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Comparative phytochemical analysis and use of some Nigerian spices

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Abstract

The qualitative and quantitative analyses of the bioactive constituents of the aqueous and ethanolic extracts of six commonly consumed spices in Nigeria; namely garlic (Allium sativum), ginger (Zingiber officinale), red onion (Allium cepa), nutmeg (Myristica fragrans), bird pepper and cayenne pepper; which are two varieties of Capsicum frutescens were investigated. The study also assessed the use of the spices through the administration of a structured questionnaire. Alkaloids was the most abundant phytochemical in ginger (11.13%), bird pepper (12.85%) and red onion (10.25%) while saponins, tannins and flavonoids were the most abundant phytochemicals in garlic (4.50%), cayenne pepper (6.81%) and nutmeg (4.18%) respectively. Although the ethanolic extracts of spices possessed higher bioactive constituents than their corresponding aqueous extracts, the results showed that the selected spices were potential sources of phytochemicals which could encourage their use as dietary supplements especially in the production of functional foods. Onion was the most frequently used spice, though it was commonly consumed as flavouring. Garlic and ginger were used occasionally but mainly for their health benefits. It may be suggested that the studied spices were still under-utilized due to lack of adequate knowledge of their health potentials.

Keywords: *Extracts, phytochemical analysis, qualitative, spices, use*

Introduction

Spices are products of plants (seeds, kernels, bulbs, stalk, roots, fruits, bark, leaves, pods or buds) which are used in various forms such as fresh, ripe, dried, broken or powdered mostly to contribute to colour, taste, aroma, flavour and pungency of food (Parveen *et al*., 2014; Ene-obong *et al*., 2015). Spices have been used for centuries by many cultures to enhance flavor, aroma and as preservative and medicinal agents (Ene-obong *et al*., 2015). Dziezak (1989) had shown that the colouring, flavouring, aromatic and pungent properties of spices were due to the rich presence of essential oils and oleoresins. Spices are widely used as condiments and ingredients in food preparation. In Nigeria, some spices are useful in the preparation of certain soups which are delicacies and also recommended for rapid relief of ailments such as cold, malaria fever, etc (Sofowora, 1993). These spices are also said to be therapeutically useful in the management of stomachache, leprosy, cough, loss of appetite, rheumatoid pain, convulsion and inflammation (Valko *et al*., 2007).

Recently, the prevention of certain degenerative diseases like cancer and cardiovascular diseases has been associated with the ingestion of spices, fresh fruits, vegetables, or teas rich in natural antioxidative compounds (Virgili *et al*., 2001; Shukla and Singh, 2007; Otunola *et al.,* 2014). The antiseptic and therapeutic effects of plant products are due to a large number of constituent components, which have distinct mechanisms of action; some are enzymes and proteins and others are low molecular weight compounds such as flavonoids, alkaloids etc (Zhang and Wang, 2002). Some preclinical studies have suggested using phytochemicals as preventive agents against colorectal cancer and other cancers (Birt *et al*., 2001). Biologically active plant chemicals other than traditional nutrients that have a beneficial effect on human health have been termed "phytochemicals" (Hasler, 1998). Foods containing these biologically active compounds in defined, effective, non-toxic amounts and which provide a clinically proven and documented health benefits for the prevention, management or treatment of chronic diseases are referred to as functional foods (Martirosyan and Singh, 2015).

Foods that can effectively aid the prevention of various diseases in our diets at relatively lower cost are of major interest to both the scientific community and the general public. As various spices are often consumed as food along with their medicinal benefits, evaluating the medicinal significance in relation to the knowledge and use of these spices can help to understand their worth and the awareness of the populace. Progress over the centuries towards a better understanding of a plant derived medicine have been focusing on the development of conclusive evidence that a medicine really does what it is claimed to do and the identification by analysis of the active compounds in the plant (Holiman, 1989). These factors are also important in choosing ingredients that may be useful in the development of functional foods for a targeted population. Despite the wide use of spices especially in traditional cuisine, there is limited information on the public knowledge and usage pattern of these spices. The objective of this study was therefore to evaluate the phytochemical composition of six

selected Nigerian spices namely *Allium sativum*, *Zingiber officinale*, *Allium cepa*, *Myristica fragrans*, and two varieties of *Capsicum frutescens* (bird pepper and cayenne pepper) using two different solvents and also to provide information on the knowledge and use of the selected spices.

Materials and methods

Collection of samples

Garlic, ginger, red onion, and cayenne pepper were purchased in their fresh state while nutmeg and bird pepper were obtained in their dried state from Ipata market in Ilorin, Kwara State, Nigeria. The spices were brought to the Department of Home Economics and Food Science, University of Ilorin, Ilorin, Kwara state in Nigeria for processing.

