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Proximate, Mineral and Phytate Profiles of Some Selected Spices Found in Nigeria

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Abstract. The proximate, mineral and phytate (phy) compositions, as well as the calculations for fatty acid, metabolisable energy, phy:Zn, Ca:phy and [Ca] [phy]/[Zn] were determined in 13 spices (S_{11} - S_{23}) used as seasoning agents in Nigeria. The mean values of various parameters for proximate composition (g/100 g) were: moisture (3.61±3.56), dry matter (96.39±3.56), crude fat (5.46±10.02), crude fibre (27.0±17.34), crude protein (13.78±9.84), ash (4.57±2.22) and carbohydrates (45.58±22.25). Fatty acids were noted to be 4.37±8.02 (g/100 g) and energy was 1211.23±317.64 (kJ/100 g). Significant differences ($P < 0.05$) existed in moisture, dry matter, fat, fibre, crude protein and fatty acid levels. Minerals (mg/100 g) included: Na (183.08±144.19), K (1621.54±1703.99), Ca (505.38±463.24), Mg (243.08±235.74), Zn (434.92±945.86), Fe (72.54±92.38) and P (740±624.64), while Pb, Cu and Co, were not detected. The relationships between Na and K as well as between Ca and P were mostly within the desirable range with the respective ratios of Na/K (0.59±0.87) and Ca/P (2.20±3.32). Significant differences existed among the levels of Na, K, Ca, Mg, Zn, Fe, Na/K and Ca/P. The [Ca] [phy]/[Zn] had an overall mean value of 1.45±1.74 showing that the bioavailability of zinc in the spices may be low (except in S_{21}, S_{22} and S_{23}) due to the high phytate content of the spices.

Keywords: spices, chemical composition, metabolisable energy, phytate levels

Introduction

Broadly speaking, spices are aromatic vegetable products of tropical origin that are used, in a pulverised state, primarily for seasoning or garnishing foods and beverages. They are characterised by pungency, strong odour, and sweet or bitter taste. Included in this category are hard or hardened parts of plants such as pepper, cinnamon, cloves, ginger, cardamom, turmeric, nutmeg and mace, all spices, and vanilla. In ancient times, they were valued as basic components of incense, embalming preservatives, ointments, perfumes, antidotes against poison, cosmetics and medicines, and were little used in food. It was only in the first century AD that spices found their way into the kitchen (Kochhar, 1986). Spices cannot be classed as foods since they are used in foods at levels that yield no significant nutritive value, but impart certain aroma and flavour to the food. The importance of spices in our daily diet is as follows (Kochhar, 1986): (1) to give an agreeable flavour and aroma (piquancy or tang) to otherwise monotonous or insipid food, particularly in the tropics where it consists mainly of starchy grains or roots, thereby adding greatly to the pleasure of eating; (2) to stimulate appetite and increase the flow of gastric juices, for which reason they are often termed as food 'accessories' or 'adjuncts'; (3) to camouflage or disguise the slightly unpleasant taste of many dried meats; and (4) to increase the rate of perspiration, thus having a cooling effect on the body.

The spices analysed in this work have been variously described (Akinadewo, 2001; Gill, 1992; McGraw-Hill Encyclopedia of Science and Technology, 1987; Kochhar, 1986; Shaw, 1973). Despite the wide utilization of spices, little work has been reported on their nutritional composition. Most works have been concentrated on tropical chillies (Adeyeye and Otokiti, 1999; Fagbemi and Oshodi, 1993; Bamgbose *et al.*, 1991; Keshinro and Ketiku, 1981). Other works on spices include: isolation of vitamin C in paprika in 1937 (Kochhar, 1986), proximate and mineral composition of black pepper (*Piper guineense*) (Udosen, 1995) and the determination of calcium, zinc, phytate, phy/Zn, Ca/phy and [Ca] [phy]/[Zn] molar ratios in bell and cherry peppers, okro, tomato, onion and sugarnut (Adeyeye *et al.*, 2000).

