

Chemical Perspectives on Some Readily Consumed Spices and Food Condiments: A Review

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Abstract
Social changes, including food diversification, the desire for new flavours, increasing importance of “ethnic” food and the increased importance of processed food, which requires condiments and aromatic herbs for its preparation, are driving an increase in the demand for spices and food condiments. In recent years, there has been growing interests in monitoring heavy metal contamination of spices and food condiments. Research results on heavy metal contamination of spices in selected countries (Nigeria, Ghana, and Saudi-Arabia) were closely studied. The concentrations of lead, zinc, nickel, copper, iron, and mercury in some common spices available at local markets in these countries were determined using Atomic Absorption Spectroscopy (AAS). The heavy metal levels in Ghana spices were acceptable, except for lead which was above the standard limit approved by World Health Organization (WHO) and FAO for some of the samples. Consumers of these spices would not be exposed to any risk associated with the daily intake of 10 g of spices per day for zinc, nickel, copper, iron and mercury. In Nigeria, the levels of lead and cadmium in the samples were generally low and below detection limit < 0.22 µg/g and demand periodic surveillance to avoid contamination.
Keywords: trace metals, spices, food condiments

1. Introduction

According to Hirasa and Takemasu (1998) and the International Spice Group (Sivaraman & Peter, 1999), 'spice' can be defined as the dry part of a plant such as roots, leaves and seeds, which impart to food a certain flavour and pungent stimuli. By clubbing spices and condiments into one group the International Organization for Standardization (ISO) illustrated that the term spice or condiment applies to "such natural plant or vegetable products or mixtures or thereof, in whole or ground form, as are used for imparting flavour, aroma and piquancy to and for seasoning food" (Manay and Shadaksharaswami,1997). Condiments are prepared food compounds containing one or more spices, or spice extracts, which when added to a food, after it has been served, enhance the flavour of the food (Farrell, 1985). Condiments can be either simple (e.g. celery salt, garlic salt, onion salt) or compound (chilli sauce, chutney, meat sauce, mint sauce, prepared mustard, etc.).

Spices are being used as diet components often to improve color, aroma, palatability and acceptability of food. Most people love spices of one kind or another, from the basic salt and pepper to cayenne, crayfish, etc. Spices are among the most versatile and widely used ingredients in food processing. As well as their traditional role in food flavouring and colouring, they are increasingly used as natural preservatives in active packaging (Seyidim and Sarikus, 2006; Mubeen *et al.* 2009). Spices have played an important role in the history of civilization, exploration and, commerce as these had a universal acceptance as condiments and flavours in human diet as well as in treatment of ailments. There are evidences of plant derived aromatic compounds especially spices being used by almost all ancient civilizations - the Indian, the Egyptian, the Babylonian, the Persian, the Jews, the Chinese, the Greek, and the Roman (Bakhru, 1992). A notable use of spices and herbs in very early times were in medicine in the making of holy oils and unguents, and as aphrodisiacs (Hemphill, 2000).

Many common spices have outstanding antimicrobial effects. On the other hand, the process of preparation and handling can make them a source of food poisoning (Sherman and Billing, 1998). Moreover, in the last three decades, mainly because of their medicinal values, the use of spices and other herbs have increased markedly in most regions of the world, including Europe and North America. For instance, during this period, herbal medication in the USA has grown into an industry worth an average of $1.5 billion per year, with projected annual growth of 15% (Abebe, 2006).

1.1 Heavy Metals in Spices

Scientific studies since the 1970s have determined varying amounts of trace metals in different spices (Al-Eed *et al.* 1997). The average amount of metal found in a spice can vary from spice to spice or location of where the spices are produced. Natural food spices such as pepper and mustard have been reported to contain significant quantities of some trace metals (Gupta *et al*., 2003). The presence of essential metals like iron, copper, nickel and zinc are very useful for the healthy growth of the body though, very high levels are intolerable. Metals like mercury, lead, cadmium etc are toxic at very low concentrations. Their presence in spices and/ or condiments is a major concern. The addition of spices that may be contaminated with trace and heavy metals to food as a habit may result in accumulation of these metals in human body organs and lead to different health troubles (Al-Ed *et al.,* 1997). There is often little information available about the safety of those plants and their products in respect to heavy metal contamination. Due to the significant amount of spices consumed, it is important to know the toxic metal contents in these spices (Choudhury and Garg, 2007).