Processing of samples

The ginger was thoroughly washed before manual removal of the light outer skin and then cut into tiny pieces with a knife. The light scaly leaves on the onion bulbs and garlic cloves were manually removed before washing in tap water and then chopped into tiny pieces to enhance effective drying. The capsicum fruits were separately washed with tap water and then cut into small slices. The fresh sliced samples were dried in hot air oven at 50°C for 24 hours. Nutmeg was pulverized using laboratory mortar and pestle, while bird pepper and the dried garlic, ginger, red onion and cayenne pepper were ground into powdery form using electric grinder (MarlexElectroline). The pulverized samples were then stored separately in an air-tight container at room temperature.

Preparation of aqueous and ethanolic extracts

Approximately 250 g of each of the pulverized spices was extracted with 100 ml distilled water and 70% aqueousethanol v/v in a shaker water bath at 45°C for 7 hours and then filtered with Whatman No. 1 filter paper. The supernatants were concentrated to dryness in an oven at 60°C and stored separately in an air-tight container at 4°C for further analysis.

Phytochemical screening

Qualitative analysis was carried out on the aqueous and ethanolic extracts of the spices using standard procedures to identify the constituents as described by Sofowora (1993), Trease and Evans (1989), Edeoga *et al.* (2005), Harbone (1973) and Harborne (1998): Mayer's test for alkaloids, Ferric Chloride test for tannins and phenolics, Alkaline Reagent test for flavonoids, Froth test for saponins, Borntrager's test for glycosides, Keller-Killani test for cardiac glycosides, Lieberman's test for steroids, Salkowski test for terpenoids, general test for carotenoids, anthraquinones, oxalates and phytates. The results were presented based on the degree of colour changes of the reactions.

Quantitative phytochemical analysis

Flavonoids, alkaloids and saponins were determined by the methods described by Bohm and Kocipai-Abyazan (1994), Adeniyi *et al*. (2009) and Obadoni and Ochuko (2002) respectively. Phenolics determination was carried out according to the Folin-Ciocalteu procedure (Singleton and Rossi, 1965). Cardiac glycoside content in the samples was determined using Buljet's reagent as stated by El-Olemy *et al.* (1994). Terpenoids, tannins, carotenoids, steroids, anthraquinone, glycosides, oxalates and phytates were determined by the spectrophotometric method.

Data collection

Data was obtained through well structured questionnaires administered randomly to 50 people comprising of students and members of staff of the University of Ilorin, Nigeria. The guided questionnaire entailed the reasons for consuming the spices and how often the spices are being used by the respondents.

Statistical analysis

Experiments were conducted in triplicates. Data obtained from the quantitative phytochemical analysis of the spices were subjected to Analysis of Variance and Duncan Multiple Range Test was used to separate the means. SPSS software (Version 20.0) was used to analyze the data and $p<0.05$ was considered statistically significant (Turkey Kramer comparison test). Data obtained from the questionnaires were analyzed using SPSS software (version 20.0) descriptive analysis including frequency and percentage counts.

Results and discussion

Phytochemical screening of aqueous and ethanolic extracts of the spices

Results of the phytochemical screening of aqueous extracts and ethanolic extracts of the samples are presented in Tables 1 and 2 respectively. The results revealed the presence of alkaloids, flavonoids, tannins, carotenoids, saponins, steroids, glycosides, cardiac glycosides, phenolics, terpenoids, anthraquinones, oxalates, phytates and anthraquinones in the spices, though, alkaloids, oxalates and phytates were absent in the aqueous and ethanolic extracts of cayenne pepper. These results did not exclusively agree with the report of Gazuwa et al. (2013) which shows the absence of tannins, saponins and phenolics in onion and garlic.

Table 1. *Phytochemical screening of the aqueous extracts of the spice*

Parameters	Ginger	Bird pepper	Red onion	Garlic	Cayenne Pepper	Nutmeg
Alkaloids	+++	++	++	+	-	+
Tannins	++	++	++	+	++	+
Carotenoids	+	+++	+	+	+	+
Saponins	+	++	++	+	+	+
Flavonoids	++	++	+	+	+	+ +
Steroids	+	+	+	+	+	+
Glycosides	+	+	+	+	+	+
Cardiac Glycosides	+	+	++	+	+	+
Phenolics	+	+	+	+	+	+

Parameters	Ginger	Bird pepper	Red onion	Garlic	Cayenne Pepper	Nutmeg
Terpenoids	+	+	+	+	+	+
Anthraqui-none	+	+	+	+	+	+
Oxalates	+	+	+	++	-	+
Phytates	+	+	+	+	-	+

KEYS: +++ = Highly present; ++= Moderately present; +=Present; - = Not present.

