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Selected Trace Metal Evaluation of raw and Commercially Processed Spices Sold in Several Municipal Markets in Benin City, Southern Nigeria

Emejulu, M.J[a*]., Amaechi, C. F[a]. and Obayagbona O. N[a]

[a]Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City, 300001, Nigeria

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Abstract

This study evaluated the trace metal profiles of fourteen (14) different spices collected from four (4) markets; Oba market, Uselu market, New Benin market and Ekiosa market, all located in Benin City. The collected spices were; Spice A; Shallot™, Spice B; Benny™, Spice C; Mivina™, Spice D; Knorr™, Spice E; Kitchen Glory™ , Spice F ; Onga™, African Locust Bean (Parkia biglobosa), Garlic (Allium sativum), Uziza (Piper guineense), Nutmeg (Myristica fragrans), Scent leaf (Ocimum gratissimum), Ginger (Zingiber officinale) and Negro pepper (Xylopia aethiopica) respectively. Trace metal analysis was conducted using wet digestion and flame atomic absorbance spectrophotometry procedures respectively. The Zn, Cu and Ni values of the examined spices varied from 0.12 mg/kg to 1.03 mg/kg, 0.30 mg/kg to 1.50 mg/kg and 0.00 mg/kg to 0.70 mg/kg. All the mean trace metal values detected in the spices were below the World Health Organization (WHO) maximum permissible limit (MPL). Pb and Cr estimated daily intake (EDI) values ranged from 0.000 mg/kg/day to 0.216 mg/kg/day and 0.056 mg/kg/day to 0.148 mg/kg/day respectively. The examined spices with regards to trace metal contamination are safe for human culinary utilization as the mean trace metal profiles of the all the examined spices was relatively low and met the WHO recommended limits.

1. Introduction

Spices have been described as dried parts of plants, utilized with the purpose of improving several organoleptic attributes of food which include; aroma, colour, palatability and acceptability [1]. Several authors have documented the impressive antimicrobial, anti-diabetic, anti-inflammatory, antioxidant and anti-hypertensive potentials of commonly utilized spices [2] [3]. Culinary utilization of natural spices in Nigeria has been attributed to rural populace although various local spices are known to have ethnic and regional peculiarities, which could be attributed to the usage of different preparation methods [3]. Due to their plant origin, spices have been described as a potential link in the environmental transfer of organic or inorganic contaminants and trace metals to humans through the food chain [3]. Trace metal contamination of these spices can easily occur either through the soil or in the form of aerial depositions in the course of sun drying these plant parts either on the ground or on roof tops [3]. Several authors have opined that the evaluation and monitoring of trace metal profiles in crops and other foods should be regarded as very critical activity in the protection of the populace from the public health risks linked with the ingestion of trace metal tainted foods [4] [5]. Some of these trace metals; Fe, Zn, Cu, Cr and Co are known to serve as essential micro nutrients and regarded to be toxic only at elevated amounts, while Pb and Cd do not possess any documented beneficial attributes and as such are considered to be exclusively toxic [6] [7]. At high concentrations, all elements could become detrimental to organisms [7]. There are variations in the trace metal compositions with regards to specific plants and these variations are known to be significantly dependent on several factors which include; fertilization, edaphic parameters and climate [4] [8]. [1] stated that the addition of possibly trace metal contaminated spices to food may culminate in the bio-accumulation of these metals in human organs.

This study seeks to assess the trace metal levels present in raw and commercial prepared spices sold in some municipal markets within Benin City, Edo State, Nigeria.

2. Methodology

2.1. Sample collection

A total of fourteen (14) different spice samples were randomly chosen and purchased from four (4) markets; Oba market, Uselu market, New Benin market and Ekiosa market, all located in Benin City. Each of the samples were collected in duplicates from the respective vendors from each of the market. This was after preliminary investigations which comprised of oral interviews of the spice retail sellers which revealed that these purchased spices were amongst the most commonly consumed by municipal residents.