Trace metals in spices and medicinal plants play vital roles as structural and functional components of metalloproteins and enzymes in living cells (Ansari *et al.* 2004). Food composition data is important in nutritional planning and provides invaluable information for epidemiological studies (Bruce and Bergstrom, 1983). Even though spices have many benefits, they can also contain some toxic chemicals derived from the environment of their production, processing and storage conditions (Krejpcio *et al.,* 2007). For instance, zinc is a metal with great nutritional importance and is particularly necessary in cellular replication and the development of the immune response (Salgueiro *et al.,* 2002); and is a cofactor of over 200 enzymes involved in metabolic pathways, but its high levels in human body can be toxic due to its interference with copper metabolism (Uruj – Adams and Keen, 2005). Therefore, dietary zinc intake should be appropriate. Similarly, iron plays an essential role in many metabolic processes including oxygen transport, oxidative metabolism, and cellular growth. In human beings, it is absorbed primarily in the duodenum, transported through the blood stream and extracellular fluid bound to transferring, and stored intracellularly predominantly in the form of ferritin (Lynch, 1997).

Environmental pollution is the main cause of heavy metal contamination in the food chain and lead (Pb), cadmium (Cd), chromium (Cr),copper (Cu), and cobalt (Co) are potentially harmful metals that have aroused considerable concern (Cabrera *et al.* 2003). These metals may reach and contaminate plants, vegetables, fruits and canned foods through air, water and soil during industrial processing and packaging (Ozores *et al.* 1997). Exposure to trace and heavy metals above the permissible level affects human health and may result in illness to human fetus, abortion and preterm labor, as well as mental retardation to children, among others. Adults also may experience high blood pressure, fatigue kidney and neurological disorders (Mubeen *et al.,* 2009). The study of trace metals in the food chain is crucial because they have potential hazardous effects. Spices and food condiments are readily consumed in large amounts in different countries. Trace element food composition data are important for both consumers and health professionals. What then is the toxic metal level of these food additives?

2.0 The Chemical Nature of Spices

2.1 Composition of Spices

Spices are storehouses of many chemically active compounds that impart flavour, fragrance and piquancy. Most spices owe their flavouring properties to volatile oils and in some cases, to fixed oils and small amount of resin, which are known as oleoresins. Phytochemicals in spices are secondary metabolites, which originated for protection from herbivorous insects, vertebrates, fungi, pathogen, and parasites. Most probably, no single compound is responsible for flavours; but a blend of different compounds such as alcohols, phenols, esters, terpenes, organic acids, resins, alkaloids, and sulphur containing compounds in various proportions produce the flavours (Manay and Shadaksharaswami, 1997). Beside these flavouring components, every spice contains the usual components such as proteins, carbohydrates, fiber, minerals, tannins or polyphenols.

Essential oils or extracts are also derived from these plant sources either as a primary processing or a secondary opportunity. Essential oils are liquid products of steam or water distillation of plant parts (leaves, stems, bark, seeds, fruits, roots and plant exudates). An essential oil may contain several hundred chemical compounds and this complex mixture of compounds gives the oil its characteristic fragrance and flavour. Essential oils have been extensively investigated for their activity against a number of storage fungi, plant and human pathogens, bacteria, insect, pests and other harmful microorganisms. Almost all essential oils of herbs and spices, whether individual components or mixtures, are highly inhibitory to select pathogenic and spoil-age microorganisms (Kalemba and Kunicka, 2003).

2.2 Proximate, Mineral and Phytochemical Analyses

Otunola *et al.* (2010) analyzed the proximate composition of garlic, ginger and pepper for protein, fat, fibre, ash moisture and carbohydrate (Table 1). Proximate analysis (Table 1) revealed that the three spices (garlic, ginger and pepper) can be ranked as carbohydrate rich due to their high calorie content. Though high in crude fat content, pepper may not be rated as an oil seed, however, the oil could be extracted for use as essential oil (Okwu and Nnamdi, 2008).

