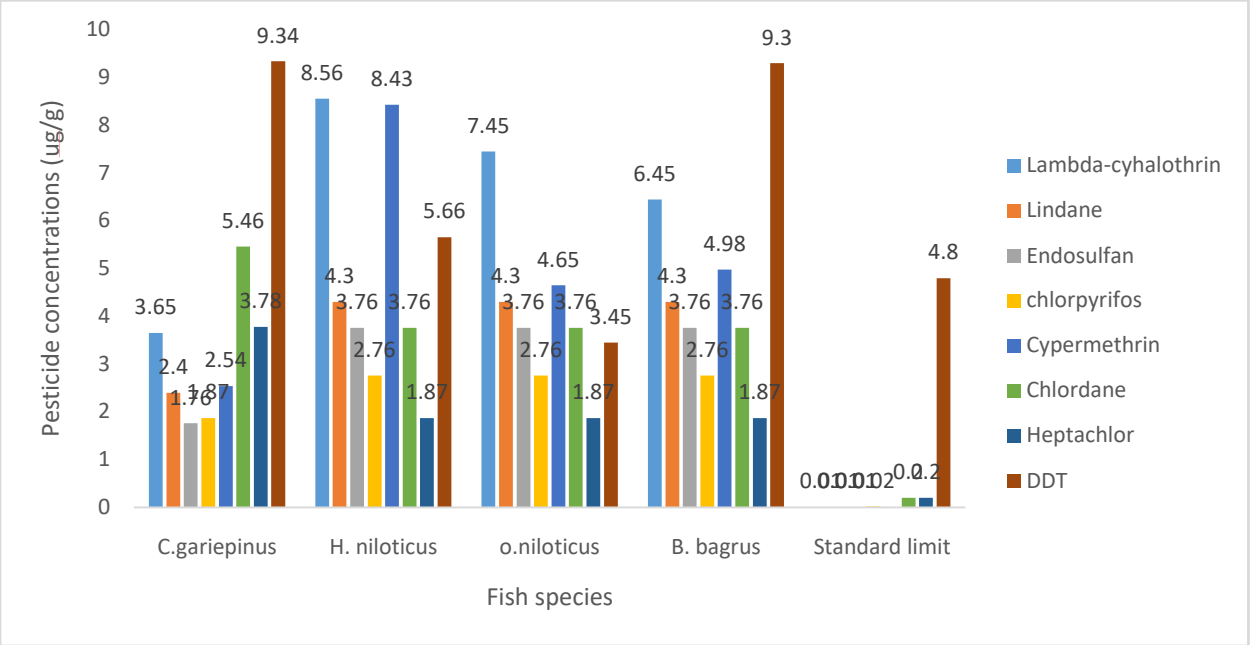

Figure 7: A comparison of the concentrations of OCPs from samples to FAO/WHO standards

Discussion

Organochlorine pesticides stay mainly in the tissues of aquatic organisms and on the sediments. The result of this work indicates that Lindane, lambda-cyhalothrin, Chlordane, Heptachlor, Lindane, Cypermethrin, Chlropyrifos are among abundant pesticides residue recovered in fish samples. Presence of these group of pesticides was the highest in all the organs, but it is highest value was observed in the liver of *H. niloticus*, while the lowest value was observed in muscle of*C. gariepinus. Similar observation was recorded by Afful et al. (2013).* Despite the adverse side effect of pesticides, organochlorine pesticides (OCPs) form an integral component of modern agriculture (Akan *et al*., 2013). The benefit increase supply of food, but problems arise when significant amount of the chemicals are left on the field as residue which tend to affect non target organisms and river bodies are one of the main recipient of pesticide residues generated on the field. These results are in agreement with the study carried out by Akan *et al*. (2015) which indicates high level of endosulfan residue in fish. However, level of this pesticide residues were also reported in lagos lagoon (Adeyeye *et al.*, 2015) were extremely low compared to the level recorded in this work. The concentrations endosulfan in all the fish samples were much higher than the WHO and FAO (2018) set maximum residue limit (MRL) 0.1 |g/kg and the Acceptable Daily Intake value (ADI) of 0.006 |g/kg. Agricultural runoff is the primary source of this pesticide in aquatic ecosystems. Chlordane was to be highly toxic to fish invertebrates and is readily absorbed in sediments indicating potential hazard in the aquatic biota. Similar observation was reported by Adeyemi et al. (2008).

