Original Research Article

Effects of different extracting solvents on non-phenolic phytochemical profiles of some Nigerian spices and spice-treated foods

ABSTRACT

The aim of this research was to investigate the impact of extraction solvents on the ono-phenolic phytochemical profiles of some spices in Nigeria. The alkaloid, saponin, oxalate, phytate contents of the spices *Ocimum viride*, *Monodora myristica*, *Monodora tenuifolia* and *Tetrepleura tetrapetra* and the spice-treated foods in five different extracting solvents were screened using standard methods. Yields (%) of extracts were small (0.32 - 0.96 %) and varied widely among extracting solvents, spices and spice-treated foods. *M. myristica* and *T. tetrpleura* had the highest yield, 0.96, in methanol extracts. Phytochemical contents differed significantly ($p < 0.05$) among spices, extracts of the same spice and among spice-treated foods. Spices had high contents of oxalate (2.0 – 7.0 mg/100g), alkaloid (0.8 – 5.76mg/100g) and phytate (2.14 – 3.88mg/100g) but relatively low content of saponin (0.03 – 0.736 mg/100g). Methanol alone or in combination with other solvents extracted higher amounts of phytochemicals than other solvent mixtures from the spices. Phytochemical contents of spice-treated foods were in the order: vegetable > rice > pork > beef.

Keywords: Spices. Nigerian spices. Phytochemicals. Extraction solvents, non-phenolic compounds.

1. INTRODUCTION

In Nigeria, a high proportion of the rural and urban population resort to natural food ingredients, particularly because of their availability. Spices are a large group of such natural ingredients, and include dried seeds, fruits, roots, rhizomes, barks, leaves, flowers and any other vegetative substances used in a very small quantity as food additives to colour, flavour or preserve food [1].

Spices are fragrant, aromatic and pleasant. Only very small fractions of dry matter of the spices, the phytochemicals are responsible for these flavouring, colouring, preservative and health-promoting characteristics [2,3].

Phytochemicals are either phenolic or non-phenolic. Phenolic phytochemicals have at least one phenol ring in their structures and are usually good hydrogen donors, exhibiting antioxidant activities in plants, foods and human. Non-phenolic phytochemicals are numerous, belonging to diverse homologues with different structures and properties, performing numerous functions in both plants and animals. Common non-phenolic phytochemicals include alkaloids, trypsin inhibitors, oxalate, hemogglutinin, saponin and phytate. At above certain thresholds in raw food, they constitute antinutritional factors. However, traditional home cooking drastically reduce them to allowable levels in food. Most non-phenolic phytochemicals have been associated with antimicrobial activities and numerous physiological activities in mammalian calls [4, 5].

Both epidemiological and clinical studies have proven that phytochemicals present in plants are mainly responsible for reduced incidence of chronic and degenerative diseases among populations whose diets are high in plant foods [6]. Phytochemicals are health-promoting and are of many disease-preventive [1, 7]. Many phytochemicals can have profound physiological effects, mimicking body hormones and suppressing development of diseases in the body [8, 9, 10]. As a result there has been an increased search for phytochemicals with antimicrobial potency for preservation and heath promoting of consumers. Many plants containing alkaloids have diuretic, antispasmodic, anti-inflammatory and analgesic effects [11]. Phytochemical compositions of many spices of international trade like rosemary, garlic and ginger have been evaluated for these important constituents since such information is important for more practical and industrial applications. Unfortunately there are no documented reports on phytochemical composition of many Nigerian spices. This study evaluated non-phenolic phytochemical composition of M*onodora tenuifolia, Monodora myristica, Ocimum viride* and *Tetrapleura tetrapetra*. These spices are commonly consumed in Nigeria.

2. MATERIALS AND METHODS

2.1 Materials

The spices *Tetrapleura tetrapetra (*Schum & Thonn*)* [12], *Monodora myristica* (Gaertn) [13], *Monodora tenuifolia (*Benth) [14] and *Ocimum viride* (Willd) [15] were purchased from

commercial stockers at Nsukka in Enugu State, Nigeria. Fresh beef and pork (thigh muscle) were purchased from meat sellers at the Ikpa market, Nsukka, Nigeria. The beef and pork were frozen ($4^{O}C$) overnight and thawed the following day before use. All the reagents used were of analytical grade.