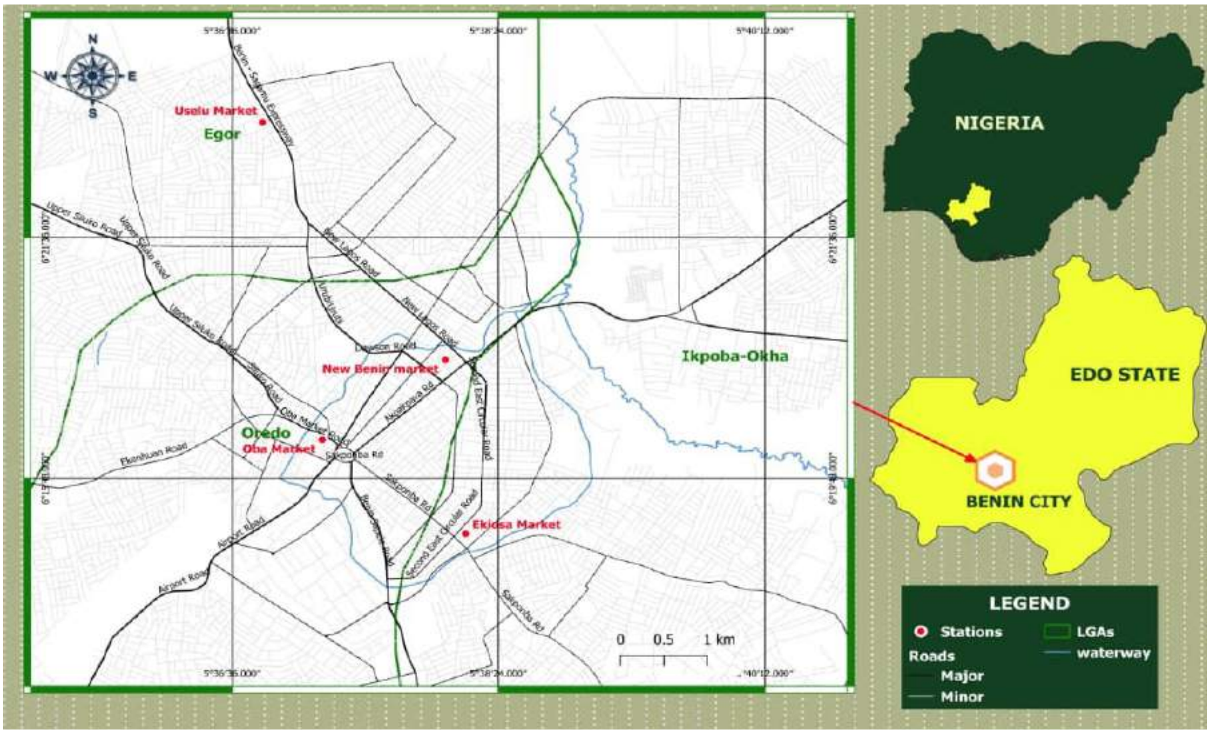

Fig. 1: Municipal map indicating the market locations where the spices were collected

2.2. Sample preparation

Seven (7) of the spice samples collected were raw plant specimens. These samples were; African Locust Bean (*Parkia biglobosa*), Garlic (*Allium sativum*), Uziza (*Piper guineense*), Nutmeg (*Myristica fragrans*), Scent leaf (*Ocimum gratissimum*), Ginger (*Zingiber officinale*) and Negro pepper (*Xylopia aethiopica*) respectively. The identity of the seven commercially prepared spices is shown in Table 1.

Table 1: List of coded commercially available spices collected from the respective markets

Code Label	Trade mark brand name
Spice A	Shallot™
Spice B	Benny™
Spice C	Mivina™
Spice D	Knorr™
Spice E	Kitchen Glory™
Spice F	Onga™
Spice G	Ducros™ (curry powder)

Prior to analysis, each of the raw plant spice was thoroughly rinsed with water and deionized water respectively. The spice samples were then air dried and oven dried at 80^{o}C until constant weight. The dried spices were then macerated into fine particles and preserved in sterile labeled polyethylene bags .

2.3. Spice digestion and heavy metal analysis

Sample digestion and trace metal analysis was conducted using wet digestion as described by Gaya and Ikechukwu [9] and flame atomic absorbance spectrophotometry respectively. About 1g of dry spice powder was weighed and dispensed onto sterile beakers. About 20 cm^3 of 2:1 HNO_3/$HClO_4$ mixture was added and the mixture was subjected to heating inside a fume cupboard for 5-10 min with the aid of an electric hot plate. The acid digests upon cooling were diluted with deionized water, and filtered into clean volumetric flasks. Calibration standards as well as blank were prepared at the same time as the samples. The filtrate emanating from the acid digests were subsequently analyzed for Pb, Cu, Fe, Cd, Zn, Cr and Ni using a Buck Scientific model 210 flame atomic absorption spectrophotometer (AAS) (VGP, USA). Standards were analyzed accordingly but devoid of the spice digest. Exact trace metal concentrations were extrapolated from calibration curves.