Heptachlor, Lindane, DDT were observed in the bones, muscle and skin in the fish samples. This could due to the lipophilic and hydrophobic nature of the compounds, and their potential to remain in the tissues compartment as reported by Imo et al. (2007). The detection of DDT and lindane an indication of photochemical degradation of p,p'-DDT. In Nigeria, DDT application in agricultural activities has being banned but its application is still in practice by

many farmers (Akan et al., 2013). DDT and its DDE and DDD metabolites remain in the soil or water column for long and were reported to bioaccumulate in aquatic biota (Abang *et al*., 2013). The concentrations of DDT and its metabolites in all the fish samples were much higher than the FAO/WHO (2018) maximum residue limit (MRL) of 1.0 ||g/kg, indicating contamination of the aquatic environment by pesticides. Similar observation was reported by (Adah *et al*., 2012). Damalas *et al.* (2011) reported that pesticides bioaccumulation in biota tissues are mainly due to its resistance to degradation. Compared to DDT and its metabolites, dieldrin pesticide is not easily metabolized in water and due to high octanol water partition coefficient and has low digestion capacity. These pesticides can easily be absorbed and transported to the metabolic pathways of biota (Essumang *et al.*, 2009). The present finding is in line with the work of Akan *et al*. (2013) which indicates the presence of alfa BHC, gamma BHC and lindane in fish samples. Lindane is used solely in seed and soil treatments; foliage applications on fruit and nut trees and vegetables, and wood and timber protection. Presence of this pesticide in the sampled fish indicates that the water body where these fishes were sourced contained residues of these pesticides. The residues might originate from fertilizer applications along the water channels. This observation is in consistent with the finding of Yadav and Devi (2017). The concentrations of this pesticide in all the fish samples were much higher than the FAO/WHO (2018) maximum residue limit (MRLs) of 0.01 ||g/kg for a-BHC and y-BHC. Akan et al. (2013) reported significant concentrations of BHC isomers in the fish's samples from Alau Dam which he attributed to the heavy use of this pesticide in the agriculture sites located around the Dam.

Conclusion

The present findings revealed the human health risks associated with organochlorine pesticides in the fish products from Galadima market, Kano State. Nigeria. The results showed that some organochlorine pesticides are present in the fish products because of contamination in the value chain. The levels of the identified organochlorine pesticide were higher than the Maximum residue limits recommended for fish and fishery products. DDT was the most abundant pesticides residue in the studied tissues of the fish species. The highest levels of these organochlorine pesticides were observed in the skin of *Clarias gariepinus*, compared to other tissues. The study indicated the extensive presence and usage of these pesticides by the respondents. Thus, the use of these pesticides to control pest with little or no knowledge must be checked through adequate control of trade and the enforcement of appropriate sanctions.

Recommendations

1. It is recommended that extensive awareness creation for safe use of agrochemicals be introduced and impact of agro-chemical usage as fish preservative by the fish sellers.
2. Ecofriendly preservatives should be used by the farmers as an alternative to the synthetic pesticides

REFERENCES

Abang, A.F., Kouame, C. M., Abang, M., Hannah, R and Fotso, A. K. (2013) Vegetable growers perception of pesticide use practices, cost, and health effects in the tropical region of Cameroon. International Journal of Agronomy and Plant Production 4: 873-883.

Adah, P. M. (2012). Assessment of Smoke Fish Packaging in Doron – Baga metropolis, Borno State Nigeria. 26th Annual Conference of the Fisheries Society of Nigeria (FISON), Minna, Nigeria, 26: 54 – 58.

Adeyemi, D., Ukpo, G., Anyakora, C. and Unyimandu, J. (2008). Organochlorine pesticides residues in fish samples from Lagos Lagoon, Nigeria. American Journal of Environmental Science, 4: 649-653.