2.2 Extracting solvents

Five solvent systems comprising distilled water, 95 % methanol, acetone / hexane (1:1 v/v), n-hexane / methanol / acetone (2:1:1, v/v/v) and acetone / water / acetic acid (70:29.5:0.5, v/v/v) were appropriately prepared based on the solvency of the constituent solvents and solubility characteristics of the extracting phytochemicals.

Determination of alkaloid content

The alkaloid content was determined using the gravimetric method of [16]. Ground sample of each spice or food (5.0 g) was dispersed in 50 ml of each solvent in 250 ml volumetric flask, shaken vigorously and allowed to rest for 4h before being filtered through what man no. 5 filter paper. Filtrates were then evaporated to one quarter (1/4) of original volumes and concentrated ammonium hydroxide (NH_4OH) added drop-wise to precipitate alkaloids. The mixtures were then filtered through weighed filter paper and washed with 1% ammonium hydroxide solution. The filter paper and residue (alkaloids) were oven-dried at $60^{O}C$ for 30 min. and alkaloids contents determined by weighing.

2.3 Determination of phytate content

Phytate content was determined according to the method of [17]. Four grams (4.0 g) of the spice sample was soaked in 100 ml of the appropriate solvents for 3 h and then filtered through what man no. 2 filter paper. The filtrate (25ml) was pipetted into 50ml conical flask, and 5ml of 0.3% ammonium thiocyanate solution and 53.5 ml of distilled water were added. The mixture was titrated against standard Iron (iii) Chloride solution (containing 0.00195 g

Fe^{3+}/ml) until a brownish yellow colour persists for 5min. Phytate content was expressed as percentage (%) phytate in the spice sample.

2.4 Determination of oxalate content

Oxalate content was determined as described by Oke [18]. A blend of each ground spice or food sample (1.0 g) was mixed with190 ml of appropriate solvent and 10 ml of 6M hydrochloric acid (HCl). This was digested at 90^{O}C for 4 hours, and then centrifuged at 2000 rpm for 5 min. The supernatant was diluted to 250 ml with distilled water and titrated with concentrated ammonium hydroxide solution until the pink colouration changed to endpoint faint yellow colour, using methyl orange indicator. This was heated (90^{O}C, 20min.) and 10ml of 5% calcium chloride ($CaCl_2$) solution added to precipitate calcium oxalate. This was rested overnight, centrifuged and decanted. The residue was oven-dried at 60^{O}C for 48 h, cooled and then weighed. This was done in triplicates and the mean weight expressed as percentage oxalate content using the expression,

% Oxalate content = weight of oxalate / weight of spice sample x 100 /1.

2.5 Determination of saponin content

Ground sample (1 g) of each spice or food sample was macerated in 10 ml of each solvent system and the extract decanted into a 50ml beaker. The residue was re-extracted with another 10ml of solvent, allowed to rest and then decanted into the formal beaker. The pooled extracts were evaporated to dryness and the residue re-dissolved in 6ml of ethanol and allowed to stand for 30min for colour development. Absorbance of the ethanol extract was read at 550 nm and used to extrapolate saponin content from a standard curve.

2.6 Statistical analysis

Data generated from all analysis were subjected to analysis of variance and means where significant ($p < 0.05$) were separated with Fisher's least significant difference using Statistical Package for Social Sciences (SPSS) version 13.0.

3 RESULTS AND DISCUSSION

3.1 Yield of spice extracts as affected by different solvents

Table 1 shows percentage yields of crude extracts from spices as affected by different extracting solvents. Very small amounts (0.32 - 0.96%) of the spices were extracted by the extracting solvents. Yields (%) varied widely among spices and also among different solvent extract of the same spices. Methanol (95%) maintained highest yields of 0.96% with *M. myristica* and *T. tetrpleura*. Also methanol in combination with hexane and acetone maintained relatively good yields (0.52 - 0.88%) of extracts among spices. Water and acetone/water/acetic acid solvents maintained close range of yields among the spices. Yields of extracts with water were relatively low (0.32 - 0.68%) compared to yields of extracts (0.73 - 0.80%) with acetone/water/acetic acid.

The solvents are all food grade solvents generally regarded as safe (GRAS). Similar solvents including absolute water, aqueous mixture of ethanol, methanol, hexane and acetone, absolute methanol, 80% methanol, 70% methanol, 95% ethanol, 80% ethanol, 70% ethanol, 80% acetone, 70% acetone and 50% acetone have been used to extract antioxidants from fruits, vegetables, legumes and cereals [19, 20, 21].