2.4. Human health risk assessment

The health risk linked directly with the dietary consumption of the spices was calculated based on daily intake as estimated daily intake (EDI). This parameter was derived on an assumed basis of 10 g of raw spice per 60 kg human body weight as described by Gaya and Ikechukwu [9].

$$EDI = \frac{(C*AC)}{bw} \quad (1)$$

Where;
C (mg/kg): amount of trace metals in the spice sample

AC :average dry weight of the spice ingested by local residents based on g/day/person and;

bw :average human adult body weight (60g)

3. Results and Discussion

Table 2: Mean trace metal concentrations (mg/kg) of the spice samples

Commercially available spices	Cd	Zn	Cu	Ni	Pb	Cr	Fe
Spice A	0.10	0.18	1.20	0.00	0.30	0.71	2.30
Spice B	0.00	0.19	0.90	0.10	0.40	0.39	1.50
Spice C	0.00	0.25	0.90	0.10	0.10	0.55	4.60
Spice D	0.00	0.15	0.60	0.10	0.00	0.51	6.80
Spice E	0.00	0.12	0.60	0.10	0.50	0.69	0.90
Spice F	0.10	0.16	0.30	0.10	1.30	0.76	4.10
Spice G	0.00	0.42	1.50	0.20	0.30	0.89	3.20
Unprocessed spices	**Cd**	**Zn**	**Cu**	**Ni**	**Pb**	**Cr**	**Fe**
African Locust bean	0.00	1.03	1.20	0.20	0.50	0.34	4.70
Nutmeg	0.00	0.21	0.90	0.30	0.10	0.59	1.30
Uziza	0.00	0.15	0.60	0.30	0.10	0.64	4.30
Ginger	0.00	0.13	0.30	0.70	0.30	0.34	8.20
Garlic	0.00	0.26	0.60	0.50	0.50	0.88	11.80
Negro pepper	0.00	0.22	1.20	0.90	0.20	0.62	7.40
Scent Leaf	0.00	0.25	1.50	0.40	0.30	0.81	4.20
WHO MPL (mg/kg)	**0.3**	**100**	**50**	**50**	**10**	**NA**	**300**

.**KEY**
WHO MPL = World Health Organization maximum permissible limit

Table 3: Estimated Daily intake (EDI) concentration of each spice for the respective metals (mg/kg/day), on an presumed amount of spice (10g) ingested by 60kg human body weight

Commercially available spices	Cd	Zn	Cu	Ni	Pb	Cr	Fe
Spice A	0.016	0.030	0.200	0.000	0.050	0.118	0.383
Spice B	0.000	0.032	0.150	0.016	0.066	0.065	0.250
Spice C	0.000	0.042	0.150	0.016	0.016	0.091	0.766
Spice D	0.000	0.025	0.100	0.016	0.000	0.085	1.133
Spice E	0.000	0.020	0.100	0.016	0.083	0.115	0.150
Spice F	0.016	0.027	0.050	0.016	0.216	0.126	0.683
Spice G	0.000	0.070	0.250	0.033	0.050	0.148	0.533

Unprocessed spices							
African Locust bean	0.000	0.172	0.200	0.033	0.083	0.056	0.783
Nutmeg	0.000	0.035	0.150	0.050	0.016	0.098	0.216
Uziza	0.000	0.025	0.100	0.050	0.016	0.106	0.716
Ginger	0.000	0.022	0.050	0.116	0.050	0.056	1.366
Garlic	0.000	0.043	0.100	0.083	0.083	0.146	1.966
Negro pepper	0.000	0.037	0.200	0.150	0.033	0.103	1.233
Scent Leaf	0.000	0.042	0.250	0.066	0.050	0.135	0.700
WHO MPL (mg/kg)	**20×10^{-5}**	**300×10^{-3}**	**10×10^{-3}**	**50×10^{-4}**	**2×10^{-4}**	**25×10^{-5}**	**70×10^{-2}**