Table 1: Percent proximate composition of garlic, ginger and pepper

	Composition (%)		
Parameters	**Garlic**	**Ginger**	**Pepper**
Moisture	4.55 ± 0.11^c	6.37 ± 0.01^a	5.70 ± 0.15^b
Ash	4.08 ± 0.10^b	6.30 ± 0.13^a	4.35 ± 0.10^b
Crude protein	15.33 ± 0.01^a	8.58 ± 0.01^c	11.70 ± 0.13^b
Crude fat	0.72 ± 0.01^c	5.35 ± 0.13^b	12.70 ± 0.10^a
Crude fibre	2.10 ± 0.01^b	3.25 ± 0.13^a	2.61 ± 0.01^b
*Carbohydrate	73.22 ± 0.01^a	68.15 ± 0.01^b	62.94 ± 0.01^c

Values are mean ± SD of 3 determinations. a – c Test values along the same row carrying different superscripts for each parameter are significantly different ($p < 0.05$). *calculated by difference.
Source: Otunola *et al.* (2010).

The high crude protein content of garlic and pepper may be due to the presence of active proteinous metabolites such as allicin, ajoene and capsaicin. According to Dashak *et al.* (2001), normal daily protein requirement for a normal adult is 45 – 50 g. Therefore, these spices could serve as supplements since they are usually combined in human main dishes. Low ash is usually an indication of low inorganic mineral content (Oloyede, 2005).
The mineral analysis by Okalebo *et al*. (2002) using Atomic Absorption Spectrophotometer (Pye Unican Sp9, Cambridge, UK.) is shown in Table 2.

Table 2: Mineral composition of garlic, ginger and pepper

	Composition (mg/100 g)		
Mineral	**Garlic**	**Ginger**	**Pepper**
Sodium	4.10 ± 0.14^b	5.00 ± 0.35^a	4.50 ± 0.00^b
Calcium	26.30 ± 0.14^a	25.76 ± 0.28^b	23.45 ± 0.00^c
Iron	5.29 ± 0.08^a	3.46 ± 0.28^b	3.39 ± 0.15^b
Phosphorous	10.19 ± 0.26^b	12.56 ± 0.21^a	9.89 ± 0.08^b
Potassium	54.00 ± 1.40^c	215.00 ± 1.06^b	229.00 ± 0.71^a
Zinc	0.34 ± 0.17^a	0.04 ± 0.00^b	0.02 ± 0.00^b
Copper	0.001 ± 0.00^a	0.001 ± 0.00^a	0.001 ± 0.00^a
Manganese	0.001 ± 0.00^a	0.002 ± 0.00^a	0.002 ± 0.00^a
Magnesium	4.10 ± 0.14^b	5.00 ± 0.35^a	4.50 ± 0.00^b
K/Na	13.17 ± 10.00	43.00 ± 3.03	50.89 ± 0.00

Values are mean ± SD of 3 determinations. a – c Test values along the same row carrying different superscripts for each parameter are significantly different ($p < 0.05$). **Source:** Otunola *et al.* (2010).

However, the mineral analysis of the three spices indicated their richness in sodium, calcium, potassium, iron, zinc, copper, manganese, phosphorous and magnesium (Table 2). The level of Ca and Fe in garlic was markedly higher than that of ginger and pepper, while the values for Na and P were significantly higher for ginger. Pepper had higher K content when compared with garlic and ginger; consequently, the highest K/Na of 51 mg/100g. A high K/Na is essential in the management of cardiovascular diseases. There was no significant difference in Zn, Cu and Mn values among the three spices, while Pb, Ca and Co was not detectable.
Phytochemicals are bioactive, non-nutrient, naturally occurring plant compounds found in vegetables, fruits and spices. Table 3 indicated that garlic, ginger and pepper are rich in phytochemicals. Pepper had a high content of carotenoids, flavonoids and saponins when compared with garlic and ginger. The tannin content in ginger was high compared to garlic and pepper. Saponin was present in trace amount in ginger, while pepper and garlic had an appreciable amount of the compound. Both pepper and ginger had significantly ($p < 0.05$) high contents of alkaloid, unlike garlic which had quite a low content.