Adeyeye, S. A, Oyewole O. B., Obadina A. O., Omemu A. M., Oyedele H. A. and Adeogun, S. O. (2015). A survey on traditional fish smoking in Lagos State, Nigeria. African Journal of Food Science, 9: 59-64. 10.5897/AJFS2014.1216

Afari-Sefa, V.,Asare-Bediako, E., Kenyon, L and Micah, J.A. (2015) Pesticide Use Practices and Perceptions of Vegetable Farmers in the Cocoa Belts of the Ashanti and Western Regions of Ghana. *Adv Crop Sci Tech*., 3(174): 3-10.

Afful, S., Awudza, J.A.M., Osae, S and Twumasi, S. K. (2013) Persistent organochlorine compounds in the water and sediment samples from the Lake Bosomtwe in Ghana. *American Chemical Science Journal* 3(1): 434-448.

Afful, S., Anim, A.K. and Serfor- Armah.Y.(2010). Spectrum of OrganochlorinePesticide Residues in Fish samples from the Densu Basin. *Research Journal of Environment and Earth Sciences,* 2(3):133-138. ISSN:2041-0492.

Agunloye, T.O. (1984). A survey of Chlorinated hydrocarbons in Rivers of Southern Nigeria. M.Sc. Thesis. Department of Chemistry, University of Ibadan, Nigeria, p 74.

Akan, J.C., Mohammed, Z., Jafiya, L andOgugbuaja, V.O. (2013) Organochlorine Pesticide Residues in Fish Samples from Alau Dam, Borno State, North Eastern Nigeria. *J Environ Anal Toxicol.,* 3(3): 171-174.

Amakwe, C. (1984). Organochlorine pesticide residues in Nigerian freshwater fish. B.Sc. Dissertation, Dept. of Chemistry, Ibadan University, Nigeria.

Amoako, P.K.,Kumah, P andAppiah, F. (2012) Pesticides usage in Cabbage (*Brassica oleracea*) Cultivation in the Ejisu-Juaben Municipality of the Ashanti Region of Ghana. International *Journal of Research in Chemistry and Environment*, 2(1): 26 - 31.

Bello, M. M, Sani, H., Bukar, A., and Rabiu, M. M. (2017). The economic effect of insurgency on smoked fish sellers in Maiduguri Metropolis of Borno State Nigeria. *Journal of Agricultural Extension*, 21: 37-45. 10.4314/jae.v21i3.4.

Calamari, D., Tremolada, P., Di Guardo, A. and Vighi, M. (1994). Chlorinated hydrocarbons in pine needles in Europe: fingerprint for the past and recent use. *Environmental Science Technology*, 28: 429–434.

Damalas, A., Christos A. and IIias, G.E. (2011). Pesticide: exposure, safety issues, and risk Assessment Indicators: *International Journal of Environmental Research and Public Health*. 2: 77-98

Essumang, D., Togoh, G.K andChokky, L. (2009). Pesticide residues in the water and fish samples from lagoons in Ghana. *Bulletin of the Chemical Society of Ethiopia*, 23(1): 19-27.

Essumang, D.K., Doboo, D.K., Adokoh, C.K., and Fumador, E.A.(2008). Analysis of some pesticide residues in tomatoes in Ghana. Hum. *Ecol. Risk assessment*, 14: 796-806.

Fayomi, S.F. (1987). Determination of Organochlorine pesticides and polychlorinated biphenyls (PCBs) in Nigerian fresh water fishes from Cross River State of Nigeria. B.Sc. dissertation, Department of Chemistry, University of Ibadan, Nigeria.

Fianko, J.R., Donkor, A., Lowor, S.T., Yeboah, P.O., Glover, E. T., et al. (2011) 'Health risk associated with pesticide contamination of fish from the Densu River Basin in Ghana'. *Journal of Environmental Protection*, 2: 115-123. 22.

Gitahi1, S.M., Harper, D.M., Muchiri, S.M., Tole, M.P. and Ng‟ang‟a, R.N. (2002). Organochlorine and Organophosphorus pesticide concentrations in water, sediment, and selected organisms in Lake Naivasha (Kenya). *Journal of Association of analytical chemist*, 75: 334

Hayes, W. and Laws, E. (1991). Pesticides in aquatic environments. Handbook of Pesticide Toxicology, 1: 257.