The importance of a foodstuff as a source of dietary zinc depends upon both the total zinc content and the level of other constituents in the diet that affect zinc bioavailability. Phytic acid (myoinositol 1, 2, 3, 4, 5, 6-hexakis dihydrogen phosphate), a compound found only in plant foods, may reduce the bioavailability of dietary zinc by forming insoluble mineral chelates at the physiological pH (Oberleas, 1983). The formation of the chelates depends on relative levels of both zinc and phytic acid (Davies and Olpin, 1979). Conse-

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quently, the phytate:Zn molar ratio is considered a better predictor of zinc bioavailability than total phytate level alone. The critical phytate:Zn molar ratio may also depend on dietary calcium level. A kinetic synergism exists between the calcium and zinc ions resulting in a Ca:Zn:phytate complex which is less soluble than phytate complexes formed by either ion alone (Oberleas, 1973). Unfortunately, only limited data are available on the critical phytate:Zn and [Ca] [phy]/[Zn] ratios associated with decreased zinc bioavailability in human diets. Consequently, we have determined proximate and mineral composition, metabolisable energy, fatty acids, phytate, phy:Zn, Ca:phy and [Ca] [phy]/[Zn] in 13 spices available for study.

Materials and Methods

Samples of spices. Samples of the spices were obtained from the Oba Market, Ado-Ekiti, Nigeria. All the samples were obtained in dry form. The names of the samples (in English language, botanical nomenclature and vernacular) are given in Table 1. The identification numbers ranged from S_{11} to S_{23} corresponding to 13 samples. Various parts of the vegetables used as spices are also indicated under the column, 'part used'. Table 2 shows the group arrangement of the samples according to the phylogenetic sequence of orders and families (Hutchinson and Dalziel, 1968; 1963; 1958; 1954). The samples were screened by removing stones and other foreign bodies. Each sample was separately ground in an all glass mortar into fine powder and packed in plastic bottles and kept in the laboratory freezer until used for analysis.

Analysis of the samples. The proximate analyses of the samples for moisture, ash, fibre and ether extract were done by the method of AOAC (1990). Nitrogen was determined by the micro-Kjeldahl method as described by Pearson (1976) and the percentage nitrogen was converted to crude protein by multiplying with 6.25. Carbohydrates were determined by difference. All determinations were performed in duplicate.

The minerals were analysed by dry-ashing the samples at 550 °C to constant weight and dissolving the ash in volumetric flasks using distilled, deionised water with a few drops of concentrated hydrochloric acid. Sodium and potassium were determined by using a flame photometer (Model 405, Corning, UK), using NaCl and KCl to prepare the standards. Phosphorus was determined colourimetrically using Spectronic 20 (Gallenkamp, UK) as described by Pearson (1976) with KH_2PO_4 as the standard. All other metals were determined by atomic absorption spectrophotometer (Perkin-Elmer Model 403, Norwalk CT, USA). All determinations were done in duplicate. All chemicals used were of analytical grade (BDH, London). Earlier, the detection limits of the metals had been determined according to Techtron (1975). The optimum analytical range was 0.1 to 0.5 absorbance units with a coefficient of variation of 0.87-2.20%. All the proximate values were reported as g/100 g, while the minerals were reported as mg/100 g.

Phytate was quantified using the method described by Harland and Oberleas (1986). The blank was also prepared as described by Harland and Oberleas. The colourimeter used was a Spectronic 20 (Gallenkamp, UK). The amount of phytate

Table 1. The part used, scientific and vernacular names of the Nigerian spices analysed

Identification number	Common English name	Vernacular name (Y)[a]	Botanical name	Part[b] used
S_{11}	Ethiopian pepper	eeru	*Xylopia aethiopica*	fruit
S_{12}	black pepper	iyere	*Piper guineense*	fruit
S_{13}	African nutmeg	ariwo	*Monodora myristica*	seed
S_{14}	ginger	aje	*Zingiber officinale*	rhizome
S_{15}	alligator pepper	atare	*Aframomum melegueta*[c]	seed
S_{16}	alligator pepper	atare	*Aframomum melegueta*[d]	seed
S_{17}	garlic	ayuu	*Allium sativum*	bulb
S_{18}	clove	konofuru	*Eugenia caryophyllus*	fruit
S_{19}		aridan	*Tetrapleura tetraptera*	seed
S_{20}		aridan	*Tetrapleura tetraptera*	seedcoat
S_{21}	cinnamon		*Cinnamomum tamala*	leaf
S_{22}	nutmeg		*Monodora fragrans*	seed
S_{23}	rose seed		*Rosa* sp	seed