KEY

WHO MRL = World Health Organization maximum daily recommended level

The Cd content of the spices was very low with only spice F having a value of 0.10 mg/kg. The mean Cd concentration detected in all the sampled spices was very low and below the WHO limit (Table 2). This trend contrasted with an earlier report by Gaya and Ikechukwu [9] which recorded high Cd concentrations in spices and attributed the phenomenon to type of agricultural practices, and calcareous nature of certain soils. The Zn value of the examined spices varied from 0.12 mg/kg for spice E to 1.03 mg/kg for African locust bean (Table 2). Mean Zn concentrations in the spices were observed to be generally below the WHO maximum permissible limit (MPL) (Table 2). It therefore does not pose a health threat to end consumers. Zn has been described as a cofactor of over two hundred (200) enzymes which participate in several metabolic pathways but elevated Zn concentrations in the human body can be toxic due to its ability to interfere with Cu metabolism [3]. The Cu content of the respective spices ranged from 0.30 mg/kg for spice F and ginger to 1.50 mg/kg for spice G and scent leaf respectively (Table 2). The Cu concentrations detected in the respective spices were below WHO (MPL) (Table 2). The range of mean Cu values recorded for the examined spices contrasted with values reported by Ibrahim *et al.* [10] with respect to popular spices and herbs collected from local markets in Erbil, Iraq. Ibrahim *et al.* [10] opined the Cu dietary intake from spices had no harmful health effect when consumed in trace levels but can be toxic at high concentrations. The Ni spice associated content varied from 0.00 mg/kg for spice A to 0.70 mg/kg for ginger (Table 2). Mean Ni values for the respective spices were below the WHO (MPL) (Table 2). High Ni concentrations in the human body have been linked with Ni substitution of other metals presently in metal dependent enzymes culminating in altered protein function [11]. Mean Pb content of the spices ranged from 0.00 mg/kg for spice D to 1.30 mg/kg for spice F (Table 2). Mean Pb concentrations recorded for the respective spices were also below the WHO (MPL) (Table 2).The very low mean Pb readings recorded for the respective sampled spices were in disagreement with high mean Pb values reported by Gaya and Ikechukwu [9] with respect to about several spices collected from a municipal market located in Kano, Northern Nigeria. Mubeen *et al.* [1] described Pb as a poisonous trace metal which can form complexes with enzyme bound oxo-groups which can significantly impact all stages in hemoglobin synthesis and porphyrin metabolism respectively. [3] further stated that Pb had no known biological function and was documented to be toxic at amounts as low as 10µg/kg.

The Cr spice associated content varied from 0.34 mg/kg for African locust bean and ginger to 0.89 mg/kg for spice G (Table 2). The Fe value of the spices ranged from 1.30 mg/kg for nutmeg to 11.80 mg/kg for garlic respectively (Table 2). Spice associated Fe levels were comparatively lower than the WHO (MPL) (Table 2). [1] opined that intake of Fe present in spices had no negative impact on human health. Comparatively, the EDI intake level of dietary Fe was higher for some of the raw spices; Garlic, ginger and negro pepper (Table 3). This trend could be of benefit to end consumers based on the fact that the metal is an essential trace metal. Fe is known to serve as a constituent of several reproductive hydrogenases active sites and in conjunction with heamoglobin and ferrodoxin, the metal is known to play a critical metabolic role [1].

The Cd derived EDI on an assumed daily food intake of 10g for spice F was 0.016 mg/kg/day (Table 3). The EDI with respect to Zn ranged from 0.022 mg/kg/day for ginger to 0.172 mg/kg/day for African locust bean (Table 3). All the Zn EDI values were below WHO MRL with respect to all the examined spices (Table 3). Cu EDI ranged from 0.050 mg/kg/day for ginger and spice F to 0.250 mg/kg/day for scent leaf and spice G respectively (Table 3). The Ni associated EDI on an assumed daily food intake of 10 g varied from 0.000 mg/kg/day for spice A to 0.116 mg/kg/day for ginger (Table 3).The Pb EDI ranged from 0.000 mg/kg/day for spice D to 0.216 mg/kg/day for spice F (Table 3). The EDI with respect to Cr ranged from 0.056 mg/kg/day for African locust bean to 0.148 mg/kg/day for spice G (Table 3). Fe EDI ranged from 0.216 mg/kg/day for nutmeg to 1.966 mg/kg/day for garlic (Table 3). The estimated daily intake (EDI) values of spices sampled revealed that the Cu and Ni concentrations were above the recommended daily intake of 0.01mg/kg day and 0.005mg/kg day as recommended by the WHO except for Spice A with respect to Ni (Table 3). The Cd EDI values documented for most of the spices was lower than the WHO recommended level (0.0002mg/kg/day) (Table 3).

4. Conclusion

The mean distribution of the spice bound trace metals indicated that Fe had the maximal concentration followed by Cu > Cr > Pb > Ni > Zn > Cd respectively. Generally, raw spices contained higher trace metal concentrates in comparison to the levels detected in the commercially available spices. All the raw and processed spices with regards to trace metal contamination are safe for anthropogenic culinary utilization as the mean trace metal profiles of the all the examined spices was relatively low and met the WHO recommended limits.

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