Yields of extraction have not always coincided with antioxidant and antimicrobial activities of extracts. This is because yields of extractions and composition of yields correlate independently on the types of solvents with varying polarities and pH,

extraction time and temperature. Under the same condition of extraction, time and temperature, the solvent used and chemical properties of the food samples remain the two most important factors [22, 23]. Thus, high yields of extracts may not always imply high phytochemical content, antioxidant and antioxidant activities of extracts.

Table 1: Yield (%) of crude extracts of spices as affected by different extracting solvents

Spices	Yields (%) of spice extracts as affected by different extracting solvents					
	ER	**OL**	**AW**	**ONE**	**AN**	**MEAN**
Monodora myristica	0.32	0.96	0.80	0.49	0.88	0.69
Monodora tenuifolia	0.32	0.56	0.80	0.60	0.56	0.57
Ocimum viride	0.68	0.32	0.76	0.76	0.52	0.61
Tetrapleura tetrapetra	0.32	0.96	0.73	0.32	0.60	0.58

ER = distilled water, OL = 95% methanol, ONE = acetone/hexane (1:1; v/v), AN = hexane/methanol/acetone (2:1:1; v/v/v/v), AW = acetone/water/acetic acid (70:29.5:0.5; v/v/v)

3.2 Effects of different extraction solvents on non-phenolic phytochemical profiles of the spices

3.2.1 Alkaloid

Alkaloid content of five different solvent extracts from four Nigerian spices is presented in Table 2. Spice extracts from different extraction solvents differed significantly (P= .05) in their alkaloid content. The alkaloid content of *Monodora myristica* from different extraction solvents ranged from 2.07 to 5.76mg/100g, *Monodora tenuifolia* from 0.80 to 6.54mg/100g, *Ocimum viride* from 3.64 to 5.42mg/100g, and *Tetrapleura tetrapetra* from 2.85 to 5.08 mg/100g.

Generally, alkaloid content of the four spices were significantly (*P*= .05) affected by the different solvents used. The alkaloid contents of the spices as affected by the extracting solvents were in the following order from high to low: acetone/hexane (1:1; v/v) >acetone/water/acetic acid (70:29.5:0.5; v/v/v) > hexane/methanol/acetone (2:1:1; v/v/v) > 95% methanol > distilled water for *monodora myristica*; acetone/water/acetic acid > acetone/hexane > 95% methanol > hexane/methanol/acetone > distilled water for *Monodora tenuifolia*; hexane/methanol/acetone > distilled water > acetone/hexane > 95% methanol, and acetone/water/acetic acid for *Ocimum viride*; and acetone/water/acetic acid (70:29.5:0.5; v/v/v) > acetone/hexane > 95% methanol > hexane/methanol/acetone > distilled water for *Tretapleura tetrapetra*. These results suggest that types of spices being extracted and types of solvent used influence the quantity of alkaloid extracted. It was also evident that the solvents work better when in combination than when used singly for alkaloid extraction from the spices. Distilled water was the weakest extraction solvent while acetone in combination with the other solvents, including hexane, methanol, acetic acid and distilled water was the best extraction solvent.

The presence of alkaloids in plants such as *Moringa oleifera* elevated the plant to such an important position to treat hypertension. Many plants containing alkaloids and flavonoids have diuretic, antispasmodic, anti-inflammatory and analgesic effect [23, 24]. The high alkaloid content of these spices could account for their popular use in the traditional treatment of hypertension. These secondary metabolites have been associated with numerous physiological activities in mammalian cells in various studies [4, 5, 25, 26].

3.2.2 Oxalate

In order to estimate the potential of oxalate as a bioactive ingredient of selected spices in foods and other biological materials, oxalate content of various solvent extracts of the spices was analyzed, and the results presented in Table 2. Different extraction solvents of the spices differed significantly ($P < 0.05$) in their oxalate contents. The oxalate content of *M. myristica* ranged from 2.0 to 3.5mg/100g; *M. tenuifolia* from 3.5 to 7.0mg/100g; *O. virdie* from 3.0 to 4.0mg/100g; and *T. tetrapetra* from 3.5 to 5.6mg/100g.. The oxalate content yields by the extraction solvents were in the following order from high to low: Acetone/hexane > acetone/water/acetic acid > Distilled water, and hexane/methanol/acetone > 95% methanol for *M. myristica*; distilled water > acetone/water/acetic acid > acetone/hexane and hexane/methanol/acetone > 95% methanol for *M. myristica*; Acetone/water/acetic acid > 95% methanol, and hexane/methanol/acetone > distilled water, and acetone/hexane for *O. viride*; and distilled water > hexane/methanol/acetone > 95% methanol> Acetone/water/acetic acid, and acetone/hexane for *T. tetrapetra*. These results suggest that distilled water was the best among the five extraction solvents for extracting oxalate from *M. tenuifolia* and *T. tetrapetra* while acetone/water/acetic acid was the best solvent for *O. viride*, and acetone/hexane was the best for *M*. *myristica*. Thus, distilled water or distilled water in combination with other solvents seemed to be the best for extracting oxalate from spices. Also *M. tenuifolia* was highest in oxalate content, followed by *T*. *tetrapetra, O. viride* and then *M. myristica*.