[a]yoruba; [b]all parts used were dry; [c]bigger variety; [d]smaller variety

in the sample was calculated as hexaphosphate equivalent by using the formula:

phytate, mg/g sample = “mean K” x A x 20/(0.282 x 1000)

where:

A: absorbance
“mean K”: std P(μg)A/n (std)
phytate: 28.2% P; the phytate values were reported in mg/100 g

Statistical analysis of the samples. Calcium/phosphorus (Ca/P) and sodium/potassium (Na/K) ratios were calculated for all the samples (Nieman *et al.,* 1992). The fatty acid values were obtained by multiplying crude fat value of each sample with a factor of 0.8 (i.e., crude fat x 0.8 = corresponding fatty acid value) (Paul and Southgate, 1978). The energy values were calculated by adding up the carbohydrates (x17 kJ), crude protein (x17 kJ) and crude fat (x37 kJ) for each of the samples (Kilgour, 1987). The phy:Zn, Ca:phy and Ca x phy:Zn values were calculated according to the method of Wyatt and Triana-Tejas (1994). Mean, standard deviations and coefficients of variation were also calculated. Also, F test calculations were done to find out if significant differences occurred in the various parameters determined among themselves, setting the level of significance at $P < 0.05$ (Christian, 1980).

Results and Discussion

The data on the proximate composition, energy and fatty acid values of the spices are shown in Table 3. The moisture content ranged between 1.10-12.23 g/100 g with a grand mean value of 3.61±3.56 g/100 g. The low values of moisture in most of the samples ensured a long shelf life of the samples without microbial spoilage but the large variation resulted in high value of coefficient of variation (CV) among them, which was 98.61. The dry matter values were generally close with

Table 2. Arrangement of samples in phylogenetic sequence of Orders and Families

Botanical grouping	Identification	Species
A. Angiospermae, Dicotyledons		
Division Archichlamydeae		
Order Annonales		
Family Annonaceae	S_{22}	*Monodora fragrans*
	S_{13}	*M. myristica*
	S_{11}	*Xylopia aethiopica*
Order Laurales		
Family Lauraceae	S_{21}	*Cinnamomum tamala*
Order Piperales		
Family Piperaceae	S_{12}	*Piper guineense*
Order Myrtales		
Family Myrtaceae	S_{18}	*Eugenia caryophyllus*
Order Rosales		
Family Rosaceae	S_{23}	*Rosa* sp
Order Fabales		
Family Fabaceae	S_{19}	*Tetrapleura tetraptera* (seed)
	S_{20}	*Tetrapleura tetraptera* (seedcoat)
B. Angiospermae, Monocotyledons		
Division Calyciferae		
Order Zingiberales		
Family Zingiberaceae	S_{15}	*Aframomum melegueta*[c]
	S_{16}	*Aframomum melegueta*[d]
	S_{14}	*Zingiber officinale*
Division Corolliferae		
Order Liliales		
Family Allaceae	S_{17}	*Allium sativum*

a mean value of 96.39±3.56 g/100 g and low value of CV (3.69). The crude fat values varied highly with values ranging between 1.03-38.46 g/100 g with a high CV of 183.50, hence this sample fits into the group of oil seeds (Adeyeye *et al.,* 2000) as reported for sugarnut (*Irvingia gabonensis*) (Oshodi and Ipinmoroti, 1990). Fat is important in diets because it promotes fat soluble vitamin absorption (Bogert *et al.,* 1994). It is a high energy nutrient and does not add to the bulk of the diet. The crude fibre values were high (except in sample S_{20}, *Tetrapleura tetraptera*) having a mean of 27.0±17.34 g/100 g. Dietary fibre has beneficial effects on the muscles of the large and small intestines (Fisher and Bender, 1995) and prevents diseases such as colon diverticula (Eastwood, 1974). The crude protein was low to high in value (5.73-38.92 g/100 g). Hot spots for the protein values were observed in S_{22} (*Monodora fragrans*, 38.92 g/100 g) and S_{23} (*Rosa* sp., 30.12 g/100 g). These values were better than the results in dry bell pepper (18.28 g/100 g) and cherry pepper (18.67 g/100 g) (Adeyeye and Otokiti, 1999). An adult man of 70 kg body weight requires 0.57 g/kg of protein (FAO/WHO, 1973), i.e., 39.9 g of protein daily. This meant that samples S_{22} and S_{23} would almost supply the required protein, assuming complete protein absorption. The available carbohydrates were high for most of the samples with the exception of S_{13} (*Monodora myristica*, 5.49 g/100 g) and S_{22} (*Monodora fragrans*, 17.94 g/100 g). The ash levels ranged between 1.72-8.48 g/100 g. The ash content is a reflection of the mineral content obtained in this study.