Hurting, A.K., San, Sebastian, M., Soto, A., Shingre, A., Zambrano, D., Guerrero, W. (2003). Pesticide use among farmers in the Amazon basin of Ecuador. *Arch Environ Health*, 58(4): 223-228.

Imo, T.S., Sheikh, M.A.E., Oomori, T. and Tamaki, F. (2007). Contamination by Organochlorine pesticides from rivers. *International Journal of Environmental Science Technology*, 4: 1- 9. Ize-Iyamu, O.K., A

Ize-Iyamu, O.K., Asia, I. O. and Egwakhide, P.A. (2007). Concentrations of residues from Organochlorine pesticide in water and fish from some rivers in Edo state, Nigeria. *International Journal of Physical Sciences*, 2(9): 237-241.

Lee, D.H., Steffes, M.W., Sjödin, A., Jones, R.S. and Needham, L.L. (2010). Low dose persistent organic pollutants predict type 2 diabetes: A nested case-control study. Environmental Health Perspective, 151(2): 342 -349

Lehotay, S.J., Hiemstra M., Van Bodegraven P. and DeKok A. (2007). Validation of a fast and easy method for the determination of more than 200 pesticide residues in Fruits and vegetables using gas and liquid chromatography and mass spectrometric detection.*J. AOAC Int.* 88(1): 584-595.

Lekei, E.E., Ngowi, A.V and London, L. (2014). Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. BMC Public Health. 14:389.

Lerro, C.C., Koutros, S., Andreotti, G, Friesen, M.C., Alavanja, M.C., Blair, A., Hoppin, J.A., Sandler, D.P.,Lubin, J.X and Ma, X(2015). Organophanosphate insecticide use and cancer incidence among spouses of pesticide applicators in the agricultural health study. *Occup Environ Med*. 72:736–744.

Liu, P., Wu, C.H., Chang, X.L., Qi, X.J., Zheng, M.L and Zhou, Z.J. (2014). Assessment of chlorpyrifos exposure and absorbed daily doses among infants living in an agricultural area of the Province of Jiangsu, China. *Int Arch Occup Environ Health*, 87:753–762.

Mackenzie, R. S. J., Brewin, C. R., Curran, H. V., Furlong, C.E., Abraham-Smith, K.M and Harrison, V. (2010). Neuropsychological and psychiatric functioning in sheep farmers exposed to low levels of organophosphate pesticides. *Neurotoxicol Teratol*. 32:452–459.

María Teresa Muñoz-Quezada, Boris Lucero, Asa Bradman, Brittney Baumert, Verónica Iglesias, MaríaPía Muñoz & Carlos Concha (2019) Reliability and factorial validity of a questionnaire to assess organophosphate pesticide exposure to agricultural workers in Maule, Chile, International Journal of Environmental Health Research, 29:1, 45-59,

Meyer-Baron M, Knapp G, Shäper M, van Thriel C. (2015). Meta-analysis on occupational exposure to pesticidesneurobehavioral impact and dose-response relationships. Environ Res. 136:234–245.

Mwevura, H., Othman, C.O. and Mhehe, G.L. (2002). Organochlorine pesticide residues in edible biota from the Coastal Area of Dar Es Salaam City. Journal of Marine Science, 1: 91-96.

Nida, M.S., Rafat, A. and Hussein, E. (2009). Organochlorine pesticide residues in dairy products in Jordan. Chromosphere , 77: 675.

Nwankwoala, A.U. and Osibanjo, O. (1992). Baseline levels of selected Organochlorine pesticides in surface waters in Ibadan (Nigeria) by electron capture gas chromatography. Science of The Total Environment, 119: 179–190.

Ogbonnaya, I.C., Abdullahi, M.,Yisa. ,J. and Bala, A. (2014) Assessement of organiichlorinepesticle Residue in soil and water from fadama farming communities in Minna, North Central Nigeria. (AASCIT Journal of Environment. 2(5):4855.

Ojo, O.O. (1991). Bottom sediments as indicators of chemical pollution in Lekki Lagoon. M.Sc. Thesis, Department of Chemistry, University of Ibadan, Nigeria.

