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HEAVY METALS AND PROXIMATE COMPOSITION OF FOREST LEAFY VEGETABLES IN OIL PRODUCING AREA OF NIGERIA

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Abstract

This work investigated heavy metals content of Forest Leafy Vegetables (FLVs) consumed in Port Harcourt, Nigeria. Fresh samples of eight commonly consumed FLV species were obtained from two major markets in Port Harcourt. FLVs were dried, digested and analysed with flame Atomic Absorption Spectrophotometer (AAS) for heavy metals. Proximate analysis of FLVs was carried out using standard method of AOAC. Concentrations of Iron (Fe) ranged from 4.69ppm (Heinsia crinata) - 8.97ppm (Gongronema latifolia), Manganese was highest in Liasanthera africana (6.03ppm) and lowest in O.gratissimum (0.45ppm) while Magnesium levels ranged from 0.609 – 1.630ppm. P.guineense accumulate highest Pb (1.004ppm) compared to Ocimum basilicum Pb (0.380ppm). Copper was highest in H.crinata (1.165ppm) and lowest in O.gratissimum (0.218ppm). O. gratissimum had lowest Cadmium (0.022ppm), Arsenic (0.003ppm), Mercury (0.002ppm) and Zinc (0.044ppm). P.guineense contains highest concentration of Chromium (3.792ppm) while H. crinata possess the lowest (0.409ppm). Nickel was highest in O.bassilicum (0.665ppm) and least in G.latifolia (0.388ppm). FLVs were rich in crude protein, fat and crude fibre. O.bassilicum (21.00%) was the richest in crude protein while H.crinata has the lowest level (11.55%). Crude fibre content of the FLVs range from 11.0% to 14.0% while fat content varied between 2.4% for O.bassilicum and 4.0% for H. crinata. FLVs sourced from natural forests in crude oil exploration areas in Nigeria is safe for consumption, since heavy metals of FLVs samples were less than maximum limits recommended by FAO/WHO. Proximate analyses showed that the FLVs possess useful nutritional contents required for healthy growth.

Key Words: *Forest leafy vegetables, Heavy metals, Proximate composition, Nigeria*

Introduction

In most developing tropical nations of sub Saharan West Africa, wild plant resources play significant role in food supply and other livelihood support (Sobukola *et al.*, 2007; Mohammed and Sharif, 2011). Leafy vegetables are essential diet components providing protein, vitamins, iron, calcium and other nutrients, which are usually in short supply among the populations of poor tropical nations (Thompson and Kelly, 1999). Forest leafy vegetables (FLV) are usually gathered freely from the forests by the rural populations in the sub Saharan West African region for domestic consumption

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and sometimes for sale to supplement important for food security and poverty alleviation in the rural and peri-urban centres in Nigeria and many other rural parts of the world (Sundriyal *et al*. 2003; Oladele *et al*., 2013). FLV also supply the body with vitamins, proteins, energy, minerals and some hormone precursors (Akubugwo *et al*., 2007). Low socio-economic status women have been implicated for collecting wild plants for vegetables (for domestic consumption and family income) in Nepal (Acharya and Acharya, 2010). Supply of animal protein in developing West Africa is inadequate and unaffordable by vast majority of people hence, alternatives in form of plant proteins are sourced from nearby forests. FLVs are a major source of plant protein to supplement poor supply of animal proteins and other essential minerals required for normal human health and development. Many of the FLVs such as *Pterocarpous* spp*., Gnetum africana, Gongronema latifolia and Piper guineense* are rich in fibre, fat and crude protein required for normal human physiological growth and healthy living. Most of FLVs are consumed fresh while some are dried and stored for future use. Redzic (2006) observed that wild plants are commonly used as a supplement for healthy diets in most developed regions of the world presently. Burlingame (2000) argued that some FLVs can be nutritionally superior to cultivated ones in many cases. The relevance of this important Non–Timber Forest Products (NTFPs) in the livelihood of rural and urban populations cannot be over stressed especially in the dry season when cultivated vegetables such as *Telfairia occidentales, Amaranthus hybridus and Celosia* species become insufficient to meet the demand for vegetables throughout the year. Production family income. These vegetables are of these agronomic vegetables relied mostly on rainfed agriculture due to scanty irrigation facilities hence, forest leafy vegetables are essential to the survival of the teeming population. FLVs are crucial in traditional health care systems in rural West African communities. Vast majority of people live in rural areas and depend on medicinal plants for health care delivery due to poverty and non-availability of modern health care facilities (Amri and Kisangau, 2012). FLVs such as *Pipers guineense, Gongronema latifolia, Ocimum* spp have been documented as antimalarial plants in local herbal medicines in Nigeria (Oladele and Adewumi, 2008; Chima *et al*., 2013). Most FLVs in southern Nigeria are utilized as food and medicine for prevalent diseases such as malaria.