The calculated fatty acid values showed that many of the samples have very low values, < 0.1 g/100 g. However, S_{13} (*Monodora myristica*) had a value of 30.77 g/100 g fatty acids. This sample needs a further study to evaluate the nutritional quality of the fatty acid composition. The calculated metabolisable energy values showed that most of the samples were concentrated sources of energy. The energy from cereals ranged from 1.3-1.6 MJ/100 g (Paul and Southgate, 1978) indicating that most of the samples have energy concentrations favourably comparable to cereals.

All the parameters were subjected to F test analysis and the following parameters were significantly different (P < 0.05) among themselves, moisture, dry matter, crude fat, crude fibre, crude protein and fatty acids. The statistical comparison was based on between the groups' variations. This is so, as comparison within the group variation would not make any sense because of the small number of samples within the groups (Table 3).

Table 3. Fatty acid, energy and proximate composition (g/100 g) of spices analysed (dry weight basis) with respect to the groups

Sample identification/ statistical test	Moisture	Dry matter	Crude fat	Crude fibre	Crude protein	Fatty acids[a]	Carbo-hydrates	Total ash	Energy[b]
S_{11}	7.36	92.64	5.21	36.65	10.85	4.17	34.63	5.30	965.93
S_{12}	1.34	98.66	2.54	18.45	12.33	2.03	57.98	7.36	1289.25
S_{13}	8.69	91.31	38.46	32.25	13.20	30.77	5.49	1.91	1740.75
S_{14}	1.62	98.38	2.60	19.73	5.53	2.08	62.88	7.64	1259.17
S_{15}	1.32	98.68	1.20	62.02	8.45	0.96	23.94	3.07	595.03
S_{16}	1.21	98.79	1.34	57.71	7.00	1.07	29.29	3.45	666.51
S_{17}	2.32	97.68	2.10	18.50	14.66	1.68	57.75	4.67	1308.67
S_{18}	1.12	98.88	3.45	19.53	5.73	2.76	65.12	5.05	1332.10
S_{19}	1.10	98.90	1.03	13.23	9.67	0.82	70.09	4.88	1394.03
S_{20}	12.23	87.70	1.34	1.34	8.56	1.07	74.45	2.01	1460.75
S_{21}	2.14	97.86	5.53	15.68	14.08	4.42	58.72	3.85	1442.21
S_{22}	3.12	96.88	3.68	34.62	38.92	2.94	17.94	1.72	1102.78
S_{23}	3.25	96.75	2.55	21.34	30.12	2.04	34.26	8.48	1188.81
$\bar{X}$[c]	3.61	96.39	5.46	27.00	13.78	4.37	45.58	4.57	1211.23
SD[d]	3.56	3.56	10.02	17.34	9.84	8.02	22.25	2.22	317.64
CV[e]	98.61	3.69	183.50	64.22	71.41	183.52	48.82	48.58	26.22
F test	14.1	352.9	1073.2	7.6	36.2	742.5	3.5	2.4	3.4
Difference	*	*	*	*	*	*	ns	ns	ns

[a]calculated fatty acids (0.8 x crude fat); [b]energy, calculated metabolisable energy (kJ/100g) (protein x17 + fat x37 + carbohydrates x17); [c]$\bar{X}$, mean; [d]SD, standard deviation; [e]CV, coefficient of variation; *significant value; ns, non-significant value