Table 3: Percentage composition of phytochemicals in the spices

Phytochemicals	Composition (%) Garlic	Ginger	Pepper
Alkaloids	0.54 ± 0.00^{c}	11.21 ± 0.00^{b}	13.44 ± 0.02^{a}
Tannins	0.07 ± 0.00^{c}	3.54 ± 0.00^{a}	1.77 ± 0.02^{b}
Carotenoids (µg/100 g)	1.00 ± 0.00^{c}	0.64 ± 0.00^{b}	648.00 ± 2.86^{a}
Saponin	4.60 ± 0.03^{c}	0.80 ± 0.41^{c}	7.40 ± 2.86^{a}
Flavonoids	1.16 ± 0.01^{c}	5.56 ± 0.00^{b}	6.38 ± 0.01^{a}
Steroids	0.04 ± 0.00^{a}	0.04 ± 0.37^{a}	0.33 ± 0.02^{a}
Cardenolides	0.20 ± 0.00^{a}	0.02 ± 0.00^{a}	0.55 ± 0.00^{a}

Values are mean ± SD of 3 determinations. a – c Test values along the same row carrying different superscripts for each parameter are significantly different ($p < 0.05$). **Source**: Otunola *et al*. (2010).

Steroids and cardenolides were present in very low amounts in all the spices. When compared with the results of Etonihu *et al.* (2011) on the phytochemical screening of the crude methanolic extracts of leaves of *Citrus medica* and stem bark of *Parinari polyandra*, these spices lack cardiac glycosides, phenols and resins.
Lonkar *et al.* (2011) analyzed the physico-chemical composition of some spices which include coriander leaves, curry leaves, chilies and cumin for chemical constituents such as fat, protein, carbohydrate, crude fiber, ascorbic acid, ash and mineral content using standard procedures suggested by Ranganna (2001). The results in Table 4 showed that the coriander leaves were good source of vitamin C, calcium, total minerals, and crude fiber, but low in protein and fat. The data further revealed that curry leaves are good source of protein, calcium and crude fiber and fairly good source of iron and ascorbic acid but low in moisture content. The lower moisture content and higher total solids observed in curry is a tribute to its suitability for dehydration (Shakale *et al.,* 2007). Again, the green chilies were good source of minerals, ascorbic acid and crude fibers, but a poor source of protein and fat. The cumin seeds were good source of protein, fat, total minerals, calcium, iron and crude fiber. The increased physico-chemical constituents were observed due to the use of dried cumin seeds (Shammina, 2008).

Table 4: Physico-chemical composition of some spices and condiments

Constituent	Coriander Leaves	Curry Leaves	Green Chilies	Cumin Seeds
Moisture (%)	87.73 ± 0.41	64.74 ± 1.73	84.93 ± 0.56	14.42 ± 0.15
Protein (%)	3.9 ± 0.035	6.69 ± 0.226	3.2 ± 0.36	20.17 ± 0.042
Fat (%)	0.47 ± 0.019	0.96 ± 0.035	0.6 ± 0.06	17.93 ± 0.183
Total (%) Carbohydrate	5.8 ± 0.049	22.68 ± 0.183	3.6 ± 0.148	40.68 ± 0.077
Crude fiber (%)	2.06 ± 0.070	5.83 ± 0.070	7.2 ± 0.070	12.38 ± 0.106
Ash (%)	2.02 ± 0.084	4.69 ± 0.254	1.1 ± 0.012	6.8 ± 0.070
Calcium (mg/100g)	1.38 ± 0.707	82.5 ± 1.27	24.0 ± 0.70	9.31 ± 2.12
Iron (mg/100g)	1.89 ± 0.091	0.90 ± 0.070	1.6 ± 0.070	66.00 ± 1.34
Ascorbic acid (mg/100g)	118.20 ± 0.636	3.9 ± 0.04	113.0 ± 1.41	8.00 ± 0.98

Results are mean ± S.D of 3 determinations; **Source:** Lonkar *et al.* (2011)

Table 5 showed the percentage chemical composition of more spices.