Heavy metals are natural components of the environment; however, human activities such as crude oil exploration, mining, industry and commercial agriculture have been linked to increased quantity of these elements in the environment (Yebpella *et al.,* 2011). Studies of heavy metals in ecosystem indicated that many areas near urban complexes, metal ferrous mines and major road systems contain anomalously high concentrations of these elements. In particular, soil in such regions have been polluted from a range of sources with Pb, Cd, Hg, As and other heavy metals (Nriagu, 1989). FLVs absorb heavy metals from contaminated soils and waters. Contamination of plants with toxic chemical elements due to contaminated soil and water has been observed as a result of the release of these toxicants into the sea, rivers, lakes and irrigation channels (Cambra *et al*., 1999). Soil pollutants affect micro flora and fauna of the ecosystem and also contaminate fruits and vegetables from such soils (Pande and Sharma, 1999; Kaur and Katnoria, 2014). Consumption of contaminated plants and plant products by man results in bioaccumulation of these metals in human body, this poses health risk both in short and long – term (Nordberg, 2004; Watanable *et al*., 2005). Heavy metals get into human body through food, water, air and skin absorption. Expansion of crude oil exploitation in Nigeria is associated with incessant oil spillage, water, soil and air pollution with heavy metals. Rivers State is a major hub of crude oil exploitation in Nigeria, oil exploration and associated activities usually predispose forest ecosystems to environmental hazards. Heavy metals such as Lead (Pb), Zinc (Zn), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Aluminum (Al) and Manganese (Mn) in various degrees have been reported in cow meat reared in polluted areas, fish from contaminated waters, cultivated vegetables and fruits from environmentally hazardous ecosystems in Nigeria (Agatha, 2011; Ogabiela *et al*., 2011;Yebpella *et al.,* 2011; Nwoko, 2014). Scientific reports exists on the heavy metals analysis of cultivated vegetables in oil exploration areas in Nigeria, however, there is paucity of information on the toxic metals analysis of frequently marketed and consumed FLVs harvested from ecosystems under crude oil exploration in relation to their health risks on the consumers of such products. In this work we aim to document the heavy metals content of FLVs marketed and consumed in Rivers State, Nigeria and possible implications on the health of rural and urban consumers with a view to create awareness, sensitize formulation of appropriate health policy and improved welfare of inhabitants.

Methodology

Study Area

Rivers State is situated between latitude 4°45′N 6°50′E and longitude 4.75°N 6.833°E of Greenwich Meridian in the Niger Delta region of Nigeria. It is bounded in the south by the Atlantic Ocean, Delta, Abia and Akwa-Ibom states in the west, north and east respectively. The administrative headquarters is situated in Port Harcourt. Rivers State is endowed with abundance of crude oil deposit both onshore and offshore which the national economy hinged on since its' discovery in the 1960s. Exploration and refinery of crude petroleum resources have attracted several professionals and expatriates from different fields into the state to service the industry.