The results of the mineral analysis are shown in Table 4. Lead, copper and cobalt were not detected in any of the samples. The samples may generally be regarded as good sources of sodium, potassium, calcium, magnesium, zinc, iron and phosphorus. Calcium in conjunction with phosphorus, magnesium, manganese, vitamins A, C and D, chlorine and protein, are all involved in bone formation (Fleck, 1976). Calcium is also important in blood clotting, muscle contraction and in certain enzymes in metabolic processes. Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves (Shils, 1973). Phosphorus assists calcium in many body reactions although it also has independent functions (Fleck, 1976). Sodium and potassium are required to maintain osmotic balance of the body fluids, pH of the body, regulate muscle and nerve irritability and control of glucose absorption (Fleck, 1976; Pike and Brown, 1967). Iron is reported to be very important for normal functioning of the central nervous system (Vyas and Chandra, 1984). Iron also facilitates the oxidation of carbohydrates, proteins and fats. Zinc is present in all tissues of the body and it is a component of more than fifty enzymes (Bender, 1992). Consumption of meat (or other animal products) with vegetables enhances the absorption of both iron and zinc (Bender, 1992; National Academy of Sciences, 1971). The values for most of the minerals have positive correlation with the corresponding mineral values in bell and cherry peppers (Adeyeye and Otokiti, 1999). Table 4 also depicts the Na/K and Ca/P ratios. Modern diets, which are rich in animal proteins and phosphorus may promote the loss of calcium in the urine (Shils and Young, 1988). This has led to the concept of the Ca/P ratio. If the Ca/P ratio is low (low calcium, high phosphorus intake), more than the normal amount of calcium may be lost in the urine, decreasing the calcium level in bones. In animals, a Ca/P ratio above two (twice as much calcium as phosphorus) helps to increase the absorption of calcium in the small intestine. Such samples in the present results included S_{11}, S_{14}, S_{21}, S_{22} and S_{23}, which may help in increasing the calcium content of bones. Food is considered "good" if the ratio is above one and "poor" if the ratio is less than 0.5 (Nieman *et al.,* 1992). This means that 38.46% of the studied samples were poor in Ca/P ratio. Sodium to potassium ratio (Na/K) is also of significance, but the Na/K ratio of 0.6 is recommended (Nieman *et al.,* 1992). About 23.08% of the samples had Na/K values greater than 0.6, while about 76.92% had lower than 0.6. This result showed that most of the spices would not promote high blood pressure. The F test values at $P < 0.05$ showed that Na, K, Ca, Mg, Zn, Fe, Na/K and Ca/P were significantly

Table 4. Mineral composition (mg/100 g) of spices analysed (dry weight basis) with Na/K and Ca/P ratios with respect to between the groups' variations

Sample identification/ statistical test	Na	K	Pb	Ca	Mg	Cu	Zn	Fe	Co	P	Na/K ratio	Ca/P ratio
S_{11}	180	90	nd[a]	270	130	nd[a]	10	360	nd[a]	70	2.0	3.86
S_{12}	120	50	nd[a]	170	270	nd[a]	10	100	nd[a]	1550	2.4	0.11
S_{13}	180	1090	nd[a]	200	110	nd[a]	10	50	nd[a]	2040	0.17	0.10
S_{14}	130	980	nd[a]	340	150	nd[a]	10	2	nd[a]	80	0.13	4.25
S_{15}	110	4120	nd[a]	170	90	nd[a]	10	60	nd[a]	1040	0.03	0.16
S_{16}	240	5540	nd[a]	290	20	nd[a]	10	30	nd[a]	980	0.04	0.30
S_{17}	190	2750	nd[a]	1330	240	nd[a]	40	80	nd[a]	1120	0.07	1.19
S_{18}	60	150	nd[a]	400	100	nd[a]	10	100	nd[a]	540	0.40	0.74
S_{19}	630	340	nd[a]	680	240	nd[a]	20	70	nd[a]	1090	1.85	0.62
S_{20}	60	2440	nd[a]	130	100	nd[a]	4.0	1.0	nd[a]	590	0.02	0.22
S_{21}	180	700	nd[a]	1580	330	nd[a]	3110	40.00	nd[a]	130	0.26	12.15
S_{22}	180	690	nd[a]	270	460	nd[a]	650	20.00	nd[a]	130	0.26	2.08
S_{23}	120	2140	nd[a]	740	920	nd[a]	1760	30.00	nd[a]	260	0.06	2.85
$\bar{X}$	183.08	1621.54		505.38	243.08		434.92	72.54		740	0.59	2.20
SD	144.19	1703.99		463.24	235.74		945.86	92.38		624.64	0.87	3.32
CV	78.76	105.08		91.66	96.98		217.48	127.35		84.41	147.46	150.91
F test value	23.90	25.80		76.6	30.6		61873.18	69.9		2.7	13.5	262.0
Difference	*	*		*	*		*	*		ns	*	*