The oxalic acid content of vegetables has been used as an index of their toxicity since a high content of it would lower the nutritive value of food [24]. Presence of oxalic acid in plants contributes to antioxidant properties and hence the therapeutic potentials of the spices. Oxalic acid content in food would be an index of toxicity level of the food. However, oxalate at low level advantageously confers antioxidant activity in both food and human. Dietary oxalate has also been shown to complex with calcium, magnesium and iron, forming insoluble oxalate salts which cause oxalate stone [18]. Oxalic acid chelate radical-initiating divalent metals thereby reducing incidence of oxidative degenerative diseases in human.

3.2.3 Saponin

The effects of various solvent extraction systems on recovery of saponin from the selected spices are presented in Table 2. Spice extracts from different extraction solvents differed significantly (P= .05) in their saponin content. Saponin contents of *M. myristica* ranged from 0.01 to 0.74mg/100g; *M. tenuifolia* from 0.01 to 0.29 mg/100g; *O. viride* from 0.14 to 0.62mg/100g; and *T. tetrapetra* from 0.16 to 0.60mg/100g. Generally, saponin content in the four spices was relatively low when compared with the compositions of other non-phenolic phytochemicals. The saponin yields by the extracting solvents were in the following order from high to low: 95% methanol > acetone/hexane (1:1; v/v) > hexane/methanol/acetone (2:1:1; v/v/v) > acetone/water/acetic acid (70:29.5:0.5; v/v/v) > distilled water for *M. myristica*; acetone/water/acetic acid > acetone/hexane > distilled water > 95% methanol > hexane/methanol/acetone for *M. tenuifolia*; hexane/methanol/acetone > acetone/water/acetic acid > acetone/hexane >95% methanol > distilled water for

O. viride; and distilled water > 95% methanol > acetone/water/acetic acid, and acetone/water > hexane methanol/acetone for *T. tetrapetra.* The results showed that saponin contents of the spices was low and differed ($p < 0.05$) significantly among the spices. The spice *T. tetrapetra* had the highest saponin content among the four spices.

Saponins possess carbohydrate moieties attached to tetraprenoid or steroidal aglycones [27]. Saponins constitute a key ingredient in traditional Chinese medicine and are responsible for many of the attributed biological effects. They reduce uptake of glucose and cholesterol through intra-lumenal physicochemical interaction during food transition in the gut. This could confer chemo-protection against heart diseases.

3.2.4 Phytate

Phytate contents of solvent extracts of the four spices are presented in Table 2. The phytate contents of the different solvent extracts ranged from 2.14 to 2.38mg/100g in *M. myristica*; from 3.02 to 5.50mg/100g in *M. tenuifolia*; from 2.32 to 2.62mg/100g in *O. viride*; and from 3.24 to 3.80mg/100g in *T. tetrapetra*. Spice extracts from different extraction solvents differed significantly ($P = .05$) in phytate contents. Meanwhile, each spice had a close range of values of phytate content among its different extraction solvents. The phytate content of the different extraction solvents were in the following order from high to low: acetone/water/acetic acid (70:29.5:0.5; v/v/v), and acetone/hexane (1:1; v/v) > hexane/methanol/acetone (2:1:1; v/v/v) > distilled water, and 95% methanol for *M. myristica*; distilled water > acetone/water/acetic acid , acetone/hexane and hexane/methanol/acetone > 95%

methanol for *M. tenuifolia*; distilled water, 95% methanol and acetone/water/acetic acid > acetone/hexane, and hexane/methanol/acetone for *O. viride*; and acetone/hexane > hexane/methanol/acetone > distilled water > 95% methanol > acetone/water/acetic acid for *T. tetrapetra*. These results suggest that the extractability of phytate by the extracting solvents varied with the type of spice being extracted; and that distilled water was the best extracting solvent for *M. tenuifolia* and *O. viride* while acetone/hexane was the best for *T. tetrapetra*. The spices could serve as good sources of phytate in food and food related systems due to the high content of phytate in them.