Oil wells and flow stations are located across the state. Water, air and soil pollution occur frequently following unrestricted gas flaring and oil spillage throughout the state. Port Harcourt, the capital city has witnessed tremendous growth in human population of different nationals and it is expanding in an unprecedented rate due to urbanization. The traditional subsistence farming and fishing of the local inhabitants have gradually given way to improved commercial activities in the metropolitan. Supplies of fresh fruits and vegetables suchas *Musa* species (plantain and banana), *Solanum* species (egg-plants), *Telfairia occidentales* (fluted pumpkin), *Talinum triangulare* (water leaf), *Gnetum africana, Pipers guinense, Ocimum* species (Basils) etc. come from towns surrounding the state capital. Rivers state is characteristics of two vegetation types: Salty mangrove forest and fresh water swamp tropical forest. Environmental pollution from oil spillage and gas flaring is a major challenge for the sustainable management of flora and fauna resources; several acres of forest cover and numerous aquatic organisms have been lost to oil exploration activities (Agatha, 2011).

Sample Preparation and Analysis

Fresh samples of eight (8) commonly consumed forest leafy vegetable (FLV) species were obtained from two major markets in Port Harcourt (Mile 1 and Oil mill markets) as indicated in Figure 1. Vegetable samples were thoroughly washed to remove all adhered soil particles in the laboratory, Department of Forestry and Wildlife Management, University of Port Harcourt. One hundred grammes (100gm) each of samples from the two markets were weighed for processing. Samples were cut into small pieces, air dried in the laboratory and same species bulked together for analysis. FLVs samples were mixed to form a composite of the particular species. The samples were pulverised and passed through 1 mm sieve. Samples were taken to Soil Science laboratory, University of Ibadan, Nigeria for Flame Atomic Absorption Spectrophotometer analysis (F-AAS) using Buck Scientific 210/211VGP model - USA. Samples were ashed at 550^{o}C for 48 hours; wet digestion of ash samples (1g each) was carried out using 5 ml of concentrated nitric acid, according to Awofolu (2005). The mixture was filtered and the filtrate of 50 ml in the standard flask with deionized water used in standardization of solution. Total of twelve heavy metals were investigated for their concentrations in the FLVs using AAS. Samples of FLVs were analysed for crude protein, fat, fibre and ash using standard method of AOAC (1995).