Table 2. *Phytochemical screening of the ethanolic extracts of the spices*

Parameters	Ginger	Bird pepper	Red onion	Garlic	Cayenne Pepper	Nutmeg
Alkaloids	+++	+++	++	+	-	+
Tannins	+	+	++	+	++	+
Carotenoids	+	+++	+	+	+	+
Saponins	+	++	+++	++	++	+
Flavonoids	++	++	++	+	++	++
Steroids	+	+	+	+	+	+
Glycosides	+	+	+	+	+	+
Cardiac Glycosides	+	+	+	+	+	+
Phenolics	+	+	+	+	+	+
Terpenoids	+	+	+	+	+	+
Anthraqui-none	+	+	+	+	++	+
Oxalates	+	+	+	+	-	+
Phytates	+	+	+	+	-	++

KEYS: +++ = Highly present; ++ = Moderately present; + = Present; - = Not present.

The presence of tannin and oxalate in garlic, onion and ginger agreed with the report of Nwinuka *et al.* (2005) but contrary to that of Green *et al.* (2012). This may be attributed to genetic and climatic factors rather than the storage time, processing and extraction methods. The presence of alkaloids, saponins, anthraquinones, cardiac glycosides and flavonoids in nutmeg and bird pepper agreed with the report of Olaleye *et al.* (2006) and Wahua *et al.* (2013) respectively. This implied that the studied spices are potential sources of phytochemicals most of which have been reported to show medicinal activity as well as exhibiting physiological activity (De and James, 2002). The present study did not entirely concur with the report of Belewu *et al.* (2009) which indicates the presence of tannins and saponins and absence of alkaloids, phenols, flavonoids and steroids in ginger. However, the presence of these vital chemical substances supported the observation of Pandey (1980) that plants have some vital chemical substances (alkaloids, carbon compounds, glycosides, tannins and others).

Quantitative phytochemical analysis of aqueous and ethanolic extracts of the spices

The phytochemical content of the aqueous extract of the studied spices is presented in Table 3. Alkaloids was found to be the most abundant phytochemical in ginger (11.13%), bird pepper (12.85%) and red onion (10.25%) while saponins, tannins and flavonoids were the most abundant phytochemicals in garlic (4.50%), cayenne pepper (6.81%) and nutmeg (4.18%) respectively. Carotenoids content ranged between 0.04µg/100 g in nutmeg and 625.00µg/100 g in bird pepper. The highest value (625.00µg/100 g) recorded for carotenoids; which is a precursor of vitamin A, in bird pepper supported the assertion of Bosland and Votava (2000) that *capsicum spp* are excellent source of vitamin A. Flavonoids and carotenoids may be the principal compounds responsible for the red colour of bird pepper. The values obtained for the alkaloids, tannins, carotenoids, saponins, flavonoids and steroids in garlic, ginger and bird pepper in this study were similar to those reported by Otunola *et al*. (2010).

The phytochemical content of the ethanolic extracts of the selected spices is shown in Table 4. The range of values; alkaloids (0.00-14.84%), tannins (0.74-9.82%), carotenoids (0.84-640.24 µg/100 g), saponins (1.32-15.41%), flavonoids (1.63-7.31%), steroids (0.26-1.63%), glycosides (0.42-1.32%), cardiac glycosides (0.52-1.20%), phenolics (0.66-1.24%), terpenoids (0.36-4.08%), anthraquinones (0.16-3.42%), oxalates (0.00-1.08%) and phytates (0.00-5.21%), obtained for most of the phytochemical components of the ethanolic extracts of the studied spices were observed to be higher than those of their corresponding aqueous extracts. This may be as a result of the similar polarity nature of ethanol and most of the phytochemicals present in the spices. The ethanolic extracts of the studied spices may therefore exhibit more therapeutic effects in health management due to the high combinative therapeutic actions of the various secondary metabolites contained in them as described by Akharaiyi and Boboye (2010) and Ogofure and Emoghene (2016).