Table 5: Percent chemical composition of cress, mustard, black cumin, fenugreek and black pepper and clove

Parameters	Cress	Mustard Black	Cumin	Fenugreek	Black Pepper	Clove
Moisture	2.88 ± 0.1	4.36 ± 0.1	2.55 ± 0.2	7.71 ± 0.2	4.68 ± 0.3	7.74 ± 0.2
Crude fat	23.19 ± 0.2	38.45 ± 0.5	31.95 ± 0.3	4.51 ± 0.2	5.34 ± 0.6	16.63 ± 0.32
Crude protein	24.19 ± 0.5	25.39 ± 0.3	20.61 ± 0.3	12.91 ± 0.4	25.45 ± 0.4	6.9 ± 0.45
Crude fiber	11.9 ± 0.4	6.36 ± 0.1	10.37 ± 0.1	13.14 ± 0.3	23.6 ± 0.3	11.47 ± 0.5
Ash	7.1 ± 0.1	4.25 ± 0.1	4.51 ± 0.1	4.23 ± 0.05	3.57 ± 0.1	5.96 ± 0.1
Total Carbohydrate**	30.74	21.19	30.01	57.5	37.36	51.3

*Means (n=3) ± SD; **Calculated by difference; **Source:** Lonkar *et al.* (2011).

The vitamin C contents of some fruits and fruit juices in Nigeria varied from 568 mg/L (for mango) to 363 mg/L (for pineapple). Likewise (mg/ 100g), kakadu plum (3100), camu camu (2800), black currant (200), red pepper (190), guava (100), strawberry (60), orange (500, lemon (40), garlic (30), water melon (10), banana and carrot (9) (Etonihu *et al.*, 2010). The results indicated that mustard, black cumin, and cress seeds had higher fat content of 38.45%, 31.95% and 23.19%, respectively when compared to clove (16.63%), black pepper (5.34%) and fenugreek (4.51%) seeds. It could be noticed that cress, mustard, black cumin and black pepper had higher protein content that ranged from 20.61% to 25.45%, as compared to fenugreek (12.9%) and clove (6.9%). Crude fiber and ash contents ranged from 6.36 to 23.6% and from 3.57% to 7.1%, respectively. The low percentage of moisture in cress and black cumin as compared to the others may increase the shelf life of these spices during packaging and storage and also limit fungal and contamination effects.

2.3 Volatile Constituents of some Food Spices and Condiments

Volatile compounds of three Nigerian food condiments (fermented melon *ogiri,* soybean *ogiri*, and locust bean *ogiri*) were identified quantitatively by comparing their retention times and mass spectra with those of the library (Onyenekwe *et al.,* 2012). Among the 57 volatiles (Table 6), aldehydes are the dominant constituent group and constitute over 50% of total volatiles in the locust and soybean ogiri and 35% of the volatiles in melon ogiri. On the contrary, Azokpota *et al.* (2008) found pyrazines as the dominant constituent group in *afitin, iru,* and *sonru*, three fermented soybean food condiments from Benin; likewise, Dajanta *et al.* (2011) reported the dominance of pyrazines in *Thua nao*, a traditional soy product of Thailand. Although the result of Onyenekwe *et al.* (2012) supported an earlier observation that pyrazine is the dominant volatile of African *soumbala* fermented by pure starter *Bacillus subtilis* while natural fermented product have greater aldehyde content. Pyrazines are the major volatile compounds in various fermented foods (Sugawara *et al.,*1985; Azokpota *et al*., 2010).

Carbonyl compounds such as aldehydes and alcohols have strong impact on odour because of their sensitivity to olfactory receptors (Grosch, 1982). Pyrazines especially, alkylpyrazines are known to have nutty aroma (Ho *et al.,* 1989) and could be generated naturally during the ageing process by the condensation of amino ketones formed through the Maillard reaction and Strecker degradation. The formation of pyrazine is associated with heating and metabolic activities of microorganisms (Owens *et al*.,1997).

Table 6: Percentage composition of the different classes of volatile constituents of some fermented food Condiments

S/N	Constituents	Ogiri (Melon seed)	Dadawa (Locust bean)	Dadawa (Soya bean)
1.	Aldehydes	35.10	52.66	57.74
2.	Alcohols	6.97	3.66	15.59
3.	Ketones	19.78	3.11	2.85
4.	Esters	2.80	1.28	4.02
5.	Pyrazines	16.53	17.51	2.69
6.	Alkanoic Acids	3.01	0.52	3.61
7.	Alkanes	1.51	1.22	3.45
8.	Alkenes	2.62	2.47	1.89
9.	Others	9.99	5.99	5.19

Source: Onyenekwe *et. al.* (2012)

Alcohols in the three products help to prevent spoillage. Hexanol has been reported to contribute to the greeny and musty odours of soybean products (Sugawara *et al*., 1985).