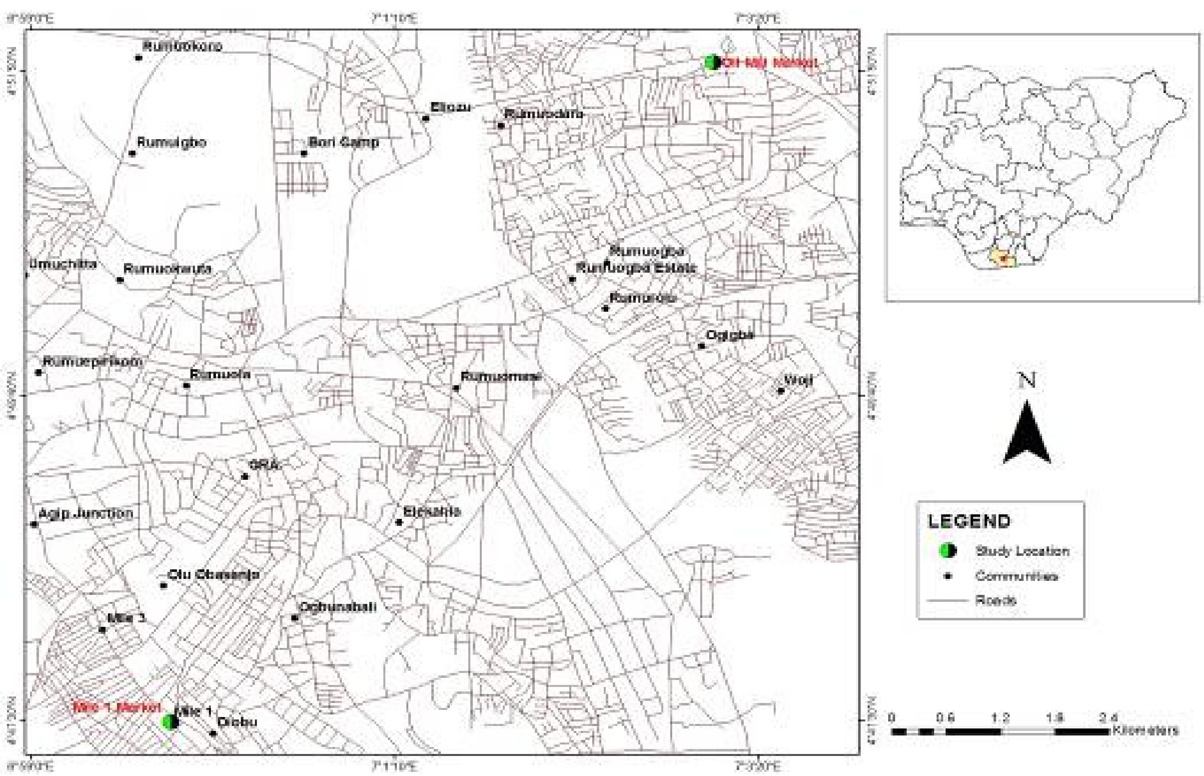

Figure 1: Map of Port Harcourt, Nigeria showing the study sites

Results and Discussions

Heavy metals concentrations in marketed and commonly consumed FLVs were shown in Table 1. Leaves of *G. latifolia* and *O. gratissimum* possess the highest concentrations of Iron (Fe) in their tissues with 8.97 and 8.87ppm respectively, *Heinsia crinata* contained the least Fe concentration (4.69ppm) among the eight FLVs investigated. Manganese was highest in *Liasanthera africana* leaves (6.03ppm) and lowest in *Ocimum gratissimum* (0.45ppm) while Magnesium levels ranged from 0.609–1.630ppm in the commonly consumed FLVs. The leaves of *Piper guineense* accumulate highest concentration of Lead (Pb-1.004ppm) compared to the least Pb (0.380ppm) concentration in *Ocimum bassilicum* leaves. Copper (Cu) is highest in *H. crinata* (1.165ppm) while *O. gratissimum* showed the lowest level of Cu (0.218ppm). *O. gratissimum* also showed lowest concentrations in Cadmium (0.022ppm), Arsenic (As - 0.003ppm), Mercury (Hg-0.002ppm) and Zinc (Zn-0.044ppm). *P. guineense* contains highest concentration of Chromium (3.792ppm) in its' leaves while *H. crinata* leaves possess the lowest level of Cr. (0.409ppm) and highest level of Selenium (0.066ppm). Nickel accumulation was highest in *O. bassilicum* (0.665ppm) and least in *G. latifolia* (0.388ppm) leaves. *Pterocarpus soyauxii* has medium accumulation of heavy metals investigated among the marketed FLVs in the study. Khanna and Khanna (2011) noted that potentially toxic metals uptake by plants generally is influenced by soil factors such as pH and plant physiologic factors. Cadmium is readily available for absorption in neutral or alkaline soils.

Iron (Fe) is an essential element in human nutrition. Minimum daily requirement depend on age, sex, physiological status, and iron bioavailability and range from about 10 to 50 mg/day. Established provisional maximum tolerable daily intake (PMTDI) of 0.8 mg/kg of body weight applies to iron from all sources (JECFA, 2005). Iron is an essential part of the haemoglobin in human blood, it is also found in the myoglobin of muscle cells. Iron is needed for transporting oxygen and carbon dioxide. Its' deficiency in humans leads to anaemia while excess of iron beyond 48mg/day have critical gastrointestinal side effects (Driskell, 2009). Impaired zinc absorption, vascular disease and cancer and systemic iron overload may be associated with iron toxicity in human body. Iron accumulation was highest in *Gongronema latifolia* (8.97mg/kg) and lowest in *Heinsia crinata* (4.69mg/kg). Iron concentration values obtained for all the forest leafy vegetables in the study were below the upper level daily intake for adults (48mg/day). Presence of chelators such as ascorbic acid and oxalate has been reported to reduce iron absorption in human meals (Aboderin *et al*., 2010). Although, commonly consumed forest leafy vegetables in this study contributes to sources of iron in human diets, other sources of iron are required to meet the minimum daily requirements for proper healthy living.

Manganese (Mn) is crucial and very important in human physiology, it is essential for haemoglobin formation. However, quantity of Manganese requirement in the body is small compared to iron; daily requirement for healthy living is 4.5mg (Sekeroglu *et al*., 2006). FLVs results showed highest concentration of Manganese in *Liasanthera africana* (6.03mg/kg) which is below the tolerable daily intake of 12mg/day. All the FLVs showed lower levels of Manganese below the allowable daily intake.