*Alkaloids comprising a large group of nitrogenous compounds are widely used as cancer chemotherapeutic agents, anaesthetics and Central Nervous Stimulants (Noble, 1990; Madziga et al., 2010). Alkaloids are known to play some metabolic roles and control development in living system (Edeoga et al., 2006). It also interferes with cell division, hence the presence of alkaloids in ginger, bird pepper, onion, garlic and nutmeg could account for their use as antimicrobial agents. Aboaba et al. (2011) had reported that the antimicrobial properties of substances are desirable tools in food spoilage and food safety. This suggests that the studied spices which have been confirmed to contain alkaloids may also be useful as pre*servatives in food. Phenolic compounds possess both antioxidant and antimicrobial activities (Zheng and Wang, 2001; Virgili *et al.*, 2001; Akharaiyi and Boboye, 2010). The high level of phenolic compounds in onion may be responsible for the ability of onion to alleviate or presumably cure certain degenerative diseases. Flavonoids are important groups of polyphenol (a range of C15 aromatic compounds) with more than one benzene ring in their structures (Kar, 2007). Flavonoids have antioxidant activities, antimicrobial properties as well as much health promoting effects such as anti-allergic, antispasmodic, anti-cancer, antidiabetic, hypoglycaemic, anti-inflammatory, anti-thrombotic, vasoprotective, tumour inhibitory and anti-viral effects (Trease and Evans, 2002; Tanko *et al.,* 2007). Saponins possess both beneficial (cholesterol-lowering) and harmful (cytotoxic permeabilization of the intestine) effects and also exhibit structure dependent biological activities (Osagie and Eka, 1998). In addition, it has been documented that saponins have antitumor, antioxidant and anti-mutagenic acti-

vities and can lower the risk of human cancers by inhibiting the growth of cancer cells (Roa *et al*., 1995; Prohp and Onoagbe, 2012). Steroidal compounds are of importance and interest in pharmacy due to their relationship with compounds such as sex hormones mostly used in the development of female contraceptive pills (Okwu, 2001). This can make these spices useful as vegetable for pregnant women and breast feeding mothers to ensure their hormonal balance, as being used in some countries, since steroidal compounds could serve as essential starting material in the synthesis of these hormones.

Table 3. *Phytochemical content of the aqueous extracts of the spices*

Parameters	Ginger	Bird pepper	Red onion	Garlic	Cayenne pepper	Nutmeg
Alkaloids (%)	11.13±0.02^{e}	12.85±0.01^{f}	10.25±0.01^{d}	0.55±0.01^{c}	0.00±0.00^{a}	0.42±0.02^{b}
Tannins (%)	3.42±0.02^{d}	1.62±0.02^{c}	9.71±0.01^{f}	0.08±0.01^{a}	6.81±0.01^{e}	0.64±0.01^{b}
Carotenoids (µg/100 g)	0.60±0.01^{c}	625.00±0.06^{f}	0.68±0.01^{d}	0.95±0.01^{e}	0.46±0.02^{b}	0.04±0.00^{a}
Saponins (%)	0.70±0.01^{a}	6.40±0.02^{e}	11.58±0.02^{f}	4.50±0.02^{d}	3.14±0.01^{c}	1.56±0.01^{b}
Flavonoids(%)	5.10±0.03^{e}	6.21±0.01^{f}	3.66±0.01^{d}	1.13±0.01^{a}	3.84±0.02^{c}	4.18±0.02^{d}
Steroids (%)	0.04±0.00^{a}	0.31±0.01^{c}	0.02±0.00^{a}	0.03±0.00^{a}	0.34±0.00^{c}	0.11±0.01^{b}
Glycosides(%)	0.03±0.00^{a}	0.53±0.01^{c}	2.13±0.02^{d}	0.02±0.00^{a}	0.28±0.02^{b}	0.05±0.00^{b}
Cardiac glycosides (%)	0.06±0.01^{a}	0.43±0.01^{c}	4.12±0.01^{e}	0.05±0.01^{a}	0.62±0.01^{d}	0.05±0.00^{a}
Phenolics (%)	0.07±0.01^{a}	0.62±0.01^{c}	1.03±0.00^{e}	0.42±0.02^{b}	0.86±0.01^{d}	0.43±0.01^{b}
Terpenoids (%)	0.12±0.01^{a}	0.41±0.01^{c}	0.06±0.00^{a}	0.26±0.00^{b}	3.16±0.02^{e}	0.62±0.01^{d}
Anthraquinone (%)	0.84±0.01^{d}	0.14±0.01^{b}	0.36±0.01^{c}	0.08±0.01^{a}	2.81±0.01^{e}	0.06±0.01^{a}
Oxalates (%)	0.06±0.00^{a}	0.11±0.01^{a}	0.44±0.02^{b}	2.10±0.10^{d}	0.00±0.00^{a}	1.03±0.01^{c}
Phytates (%)	0.05±0.01^{a}	0.26±0.01^{b}	0.35±0.01^{c}	0.46±0.01^{d}	0.00±0.00^{a}	1.03±0.01^{c}

Each value is a mean of three determinations ± standard deviation; Means within rows having different superscripts differ significantly ($p<0.05$) from one another.