2.4 Trace Metals Levels of Some Spices and Food Condiments

The widespread contamination with heavy metals in the last decades has raised public and scientific interest due to their dangerous effects on human health. This has led researchers all over the world to study the pollution with heavy metals in air, water, and foods to avoid their harmful effects (Kennish, 1997) and to determine their permissibility for human consumption. In this vein, Nnorom *et al.* (2007) determined the trace metals level in some spices that represent the most widely used taste enhancers in Nigeria including bouillon cubes, curry powder, dried thyme, mixed spices, natural (unprocessed) spice, uziza (name in Igbo language of Nigeria) and table salt purchased from open market in Umuahia, Southern Nigeria using atomic absorption spectroscopy (Table 7). From the result the lead (Pb) content of the samples used in their research was generally below the detection limit of technique used (0.02 µg/g). Higher mean values were observed for iron (Fe) in the various sample groups compared to zinc (Zn) and cadmium (Cd). The very low levels of toxic metal, especially lead (Pb) in the sample indicated that these products meet the safe limits for toxic elements specified by most food standards. The relatively high level of the essential elements iron (Fe) and zinc (Zn) in their research corroborate the result of Onianwa *et al.* (1999) and reflects the normal composition expected of plant-derived products, which most of the samples are. Plant foods and plant derived foods contain iron in the form of metalloproteins, plant ferritins, iron present in the sap and iron complexed to structural components or storage compounds predominantly as phytates. In addition, food may contain contaminant inorganic iron salts such as ferric oxides and hydroxides or iron compounds added during processing to fortify the food (Lynch, 1997). The highest cadmium concentration was found in chicken seasoning (5.05 µg). The mean values of iron and zinc concentration of the various samples is in the order thyme > curry > beef seasoning > mixed spices > bouillon cubes (Table 7). Evidences from nutritional studies demonstrate the important role of micronutrients in the prevention of various diseases (Natera *et al.,* 2002). Low level of zinc and iron in common salt was observed in the analyzed sample. The Cd content of the salt sample (4.5 µg/g) may indicate contamination from the production, packaging or distribution of the product.

Table 7: Lead, Cadmium, iron and Zinc levels in spices and food condiments readily available in Nigeria

Sample	Metal Concentration (µg/g) Pb	Cd	Fe	Zn
Bouillon cubes	< 0.02	3.63±0.03* (3.63)‡ 3.60-3.65**	3.63±0.03* (6.37) 3.65-8.95	2.87±1.42 (2.64) 1.60-4.40
Chicken Seasoning	< 0.02	4.58±0.60 (4.56) 3.90 – 5.05	18.43± 12.36 (16.10) 11.05 – 32.70	3.02±0.68 (2.97) 3.00 – 3.70
Curry Powder	< 0.02	1.03 ± 0.93 (0.78) ND – 1.80	202.25 ± 150.94 (138.06) 32.35 – 320.85	21.22 ± 8.18 (20.17) 13.65 – 29.90
Beef Seasoning	< 0.02	2.83 ± 2.79 (2.02) 0.85 – 4.80	52.95 ± 28.64 (48.92) 32.70 – 73.20	12.48 ± 12.41 (8.87) 3.70 – 21.25
Mixed Spices	< 0.02	3.04 ± 1.76	0.80 – 4.90	8.90 ± 7.94 8.91 (6.90) 3.40 – 22.55
Thyme	< 0.02	29.34 ± 19.52 ND – 50.60	17.17	37.03 ± 15.66 (35.33) 25.95 – 48.10
Natural Spices	< 0.02	1.13 ± 0.04	255.70 ± 231.01	14.30
Table Salt	< 0.02	0.06 4.50	91.20 ND	1.00

*Mean ±SD; **Range ‡Geometric mean; ND =Not Detected; **Source:** Nnorom *et al.* (2007).

The high level of especially iron in the curry powder, beef seasoning and chicken seasoning may be as a result of intentional fortification of these products with Fe by the industries or from the cumulative contributions of the raw materials used. Human intake of a given element has been observed to be directly or indirectly related with the intake of other nutrients, particularly minerals and vitamins (Garcia *et al.,* 2001). Micronutrients play very important roles in different metabolic processes and their excess or deficiency may disturb normal biochemical function of the body (Akhter *et al.,* 2002).