Leafy vegetables from open field have been documented to possess higher concentrations of Lead (Pb) than vegetables grown in green houses (Song *et al*., 2009). About 50% of Pb intake by man comes from drinking water due to its high solubility in water ((Singh and Kumar, 2006). Plants absorb Pb from deposits on the leaves and other exposed parts to polluted environments, vegetables such as carrot and cabbage was observed to take up Lead and Cadmium in contaminated soils from irrigation water in Ghana (Mensah *et al*., 2008). Pb posed high health risk to man especially infants and young children; there is no established health benefit of Pb in human body. Young children up to six years and pregnant women face adverse health effects from Pb while it is capable of increasing blood pressure and possibly ignite cancer in adults (Khanna and Khanna, 2011; Satsananan, 2014). High gastrointestinal uptake and permeable blood-brain barrier have been documented to predispose children to lead and some other heavy metals exposure, consequently resulting in great health risk (Jarup, 2003). JECFA recommended provisional tolerable weekly intake 25 µg/kg of body weight (equivalent to 3.5 µg/kg of body weight per day) for infants and children and 0.005mg/kg body weight per day in adults. Permissible total daily intake (PTDI) of 3.57 (µg/(kg body weight per day) suggested for lead (FAO/WHO, 2001) was higher than concentration levels in all the FLVs used in this study. Results from the present study showed that FLVs marketed in Port Harcourt, Nigeria do not pose health hazards to the consumers presently regarding associated health issues linked to lead contamination in forest vegetables.

Copper (Cu) is essential to human life as metalloproteins and function as enzymes, however, critical doses leads to health risks such as anemia, diabetes, inflammation, kidney and liver dysfunction and vitamin C deficiency (Lokeshappa *et al*., 2012). JECFA suggested safe limits of 40mg/kg in adults (FAO/WHO, 2001). Maximum copper levels in FLVs obtained in this study (Table 1) fall below the safe limits recommended, hence FLVs in the study area is safe for consumption without fear of illness associated with very high levels of copper in human food. Although toxicity of copper is rare, it's metabolism is enhanced by molybdenum and zinc constituents in the body. FLVs growers and collectors need avoid sourcing FLVs from environments and soils contaminated with molybdenum and zinc to reduce the intake of such trace elements and consequently reduce the concentration of copper available in the body.

Primary source of Cadmium (Cd) in human body is through consumption of food grown in contaminated areas and if taken over a relative long time can cause renal, prostrate and ovarian cancers (Turkdogan *et al.,* 2002). Cadmium accumulates primarily in the kidneys and has a long biological half-life in humans of 10-35 years. Critical cadmium level in the kidney of 200mg/kg is capable of causing renal failure in adults; however this condition occurs after a daily dietary intake of about 175 µg per person for 50 years. JECFA (2005) advised a permissible tolerable weekly intake (PTWI) of 0.007mg/kg of body weight. The provisional tolerable weekly intake (PTWI) of 7 µg/kg of body weight was suggested.

Table 1 revealed that samples of all the FLVs contained lesser concentrations of cadmium compared to the PTWI of 7µg/kg, maximum level of cadmium was obtained in *Heinsia crinata* (0.076ppm) and the least in *Ocimum gratissimum* (0.022ppm) this indicate safety in the consumption of the FLVs despite oil explorations in the study area.

Arsenic (As) is not known as an essential elements in man, however regulated quantities may be added to animal feeds for improved growth in pigs and poultry. Large quantities of Arsenic compounds can cause food poisoning in man. Satsananan, (2014) noted that arsenic contamination can harm food digestion and blood vessels system, central nerves system and spinal cord, causing red blood cell damage, it is also implicated for liver damage and could pose risk of cancer to lung and kidney. Morrison *et al*., (1989) and Yost *et al*., (2004) asserted that inorganic Arsenic compounds (III and IV) are far more toxic and potent human carcinogen than organic Arsenic compounds. Maximum permissible limits in dietary components range between 0.025 to 0.033mg/kg body weight (FAO/WHO, 1967) and permissible tolerable weekly intake (PTWI) of 0.015mg/kg body weight for adult (JECFA, 2005). Concentrations of arsenic in FLVs in this study were lower than the maximum permissible limits in all the samples except *P.guineense and O.bassilicum* which their concentrations were 0.025mg/kg and 0.015mg/kg respectively. Excessive consumption of these two FLVs may expose populations in Port Harcourt to health risks from arsenic.