Table 4. *Phytochemical content of the ethanolic extracts of the spices*

Parameters	Ginger	Bird pepper	Red onion	Garlic	Cayenne pepper	Nutmeg
Alkaloids(%)	13.66±0.01e	14.84±0.01f	10.84±0.02d	0.84±0.02c	0.00±0.00a	0.62±0.02b
Tannins (%)	3.84±0.02c	1.84±0.01b	9.82±0.02e	0.82±0.01a	7.42±0.02d	0.74±0.01a
Carotenoids (µg/100 g)	1.43±0.01d	640.24±0.03e	1.06±0.01b	1.12±0.02bc	1.21±0.01c	0.84±0.01a
Saponins (%)	1.32±0.01a	7.22±0.02e	15.41±0.02f	5.21±0.01d	3.48±0.01c	1.85±0.01b
Flavonoids(%)	6.52±0.00e	7.31±0.01f	4.64±0.01c	1.63±0.00a	3.92±0.01b	5.21±0.02d
Steroids (%)	1.06±0.01e	1.63±0.01f	0.85±0.01c	0.69±0.01b	0.86±0.00d	0.26±0.01a
Glycosides(%)	1.02±0.01c	1.32±0.01d	0.64±0.00b	0.66±0.01b	1.00±0.01c	0.42±0.01a
Cardiac glycosides (%)	1.04±0.00c	0.86±0.01b	0.84±0.01b	0.82±0.00b	1.20±0.02d	0.52±0.01a
Phenolics (%)	1.10±0.01c	0.88±0.01b	0.69±0.01a	0.66±0.02a	1.24±0.00d	0.82±0.01b
Terpenoids (%)	0.36±0.01a	0.41±0.01a	0.64±0.01b	0.63±0.01b	4.08±0.01e	0.84±0.02c
Anthraquinone (%)	1.21±0.01d	0.38±0.02b	0.76±0.01c	0.74±0.01c	3.42±0.01e	0.16±0.01a
Oxalates (%)	1.04±0.01d	0.26±0.01c	0.05±0.01b	0.08±0.00b	0.00±0.00a	1.08±0.01d
Phytates (%)	0.56±0.02a	1.14±0.09c	0.61±0.01a	0.63±0.01d	0.00±0.00a	5.21±0.01b

Each value is a mean of three determinations ± standard deviation; Means within rows having different superscripts differ significantly ($p<0.05$) from one another.

The importance of tannins in promoting wound healing has been documented (Okwu and Josiah, 2006). Iwu (1983) has also reported that tannins possessed anti–diabetic properties. At high concentration, tannin may also be considered as an anti-nutritional factor due to its ability to bind and precipitate proteins and other organic compounds including alkaloids (Van-Burden and Robinson, 1981). Cardiac glycosides have a strong and direct action on the heart, helps in supporting its strength and rate of contraction when it is failing (Malik and Siddiqui, 1981). Anthraquinones possessed laxatives, anti-malarial and anti-carcinogenic effects (Anonymous, 2014). Plant based chemicals have enormous therapeutic potentials owing to their ability to serve the purpose with lesser side effects that are often associated with synthetic chemicals (Iwu *et al.,* 1999). Oxalates and phytates may be regarded as anti-nutritional factors because of their strong binding affinity to important minerals such as calcium, iron and zinc at high concentrations but they are often destroyed or reduced to non-toxic levels by long slow heating (Munro and Bassir, 1969; Dendougui and Schwedt, 2004; Coe *et al*., 2005). However, oxalates possessed certain health benefits especially when present at low concentration by maintaining

the levels of certain minerals in the body. The anti-nutritional activity of phytates can also be beneficial especially in menopause women and most adults as they tend to have high levels of iron which can be a very strong oxidant and causes biological stress.

Usage of the spices

Data obtained from the analysis of information contained in the questionnaires are presented in Tables 5 and 6. Table 5 showed that the spices mostly utilized for health purposes were garlic (50%) and ginger (48%) while the other spices were mainly used as flavourings. Regrettably, the spices that were known for their medicinal values were often consumed occasionally (Table 6). The results of the evaluations revealed that even though the studied spices were well known and commonly used by the respondents, their knowledge and awareness especially of the health benefits of the spices were not adequate enough.