In Ghana, Nkansah and Amoako (2010) analyzed for iron, zinc, copper and nickel, lead and mercury on 15 local spices (Galbanum, Pepper, White Pepper, Nutmeg, Garlic, Calabash-Nutmeg, Negro Pepper, Black Pepper, Bay Leaf, Curry Powder, Cinnamon, Rosemary, Ginger, Aniseeds, W.A. locust bean) bought from a local market in Ghana.

For the selected metals, copper, nickel, zinc, iron, lead, mercury, the recorded concentrations in mg/kg range is presented in Table 8. However, the WHO limits in spices for Cu, Ni, Zn, Fe, Pb, Hg are 50, 50, 100, 300, 100, 10 mg/kg respectively. All the samples recorded less than half the WHO limit for Cu in the spices.

Table 8: Concentrations (mg/l) of the heavy metals in some spice samples

Spices	Cu	Ni	Zn	Fe	Pb	Hg*10^{-5}
Aniseed	16	50	73	448	99	1.308
Bay leaf	10	43	59	280	98	3.800
Black pepper	15	37	65	286	97	2.000
Calabash nutmeg	19	38	72	141	98	1.920
Cinnamon	10	37	74	346	107	5.000
Curry	13	42	71	248	98	2.493
Nutmeg	20	39	68	138	97	3.350
Pepper	16	36	68	494	96	1.450
Rosemary	11	35	71	292	99	3.500
W.A Locust Bean	21	50	61`	110	99	2.100
White pepper	13	44	68	271	98	4.200
WHO Limits	50	50	100	300	100	10

Source: Nkansah and Amoako (2010)

Therefore, the Cu levels of the samples are relatively very tolerable. Ozkutlu and Kara (2006) reported of a range of 3 to 11 mg/kg for Cu levels in some spices. All the samples met the WHO limit of 50 mg/kg for Ni. However the levels were apparently greater than half the WHO limit. West African Locust bean and aniseeds had values equal to the WHO limit. It is therefore imperative to perform routine monitoring on the levels of Ni in these well-patronized spices so as to avert encountering prolific nickel toxicity. Zinc plays an important role in growth and has a recognized action on more than 300 enzymes by participating in their structure or their catalytic and regulatory action. Zinc deficiency has been known to cause growth retardation and hypogonadism. Several mechanisms of growth retardation and hypogonadism due to zinc deficiency have been suggested. Zinc affects growth hormone (GH) metabolism. Conversely, growth hormones affects zinc metabolism. Zinc deficiency may also affect bone metabolism and gonadal function (Nishi, 1996). Just as inordinately high amounts of zinc could be more deleterious than nutritious, the WHO limit is not to be exceeded. However, the range of zinc (59 to 74 mg/kg) was very well below the limit and may be considered tolerable. A study on some Nigerian spices showed relatively very low levels of Zn of 0.06 - 56.9 mg/kg (Oninwa *et al.*, 2001). Aniseed, Cinnamon, and Pepper had iron levels of 448, 346 and 494 mg/kg, respectively and are distinctly beyond the WHO limit. Bay Leaf, Black Pepper, Galbanum, Curry Powder, Ginger, Rosemary and White Pepper may be considered alternate sources of iron, as they recorded levels below that of the WHO but rich in Fe, would be considered safe for human consumption except for Aniseed (448 mg/kg Fe), Cinnamon (346 mg/kg Fe; 107 mg/kg Pb), Ginger(115 mg/kg Pb), and Pepper (494 mg/kg Fe) which exceeded one or more of the WHO limits for either iron and or lead.

In the same vein, Al-Eed *et al.,* (1997) estimated the levels of lead, cadmium, cobalt, and selenium present in spices available in local markets in Al-Hasa region of Saudi Arabia. The contents of lead, cadmium, cobalt and selenium in different common spices are presented in Table 8. The values of metal concentrations were compared with the maximum permissible concentration of 0.30, 0.2, and 3.50 mg/kg for lead, cadmium, cobalt and selenium respectively as recommended by Codex Alimentarius Commission (FAO/WHO, 1984). Comparing with standard limit, the basilica sample had the highest content of lead (1.4 mg/kg) that far exceeded the standard level recommended by FAO/ WHO (1984) (0.30 mg/kg). Samples of ginger, cardamon and thyme also contained higher concentrations of lead (0.4 to 0.9 mg/kg) than that recommended by FAO/ WHO. However, zero readings were obtained for turmeric, safflower, nutmeg, fenugreek, garden sage, mahaleb cherry, cinnamon, nasturitum, basibic, nigella, black pepper, cumin and coriander. The amount of cadmium was in the range 0.04