Cobalt (Co) induces a rise in hemoglobin in anemic patients with nephritis, cancer and chronic infections. Normal daily intake of Co is reported to be in the range of 2.5 to 3.0 µg/day. Results showed concentrations within safe daily intake limits, implying no toxicological hazard expected from cobalt on the consumers of FLVs.

Mercury (Hg) has been implicated for abnormalities in children (Gibb and Chen, 1989). Mercury is a cumulative poison and serves no essential function in man. Alfred *et al*., (2004) reported long term exposure could cause renal dysfunction and neurological symptoms in people working in environment polluted with mercury beyond 0.1mg/m^3. Mercury causes poor reproductive capacity, hypertension, tumour and hepatic dysfunction (Iwegbue, 2010). Permissible tolerable weekly intake suggested by WHO (1993) is 0.5mg/kg body weight, none of the values obtained for FLVs in Table 1 is up to the weekly intake allowed for mercury.

Zinc (Zn) is readily absorbed by plants from polluted environments which are subsequently eaten by man. It is an essential element for living organisms for its involvement in a large number of enzymes and stabilizing molecular structures of membranes (WHO, 1996). It participates in the synthesis and metabolism of lipids, carbohydrates and proteins. Zn has the capability to interfere with metabolism of other metals such as Copper (Cu). Salgueiro *et al.,* (2000) and Odebunmi *et al*., (2004) hinted that high concentration of Zn may be carcinogenic and capable of causing vascular shock, dyspeptic nausea, pancreatitis, damage of hepatic parenchyma among other ailments in man and animals. Hambidge, (1987) noted Zn deficiency could lead to stunted growth in humans and delay in sexual maturation. (EVM, 2003) suggested safe upper limit (SUL) for Zn as 4.2 mg/day (equivalent to 700 µg/kg body weight/day in a 60 kg adult) for total dietary intake while WHO (1993) recommended 50mg/kg as permissible tolerable weekly intake. Considering the zinc concentration in FLVs assessed in Table 1, the FLVs could be adjudged to be safe for consumption and free of toxicological threat from zinc compounds.

Table 1: Heavy Metals concentration (ppm) in local forest leafy vegetables in Port Harcourt, Nigeria

Leafy vegetables species	Fe	Mn	Mg	Pb	Cu	Cd	As	Co	Hg	Zn	Cr	Se	Ni
*Ocimum gratissimum (L.)*Lamiaceae	8.87	0.45	1.630	0.725	0.218	0.022	0.003	0.343	0.002	0.044	1.473	0.028	0.416
*Ocimum bassilicum (L.)*Lamiaceae	7.63	0.50	1.308	0.380	0.970	0.032	0.015	0.118	0.014	0.055	2.615	0.061	0.665
Pterocarpus soyauxii(Jacq.) Fabaceae	6.72	0.74	0.805	0.777	0.375	0.028	0.009	0.197	0.005	0.053	1.464	0.024	0.527
Piper guineense(L.) Piperaceae	5.80	0.54	1.235	1.004	0.936	0.025	0.025	0.180	0.017	0.068	3.792	0.033	0.614
Gongronema latifolia (Benth.) Asclepiadaceae	8.97	4.29	1.556	0.648	0.718	0.056	0.006	0.091	0.008	0.046	1.959	0.021	0.388
Liasanthera africana (P. Beauv.) Icacinaceae	7.18	6.03	0.609	0.603	0.629	0.057	0.008	0.104	0.013	0.057	2.106	0.049	0.496
Heinsia crinata (Afzel.) Rubiaceae	4.69	1.08	1.321	0.468	1.165	0.076	0.012	0.097	0.009	0.061	0.409	0.066	0.516
Gnetum africana (Welw.) Gnetaceae	6.88	4.05	1.330	0.172	0.995	0.058	0.008	0.058	0.01	0.045	3.743	0.053	0.519