Phytate is a natural plant inositol hexaphosphate constituting about 1.5% of many plants [28]. Phytate is a very stable and potent chelating food component that is considered to be an antinutrient by virtue of its ability to chelate divalent metals and prevent their absorption [29]. However, it has also been shown to have anticancer and antioxidant activity. It forms an iron chelate that suppresses lipid oxidation by blocking iron driven hydroxyl radical generation. Metal phytate complexes are highly insoluble over a wide range of pH and as a result inhibit iron-related hydroxyl radical formation by forming an inactive iron-chelate [30].

Presence of phytate in foods has been associated with reduced mineral absorption due to the structure of phytate with high density of negatively charged phosphate groups which can complex with many mineral ions, causing non-availability for intestinal absorption. However, presence of phytate in high fibre foods may reduce the incidence of breast cancer and cardiovascular diseases. Phytates are stable compounds that chelate excess divalent metals and control their excess absorption, thereby lowering the incidence of cancer in human [29, 31].

Table 2: Effects of different extraction solvents on non-phenolic phytochemicals of spices

Spices/solvents	Alkaloid (mg/100g)	Oxalate (mg/100g)	Saponin (mg/100g)	Phytate (mg/100g
Mondora myristica				
Distilled water	2.07^{c}+0.02	2.5^{c}+0.01	0.016^{d}+0.00	2.14^{b}+0.00
95% Methanol	4.88^{b}+0.04	2.0^{d}+0.02	0.736^{a}+0.02	2.15^{b}+0.00
Acetone/water/aceticacid	5.22^{ab}+0.06	3.0^{b}+0.01	0.503^{c}+0.01	2.37^{a}+0.02
Acetone/hexane	5.76^{a}+0.02	3.5^{a}+0.00	0.719^{a}+0.01	2.38^{a}+0.02
Hexane/methanol/Acetone	5.04^{b}+0.01	2.5^{c}+0.00	0.60^{b}+0.01	2.32^{a}+0.02
Monodora tenuifolia				
Distilled water	0.8^{e}+0.01	7.0^{a}+0.04	0.16^{bc}+0.00	5.50^{a}+0.02
95% Methanol	3.66^{c}+0.04	3.5^{c}+0.00	0.10^{c}+0.00	3.02^{c}+0.00
Acetone/water/acetic acid	6.54^{a}+0.03	4.0^{b}+0.01	0.29^{a}+0.01	3.88^{b}+0.10
Acetone/hexane	4.54^{b}+0.05	4.0^{b}+0.01	0.23^{a}+0.00	3.84^{b}+0.04
Hexane/methanol/Acetone	3.05^{d}+0.02	4.0^{b}+0.01	0.06^{a}+0.00	3.84^{bc}+0.02
Ocimum viride				
Distilled water	5.08^{a}+0.03	3.0^{c}+0.01	0.14^{b}+0.00	2.62^{a}+0.02
95% Methanol	3.64^{c}+0.02	3.5^{b}+0.01	0.19^{b}+0.01	2.63^{a}+0.02
Acetone/water/acetic acid	3.73^{c}+0.02	4.0^{a}+0.02	0.4^{a}+0.02	2.61^{a}+ 0.01
Acetone/hexane	4.67^{b}+0.02	3.0^{c}+0.1	0.38^{a}+0.02	2.34^{b}+0.00
Hexane/methanol/Acetone	5.42^{a}+0.01	3.5^{b}+0.02	0.06^{c}+0.05	2.32^{b}+0.04
Tetrapleura tetrapetra				
Distilled water	2.85^{c}+0.01	5.55^{a}+0.04	0.60^{a}+0.02	3.38^{ab}+0.02
95% Methanol	3.96^{b}+0.02	4.0^{b}+0.02	0.44^{b}+0.01	3.24^{bc}+0.02
Acetone/water/acetic acid	5.08^{a}+0.01	3.50^{c}+0.01	0.33^{c}+0.01	2.79^{c}+0.01
Acetone/hexane	4.32^{b}+0.01	3.50^{c}+0.02	0.03^{e}+0.01	3.80^{a}+0.04
Hexane/methanol/Acetone	3.25^{c}+0.08	4.50^{ab}+0.03	0.16^{d}+0.02	3.43^{ab}+0.00

Data are means ± standard deviations (n = 3); values within each type of spice marked by the same letter within the same column are not significantly different ($p < 0.05$).