nd[a], not detected; *significant value; ns, non-significant value different among themselves. The statistical comparison was done between the variation in groups.

The phytate, phy/Zn, Ca/phy and [Ca] [phy]/[Zn] levels of the spices are shown in Table 5. All the phytate values in this report were higher than those reported for *Capsicum annuum*, *Piper nigrum*, *Hibiscus esculentus*, *Lycopersicon lycopersicum*, *Allium cepa* and *Irvingia gabonensis* (Adeyeye *et al.,* 2000). The above trend was not consistent for phy/Zn and Ca/phy values in the current report and literature values enumerated above. A high incidence of suboptimal zinc status may exist among rural populations of low income countries consuming cereal-based diets, low in animal products (Prasad, 1983). Indeed, the first case of severe zinc deficiency in humans was reported among rural populations in Egypt and Iran (Halsted *et al.,* 1972; Sandstead *et al.,* 1967; Prasad *et al.,* 1963), where 50-75% of the dietary energy was provided by cereals (Reinhold *et al.,* 1973). The high phytic acid level of cereals in these diets was probably a significant etiological factor in the development of zinc deficiency (Davies, 1982).

Oberleas and Harland (1981) reported that foods with a molar ratio of phy:Zn less than 10 showed adequate availability of Zn, while problems were encountered when the value was greater than 15. In Table 5, samples S_{11}, S_{12}, S_{17}, S_{18}, S_{19}, S_{21}, S_{22} and S_{23}, i.e., in 61.54% of the samples, had phy:Zn ratio less than 15. This means Zn in 61.54% of the samples would be bioavailable. Franz *et al.* (1980) demonstrated a lower availability of Zn in rats when fed with foods of high molar ratios of phy:Zn. In human studies, phy:Zn molar ratios of 15:1 have also been associated with reduced zinc bioavailability (Turnlund *et al.,* 1984). The high phy:Zn molar ratio in most of the Nigerian diets may have serious implications, furthermore, because animal products, which are the alternative sources of zinc, are sold at unaffordable prices, particularly to the rural Nigerians (Adeyeye, 1996).

The solubility of the phytates and the proportion of zinc bound in a mineral complex in the intestines depends on the levels of calcium (Wise, 1983). In this model, phytate precipitation is not complete until dietary Ca:phy molar ratios attain a value of approximately 6:1. At Ca:phy molar ratios lower than 6:1, phytate precipitation is incomplete, so that some of the dietary zinc remains in solution. The proportion remaining in solution increases with decreasing Ca:phy molar ratios (Wise, 1983). In the present studies, only samples S_{17}, S_{18}, S_{19}, S_{21}, S_{22} and S_{23} were above the critical molar ratio of 6:1. These accounted for 46.15% of the samples studied. In the typical rural Nigerian diet, however, a leaf, leg-

Table 5. Phytate and calculated phy:Zn, Ca:phy and [Ca] [phy]/[Zn] molar ratios of the spices analysed (dry weight basis)[a] with respect to between the groups' variations

Sample identification/ statistical test	Phytate[b] (phy) (mg/100g)	phy/Zn[c]	Ca/phy[d]	[Ca] [phy][e]/ [Zn]
S_{11}	845	8.42	5.26	0.57
S_{12}	1141	11.37	2.45	4.88
S_{13}	1648	16.42	0.20	0.83
S_{14}	6210	61.90	0.90	5.31
S_{15}	2154	21.47	1.30	0.92
S_{16}	2070	20.63	2.31	1.52
S_{17}	972	2.41	22.53	0.80
S_{18}	929	9.26	7.09	0.94
S_{19}	887	4.39	12.62	0.73
S_{20}	2873	71.36	0.74	2.34
S_{21}	820	0.03	31.79	0.01
S_{22}	390	0.06	11.42	0.004
S_{23}	540	0.03	22.51	0.01
$\bar{X}$	1652.08	17.52	9.32	1.45
SD	1546.42	13.10	10.32	1.74
CV	93.60	131.84	110.73	120.00
F test value	70.9	48.9	19.15	45.79
Difference	*	*	*	*