mg/kg (in fenugreek and coriander) to 0.14 mg/ kg (for cardamon). This high level of cadmium might be due to the use of cadmium-containing phosphate fertilizers, or from the practice of growing these plants on soil amended with sewage sludge, or both. However, other samples like turmeric, garden sage, thyme, mahaleb cherry, cinnamon, and black pepper showed no detectable amount of cadmium. When compared with levels of toxic metals in edible salt deposits in Awe and Keana areas of Nasarawa State in Nigeria that ranged from Not Detected (ND) to 0.27% (Etonihu *et al.*, 2012), these spices are higher in their toxic metals. Varied levels of cobalt concentration were found as shown in Table 8. Samples of turmeric, nutmeg, fenugreek, garden sage, mahaleb cherry, cinnamon, cardamon, nigella, black pepper, cumin and coriander are almost free from cobalt. While the rest of samples contained variable amount of cobalt that ranged from 0.32 to 0.64 mg/kg. The data given by Al-Eed *et al.* (1997) showed variation in concentration of selenium for the investigated spices thus zero readings were obtained for nutmeg, basisic, nasturitum, fenugreek, ginger, cardamon, black pepper, and coriander. The rest of the samples contained amount in the range 2.2 mg/ kg in cinnamon to 13.3 mg/ kg in safflower.

Other spices that exceed the recommended FAO/ WHO (1984) level included turmeric, safflower, garden sage, thyme, mahaleb cherry, nigella and cumin (3.50 mg/ kg).

Table 9 showed that no risk from daily intake of the most of spices under study for hazardous lead, cadmium, cobalt, and selenium if the human intake is about 20 g of spices per day. But there are dangerous signal from basisic, thyme and ginger for lead. Due to the high level of cadmium found in fenugreek therefore, it could be poisonous.

Table 9: Daily intake (mg/ kg/day) more than 20 g of metals of studied common spices effect based on 50 g of human body

	Risk Duration for Metal			
Spices	**Pb**	**Cd**	**Co**	**Se**
Turmeric	No effect	No effect	No effect	No effect
Safflower	No effect	No effect	No effect	No effect
Nutmeg	No effect	No effect	No effect	No effect
Basisic	Acute	No effect	No effect	No effect
Nasturitum	No effect	No effect	No effect	No effect
Fenugreek	No effect	Acute	No effect	No effect
Garden sage	No effect	No effect	No effect	No effect
Thyme	Acute	No effect	No effect	No effect
Mahlib	No effect	No effect	No effect	No effect
Cinnamon	No effect	No effect	No effect	No effect
Ginger	Acute	No effect	No effect	No effect
Cardamom	No effect	No effect	No effect	No effect
Nigella	No effect	No effect	No effect	No effect
Black Pepper	No effect	No effect	No effect	No effect
Cumin	No effect	No effect	No effect	Acute
Coriander	No effect	No effect	No effect	No effect
Minimal risk levels	0.0002	0.0002	0.01	0.005

Source: Al-Eed *et al.* (1997).

3. Conclusion and Recommendations

Trace metals are present in spices at different concentrations, which in some cases exceeded the permissible levels. This could be attributed to the use of contaminated irrigation water, the addition of some fertilizers and herbicides, and air pollution from traffic, sewage sludge, industrial activities, fuel, and automobile tyres. Although the human needs from spices are very few grams per day, there is no health risk from the used spices under study in foods. There should be thorough control for imported food stuff as Custom duties so as to meet FAO/ WHO recommendations and tolerable daily intake limits for toxic metals, in order to avoid the passing for human consumption and prevent disease, especially with the continuing and expanding international demand for herbs, spices and essential oils. Food labeling legislation should be encouraged in order to enforce the requirement for the identity of food content. Though some of the spices consumed have medicinal values, the consumers should be educated to know that exceeding a certain dosage might pose a health risk to them.

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