Table 5. *Reasons for consuming the studied spices by the respondents*

Samples	FLA		MEDV		COL		FLA & MEDV		FLA & COL		Others	
	F	(%)	F	(%)	F	(%)	F	(%)	F	(%)	F	(%)
Onion	35	70.0	7	14.0	-	-	7	14.0	-	-	1	2.0
Garlic	12	24.0	25	50.0	-	-	11	22.0	-	-	2	4.0
Ginger	14	28.0	24	48.0	-	-	10	20.0	-	-	2	4.0
Nutmeg	38	76.0	6	12.0	1	2.0	3	6.0	-	-	2	4.0
Bird pepper	26	52.0	8	16.0	7	14.0	1	2.0	2	4.0	6	12.0
Cayenne pepper	22	44.0	9	18.0	16	32.0	-	-	-	-	3	6.0

F = Frequency, FLA = Flavour, MEDV = Medicinal Value, COL = Colour

Table 6. *Use of the studied spices by the respondents*

Samples	Frequently		Occasionally		Rarely		Not at all	
	F	(%)	F	(%)	F	(%)	F	(%)
Onion	49	98.0	2	4.0	0	0.0	0	0.0
Garlic	10	20.0	24	48.0	13	26.0	3	6.0
Ginger	8	16.0	28	56.0	12	24.0	2	4.0
Nutmeg	4	8.0	30	60.0	14	28.0	2	4.0
Bird pepper	23	46.0	14	28.0	7	14.0	6	12.0
Cayenne pepper	24	48.0	16	32.0	8	16.0	2	4.0

F = Frequency

Conclusion

Data on the selected spices indicated that spices contain natural antioxidants and phytochemicals which may be accountable for their use in treating infections, curing certain diseases and as ingredients in traditional medicine. The inclusion of these spices or their extracts in the production and development of functional foods should be encouraged. The variability of the composition of phytochemical compounds in different extracts of the same sample indicated the importance of choosing suitable solvent for the extraction of the active biological substances of the plants especially for preservative and pharmaceutical purposes. The results of this study also provide ample evidence that most of the spices were still under-utilized either as medicinal plants or flavouring agents. Based on these findings, this study suggests the need to lay emphasis on the consumption of spices as well as create more public awareness of their health benefits. Further studies should focus on the production of functional foods from these spices as well as the establishment of their recommended daily intake to obtain the most beneficial effects.

References

Aboaba, O. O., Ezeh, A. R., Anabuike, C. L. (2011) Antimicrobial activities of some Nigerian spices on some pathogens. *Agriculture and Biology Journal of North America*, 2(8), 1187-1193.

Adeniyi, S. A., Orjiekwe, C. L., Ehiagbonare, J. E. (2009) Determination of alkaloids and oxalates in some selected food samples in Nigeria. *African Journal of Biotechnology*, 8, 110-112.

Akharaiyi, F.C., Boboye, B. (2010) Antibacterial and Phytochemical Evaluation of Three Medicinal Plants. *Journal of Natural Products*, 3, 27-34.

Anonymous (2014) "Anthraquinone". Available at: http://en.wikipedia.org/wiki/anthraquinone. Accessed: 02.07.2014.

Belewu, M. A., Olatunde, O. A., Giwa, T. A. (2009) Underutilized medicinal plants and spices: Chemical composition and phytochemical properties. *Journal of Medicinal Plants Research,* 3(12), 1099-1103.

Birt, D. F., Hendrich, S., Wang W. Q. (2001) Dietary agents in cancer prevention: Flavanoids and isoflavonoids. *Pharmacology & Therapeutics*, 90, 157- 177.

Boham, B. A., Kocipai-Abyazan, R. (1994) Flavonoids and condensed tannins from leaves of Hawaiian *Vaccinum*

vaticulatum and *V. calycinium*. *Pacific Science,* 48, 458-463.

Bosland, P. W., Votava, E. J. (2000) Peppers: Vegetable and spice capsicums. CABI Publishing, Oxon, UK and N.Y. pp. 204.

Coe, F. L., Evan, A., Worcester, E. (2005) Kidney stone disease. *Journal of Clinical Investigation*, 115(10), 2598-2608.

De, N., James, N. E. (2002) Antibacterial spectrum of extracts of *Ocimum gratissimum L* (Basil) ND *Xylopia aetiopica A*. Rich (Dunal). *Nigerian Journal of Basic and Applied Sciences*, 11, 165-175.

Dendougui, F., Schwedt, G. (2004) In vitro analysis of binding capacity of calcium to phytic acid in different food samples. *European Food Research and Technology*, 4, 219.

Dziezak, J. D. (1989) Innovation food trends, Spices. *Journal of Food Technology,* 43(1), 102 – 116.

Edeoga, H. O., Okwe, D. E., Mbaebie, B. O. (2005) Phytochemical constituent of some Nigerian Medicinal Plants. *African Journal of Biotechnology,* 4(7), 685- 688.