[a]mean of duplicate determinations; [b]phytate content calculated by assuming that it contains 28.2% phosphorus; [c]mg of phy/MW (molecular weight) of phy: mg of Zn/MW of Zn; [d]mg of Ca/MW of Ca: mg of phy/MW of phy; [e][mol/kg Ca] x [mol/kg phy] / [mol/kg Zn]; *significant value

ume, or fish relish is always consumed with spices as seasoning agents. Such relishes, with the exception of legumes, are high in calcium (Adeyeye *et al.,* 2000). Hence, the calcium content of the relishes in these diets may be sufficient to promote phytate-induced decrease in zinc bioavailability (Ferguson *et al.,* 1988). Ferguson *et al.* (1989) showed that the molar ratio varies with different foods and recommended that this value be used in conjunction with other data to explain the availability of Zn using the Ca:phy ratio.

The results for [Ca] [phy]/[Zn] are shown in Table 5. Ellis *et al.* (1987), and Davies and Warrington (1986) indicated that the ratio of Ca x phy:Zn is a better predictor of Zn availability and noted that if the value was greater than 0.5 mol/kg, then there would be interference with the availability of Zn. In the present results, Ca x phy:Zn values were greater than 0.5 mol/kg in S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19} and S_{20} samples, in other words 76.92% of the samples would interfere with the Zn bioavailability. However, 23.08% of the samples would promote Zn bioavailability among the spices, which had the following corresponding mol/kg molar ratios: S_{21} (0.01), S_{22} (0.004) and S_{23} (0.01). This means only samples S_{21}, S_{22} and S_{23} could satisfy the critical values of phy:Zn (< 10-15), Ca:phy ($\leq$ 6.0) and Ca x phy:Zn ($\leq$ 0.50 mol/kg). Statistical values of F test ($P < 0.05$) showed that phytate, phy:Zn, Ca:phy and Ca x phy:Zn were all significantly different among themselves based on between the groups' variations.

There is a special delicacy in Nigeria called "pepper soup" prepared mainly from fish or meat, water, salt and pepper. The pungent taste of red pepper is due to capsaicin ($C_{18}H_{27}NO_3$) while the pungent taste of black and white peppers is due to the alkaloid piperine ($C_{17}H_{19}NO_3$). The piperine content of pepper is as high as 5%. Formation of N-nitrosopiperidine, a mutagen, by the reaction of nitrite with piperine in an acid solution (human stomach is acidic) has already been reported (Rao *et al.,* 1981). Also, cooked meat is often laced with spices around its whole body surface (suya) before being consumed. Nigerian peasants normally consume large quantities of fruits and vegetables in their diet and these food materials usually contain ascorbic acid in appreciable amounts. This habitual ingestion of vitamin C in the diet is bound to ameliorate the toxic effect of N-nitrosopiperidine as reported by Greenblatt (1973).

Conclusion

Looking at the spice samples across board (Table 3-5) it is observed that samples S_{21} (*C. tamala*), S_{22} (*M. fragrans*) and S_{23} (*Rosa* sp.) have low moisture content, average crude fat, high crude fibre, high crude protein, moderate fatty acids and high metabolisable energy. These three are very good sources of Na, K, Ca, Mg, Zn and non-hazardous Na/K and Ca/P ratios. They have the lowest values for phytate and phy:Zn, good values for Ca:phy and lowest values for Ca x phy:Zn, thereby making them the best among the samples. It is, however, advocated that the level of research devoted to the investigation of the nutritional qualities of spices be increased to cover all the spices available in Nigeria. This is because they are less expensive and replacing synthetic seasoning agents which have been blamed for promoting high blood pressure. Where their consumption may interfere with zinc bioavailability, meat or fish or leaves could be eaten with them to get enough supply of calcium in the diet.

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