Chromium (III) is an essential element for healthy growth while Chromium (VI) compounds are toxics and carcinogenic in humans. Elevated levels can lead to asthma and shortness of breath while long term exposure damage the liver and kidney. Recommended Daily Allowances for chromium as 50–200 µg/day for adult men and women. Chromium levels in the FLVs are below the recommended value, this makes them a healthy food for normal growth and development. Nickel is essential for growth and reproduction in livestock and man, but could be carcinogenic in high amount in the body. Estimated maximum guideline set by USFDA for Nickel is 70-80 µg g^{-1} (Iwegbue, 2010). FLVs sold in Port Harcourt have lower levels of Nickel concentration compared to the USFDA recommended levels.

FLVs proximate composition is reflected in Table 2, FLVs are rich in crude protein, fat and crude fibre. *O.bassilicum* (21.00%) was richest in crude protein while *H.crinata* has the lowest level (11.55%), these levels competes favourably with protein content of some commercial fruits in India (Seal, 2011). Crude fibre content of the FLVs range between 11.0% to 14.0% for *O.bassilicum, P.soyauxii, G latifolia G.africana and O.gratissimum* respectively while fat content range between 2.4% for *O.bassilicum* and 4.0% for *H. crinata.* High ash content value is an index of the FLVs richness in minerals. Wild plants provide adequate level of nutrition to people in developing countries where there is high cost and poor living standard. The under - utilized wild FLVs have high nutritive potential and provide variety to our diets, (Pradheep *et al*., 2003). FLV species yield substantial fibre content which has the potential to enhance healthy living by reducing plasma and liver cholesterol concentration. Dietary fibres also help detoxify poisonous metals (Cohn and Cohn, 1996) while adequate protein promotes healthy living. The nutritional contents of FLVs samples were higher than many commercially cultivated leafy vegetables in Lagos and Osun states, Nigeria and compared to cultivated leafy vegetables in Côte D'ivoire (Onwordi *et al*., 2009; Adeleke and Abiodun, 2010; Oulai *et al*., 2014). Mg, Se and Ni concentrations were all within the safe limits.

Table 2: Proximate Composition (%) of local forest leafy vegetables FLVs in Port Harcourt, Nigeria

Leafy Vegetable species (LFVs)	% Crude Protein	% Ash	% Fat	% Crude Fibre	% Dry matter
*Ocimum gratissimum (L.)*Lamiaceae	18.55	16.00	3.00	14.00	87.38
*Ocimum bassilicum (L.)*Lamiaceae	21.00	26.00	2.40	11.00	87.91
Pterocarpus soyauxii (Jacq.) Fabaceae	17.50	9.00	3.00	11.50	88.59
Piper guineense (L.) Piperaceae	15.75	18.00	3.00	12.40	88.44
Gongronema latifolia (Benth.) Asclepiadaceae	19.25	18.00	3.00	11.00	87.53
Liasanthera africana (P. Beauv.) Icacinaceae	17.85	12.00	3.00	13.00	87.62
Heinsia crinata (Afzel.) Rubiaceae	11.55	8.00	4.00	12.00	89.71
Gnetum africana (Welw.) Gnetaceae	18.20	9.00	3.50	11.00	88.45

Conclusion

Various studies globally have linked excessive bio-accumulation of heavy metals to numerous health abnormalities. Heavy metal contamination in the natural environment poses both short and long term environmental health risks. Leafy vegetables produced in open-fields or with contaminated irrigation waters are known to possess high concentration of heavy metals that pose high risk for healthy living. This work revealed that consumption of FLVs sourced from natural forests in crude oil exploration areas in Nigeria is still safe, since heavy metal accumulation of FLVs samples were not up to safe limits recommended by FAO/WHO. Proximate analyses showed that the FLVs possess useful nutritional contents required for healthy growth such as crude protein and fibre. Integration of selected species of FLVs in agro-forestry fields could be a panacea for sustainable food security in developing countries facing food insecurities such as Nigeria.

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