Edeoga, H. O., Omobuna, G., Uche, L. C. (2006) Chemical composition of *Hyotissu aveoleus* and *Ocimum gratissium* hybrids from Nigeria. *African Journal of Biotechnology,* 5(910): 892-895.

El-Olemy, M. M., Al-Muhtadi, F. J., Afifi, A. F. A. (1994) Experimental phytochemistry: A laboratory manual. King Saud University Press, Saudi Arabia, pp. 21-27.

Ene-Obong, H. N., Onuoha, N. O, Aburime, L. C., Mbah, O. (2015) Nutrient composition, phytochemicals and antioxidant activities of some indigenous spices in Southern Nigeria. 11TH IFDC, Hyderabad, India, pp 1-31.

Gazuwa, S. Y., Makanjuola, E. R., Jaryum, K. H., Kutshik, J. R., Mafulul, S. G. (2013) The phytochemical composition of *Allium Cepa/Allium Sativum* and the effects of their aqueous extracts (cooked and raw forms) on the lipid profile and other hepatic biochemical parameters in female albino wistar rats. *Asian Journal of Experimental Biological Sciences*, 4(3), 406-410.

Green, B. O., Nworgu, F. C., Obazee, M. N. (2012) Spices and food condiments in Niger-Delta region of Nigeria. *African Journal of Biotechnology,* 11(79), 14468-14473.

Harbone, J. B. (1973) Phytochemical methods, London. Chapman and Hall, Ltd., pp. 49-188.

Harborne, D. B. (1998) Phytochemical methods, a guide to modern techniques of plant analysis. 3rd ed. Springer, New Delhi.

Hasler, C. M. (1998) Functional foods: Their role in disease prevention and health promotion. *Journal of Food Technology, 52(11), 63-70.*

Holiman, A. (1989) Plants in medicine. Chelsea Physic Garden: The Chelsea Physic Garden Co Ltd.

Iwu, M. M. (1983) Hypoglycemic properties of *Bridelia furruginear* leaves. *Fitoterapia*, 54, 243 -248.

Iwu, M. W., Duncan, A. R., Okunji, C. O. (1999) New antimicrobials of plant origin. In: ed 'Perspectives on new crops and new uses'. ASHS Press, Alexandria, VA, pp. 457-462.

Kar,A.(2007)PharmacognosyandPharmacobiotechnology (Revised-Expanded Second ion). New Age International Limited Publishers, New Delhi, pp. 332-600.

Macmillan, H. F. (1984) A Handbook for Tropical Planting and Gardening. Macnidlan scientific Publishers, London, pp. 326.

Madziga, H. A., Sanni, S., Sandabe, U. K. (2010) Phytochemical and Elemental Analysis of *Acalypha wilkesiana* Leaf. *Journal of American Science*, 6(11), 510-514.

Malik, Z. A., Siddiqui, S. (1981) Hypertensive effect of freeze dried garlic (*Allium sativum*) sap in dogs. *J. Phytomed. and Appl. Sci*., 31, 12-13.

Martirosyan, D., Singh, J. A. (2015) Definition of functional by Functional Foods Center: what makes a new definition unique? Review article. *Functional Foods In Health And Disease*, 5(6), 209-223.

Noble, R. L. (1990) The discovery of vinca alkaloids chemotherapeutic agents against cancer. *Biochemistry and Cell Biology*, 68(12), 1544-1351.

Nwinuka, N. M., Ibeh, G. O., Ekeke, G. I. (2005) Proximate composition and levels of some toxicants in four commonly consumed spices. *Journal of Applied Sciences & Environmental Management*, 9(1),150-155.

Obadoni, B. O., Ochuko, O. (2002) Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria. *Global Journal of Pure and Applied Sciences*, 8(2), 203–208.

Ogofure, A. G., Emoghene, A. O. (2016) Evaluation of proximate, phytochemical and antibacterial properties of the pseudostem and hand of plantain (*Musa paradisiaca*). *Nigerian Journal of Agriculture, Food and Environment*. 12(2), 19-26.

Okwu, D. E., Josiah, C. (2006) Evaluation of the chemical Composition of two Nigerian medicinal Plants. *African Journal of Biotechnology*, 5(4), 357-361.

Okwu, D. E. (2001) Evaluation of the chemical composition of indigenous spices and flavoring agents. *Global Journal of Pure and Applied Sciences*, 7(3), 455-459.