Osibanjo, O. and Adeyeye, A. (1999). Residues of organochlorine pesticides in fruits, vegetables and tubers from Nigerian markets. Science of The Total Environment, 231(2): 227-233.

Osibanjo, O. and Bamgbose, E. (1990). Review of Chlorinated substances in Marine fish and shellfish of Nigeria. Marine Pollution Bulletin, 21: 581-586.

Pandit, G. G., Sharma, S., Srivastava, P. K. and Sahu, S. K. (2002). Persistent organochlorine pesticide residues in milk and dairy products in India. Food Additives and Contaminents, 19 (2): 153-157. http://dx.doi.org/10.1080/02652030110081155 PMid:11820496

Rajendran, R. B., Imagawa, T., Tao, H and Ramesh, R. (2005). Distribution of PCBs, HCHs and DDTs, and their ecotoxicological implications in Bay of Bengal, India. *Environ Int* 31: 503- 512.

Rena, M.C., Caldas, E.D., Pires, D.X and Pontes, E. R. (2006). Pesticides exposure in Culturama, Brazil-knowledge, attitude and pracices. *Environ Res*., 102(2):230-236

Servicio, A. G. (2012). Informe de venta de plaguicidas de usoagrícola en Chile [Report of sale of pesticides for agricultural use in Chile]. [Internet]. [accessed 2018 Feb 10]. http://www.sag.cl/sites/default/ files/declaracion_de_venta_de_plaguicidas_ano_2012.pdf

Starks, S. E., Hoppin, J.A., Kamel, F, Lynch, C.F., Jones, M.P, Alavanja M.C, Sandler,DP.,Gerr F. (2012). Peripheral nervous system function and organophosphate pesticide use among licensed pesticide applicators in the agricultural health study. Environ Health Perspect. 120:515–520.

Suleiman, F., Nuhu, A. A., Omoniyi, K. I. and Yashim, Z. I. (2020). Determination of Organochlorine Pesticide Residues In Some Vegetables And Fruit By Quechers Techniques And Gas Chromatography /Mass Spectrometry. *FUDMA Journal of Sciences*, 4(2): 365-370.

Sunday, M. (1990). Determination of Chlorinated pesticide residues and metals in sediments from rivers and streams in Ibadan, Oyo State, Nigeria. M.Sc. Thesis, Department of Chemistry, University of Ibadan, Nigeria.

Suratman S, Edwards JW, Babina K. (2015). Organophosphate pesticides exposure among farmworkers: pathways and risk of adverse health effects. Rev Environ Health. 30:65–79.

Tongo, A.A. (1985). Baseline study of levels of organochlorine pesticides in Nigerian rivers and their sediments. MSc. Thesis, Department of Chemistry, University of Ibadan, Nigeria

Urlacher, E., Monchanin, C., Rivière, C., Richard, F.J., Lombardi, C., Michelsen-Health, S., Hageman, K.J., Mercer, A.R. (2016). Measurements of chlorpyrifos levels in forager bees and comparison with levels that disrupt honey bee odormediated learning under laboratory conditions. *J Chem Ecol*. 42:127–138.

Uyimandu, J.P. and Udochi, P.U. (2002). Comparative studies of Organochlorine and PCBs in Fish from the Lagos Lagoon. Journal of Agriculture, Biotechnology and Environment, 4: 14-17.

Walter, J.C. (2009). Chlorinated pesticides threats to health and importance of detection". Environmental Medicine. 14(4):347-59.

WHO- World Health Organization, the WHO recommended classification of pesticides by hazard and guidelines to classification: 2009.2010 [cited on 2018 may 6] available from http://www.who.int/ipcs/publications/pesticides _2009.pdf.

Yadav, I.C and Devi, N.L. (2017). pesticides classification and its impact on Human and environment environ. Sci & engg. vol 6: Toxicology 2017 p.140-158.

Yerima, I. and Ngulde, Y. M. (2015): Sources and Uses of Fuel for Fish Smoking Around the Lake Chad in Borno State, Nigeria. Journal of Environment and Ecology, 6(2) 35 – 47. doi:10.5296/jee.v6i2.8707 URL: http://dx.doi.org/10.5296/jee.v6i2.8707