Olaleye, M. T., Afolabi, C. A., Akindahunsi, A. A. (2006) Antioxidant properties of *Myristica fragrans* (Houtt) and its effect on selected organs of albino rats. *African Journal of Biotechnology*, 5(13), 1274-1278.

Osagie, A. U., Eka, O. U. (1998) Mineral elements in plant foods. In: 'Nutritional quality of Plant foods'. Ambik press, Benin City, Edo State, Nigeria, pp. 8, 14, 43 and 86.

Otunola, G. A., Oloyede, O. B., Oladiji, A. T., Afolayan, A. J. (2010) Comparative analysis of the chemical composition of three spices – *Allium sativum L. Zingiber officinale Rosc*. and *Capsicum frutescens L*. Commonly Consumed in Nigeria. *African Journal of Biotechnology*, 41, 6927-6931.

Otunola, G. A., Oloyede, O. B., Oladiji, A. T., Afolayan, A. J. (2014) Selected spices and their combination modulate hypercholesterolemia-induced oxidative stress in experimental rats. *Biological Research*, 47, 5. doi:10.1186/0717-6287-47-5

Pandey, B. P. (1980) Economic Botany for degree honours and postgraduate students. S Chand and Company Ltd., Ram Nagar.

Pandey, M. A. B, Abidi, S., Singh, R. P. (2006) Nutritional evaluation of leafy vegetables paratha. *Journal of Human Ecology*, 19, 155–156.

Parveen, S., Das, S., Begum, A., Sultana, N., Hoque, M., Ahmad, I. (2014) Microbiological quality assessment of three selected spices in Bangladesh. *International Food Research Journal*, 21, 1327-1330.

Prohp, T. P., Onoagbe, I. O. (2012) Determination of phytochemical composition of the stem bark of *triplochiton*

scleroxylon k. schum. (sterculiaceae). *International Journal of Applied Biology and Pharmaceutical Technology*, 3(2), 68-76.

Roa, R. R., Babu, R. M., Rao, M. R. V. (1995) Saponins as anti-carcinogens. *The Journal of Nutrition*, 125, 717-724.

Shukla, Y., Singh, M. (2007) Cancer preventive properties of ginger: a brief review. *Food and Chemical Toxicology*, 45, 683–690.

Singleton, V. L., Rossi, J. A. (1965) Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture*, 16, 144-158.

Sofowora, E. A. (1993) Medicinal plants and traditional medicine in Africa. Spectrum Books Ltd, Ibadan, pp. 55–71.

Tanko, Y., Yaro, H. A., Isa, M., Yerima, M., Saleh, I. A., Mohammed, A. (2007) Toxicological and hypoglycaemic studies on the leaves of *Cissampelos mucronata* (Menispermaceae) on blood glucose levels of streptozotocin-induced diabetic wistar rats. *Journal of Medicinal Plants Research*, 1(5), 113 -116.

Trease, G. E., Evans, W. C. (1989) Pharmacognsy. 11th edn. Brailliar Tiridel Can. Macmillian publishers.

Trease, G. E, Evans, W.C. (2002) Phytochemicals. In: Pharmacognosy. 15th ed. Saunders Publishers, London, pp. 42-44, 221- 229, 246- 249, 304-306,331-332, 391-393.

Valko, M., Leibfritz, D., Moncol, J., Cronin, M. T., Mazur, M., Telser, J. (2007) Free radicals and antioxidants in normal physiological functions and human disease. The *International Journal of Biochemistry and Cell Biology*, 39, 44-84.

Van-Burden, T. P., Robinson, W. C. (1981) Formation of complexes between protein and tannin acid. *Journal of Agricultural and Food Chemistry*, 1, 77.

Virgili, F., Scaccini, C., Packer, L., Rimbach, G. (2001) Cardiovascular disease and nutritional phenolics. In: Pokorny, J., Yanishlieva and M. Gordon, (Eds.). Antioxidants in Food, Wood head Publishing Ltd., Cambridge, pp. 87–99.

Wahua, C., Okoli, B. E., Sam, S. M. (2013) Comparative Morphological, Anatomical, Cytological and Phytochemical Studies on *Capsicum frutescens Linn*. and *Capsicum annuum Linn*. (Solanaceae). *International Journal of Scientific & Engineering Research*, 1, 4. ISSN 2229-5518.

Zhang, H. Y., Wang, L. F. (2002) Theoretical elucidation on structure– antioxidant activity relationships for indolinonic hydroxylamines. *Bioorganic & Medicinal Chemistry Letters*, 12, 225–227.

Zheng W., Wang S. Y (2001) Antioxidant activity and phenolic compounds in selected herbs. *Journal of Agricultural and Food Chemistry*, 49(11), 5165-5170.