3.3 Phytochemical composition of cooked spice-treated food extracts

Table 3 shows non - phenolic photochemical composition of cooked food extracts [10 % (w/w)] treated with 2.5% (10 mg/ml) and 7.5% (30 mg/ml) of the spice samples. Phytate, Alkaloid, oxalate and saponin earlier recorded (Tables 2) in theses spices were also present in the cooked spice-treated food extracts and even in the controls (without spice). The food extracts are from plant materials. Phytate (mg/100g) ranged from 0.064 in control pork to 2.94 in rice treated with 7.5% of *O. viride*, alkaloid (mg/100g) from 0.003 in control pork to 9.01 in pork treated with 7.5% of *M. myristica*, oxalate (mg/100g) from 0.023 in control pork to 9.21 in beef treated with 7.5% of *O. viride*, and saponin (mg/100g) from 0.04 in control beef to 2.31 in vegetable treated with 7.5% *M. tenuifolia.* These phytochemicals were lower in these food extracts than in the spices. Vegetable extract had highest content of these chemicals, followed by rice, beef and pork. Thus, food types also influenced the photochemical contents. The control (without spices) beef and pork sample had significantly (P= .05) low contents of these chemicals. In most of the food extracts, phytochemical contents increased slightly with high increase, (from 10mg/ml to 30mg/ml spice concentration, 75% increase), of spices. One would presume at this point that spices have maximum thresholds for photochemical contents in food. This could be attributed to low contents (2.5% and 7.5%) of these spices in the food and also the likely effect of heat in destroying part of these phytochemicals [32]. Phytochemicals are plant metabolites and are richly found in fruits and vegetables. Presence of these photochemical in cooked food extracts confirms that they contribute to preservative and health promoting quality of menu.

Table 3: Non-phenolic phytochemical profiles of water extracts of spice-treated cooked food samples

Food/spices	Spice treatment mg/100g	Alkaloid (mg/100g)	Oxalate (mg/100g)	Saponin (Mg/100g)	Phytate (Mg/100g)
BEEF					
O. viride	10	0.943^{d} ±0.02	4.093^{b}±0.07	0.544^{b}±0.01	0.639^{b}±0.00
	30	1.763^{c} ±0.02	9.218^{a}±0.12	0.772a$^{\pm}$0.03	0.773^{ab}±0.03
M. myristica	10	1.937^{c}±0.08	2.274^{c}±0.06	0.257^{c}±0.03	0.076^{e}±0.00
	30	1.981^{c}±0.20	3.880^{b}±0.04	0.514^{b}±0.0	0.460^{c}±0.00
T. tetrapetra	10	0.813^{d}±0.08	1.490^{d}±0.10	0.257^{c}±0.01	0.774^{ab}±0.02
	30	3.775^{a}±0.03	1.495^{d}±0.01	0.514^{b}±0.02	0.940^{a}±0.03
M. tenuifolia	10	1.485^{c}±0.31	3.558^{b}±0.02	0.257^{c}±0.00	1.165^{a}±0.02
	30	2.252^{b}±0.02	0.779^{e}±0.01	0.772^{a}±0.01	0.064^{d}±0.01
Control	0.00	0.037^{e}±0.00	N.D.	0.043^{d}±0.00	0.070^{d}±0.00
VEGETABLE					
M. myristica	10	2.710^{d}±0.07	5.830^{b}±0.13	0.544^{c}±0.02	1.439^{b}±0.04
	30	3.252^{c}±0.02	8.974^{a}±0.11	0.772^{b}±0.03	2.242^{a}±0.06
O. viride	10	2.195^{e}±0.06	5.976^{b}±0.08	0.557^{c}±0.01	2.711^{a}±0.05
	30	7.2711^{a}±0.30	8.926^{a}±0.12	0.772^{b}±0.01	2.711^{a}±0.10
T. tetrapetra	10	2.375^{e}±0.01	5.386^{b}±0.06	0.772^{b}±0.01	2.038^{a}±0.03
	30	2.710^{d}±0.05	5.716^{b}±0.02	0.772^{b}±0.00	2.465^{a}±0.02
M. tenuifolia	10	2.671^{de}±0.05	5.813^{b}±0.04	0.772^{b}±0.00	1.186^{b}±0.01
	30	4.065^{b}±0.02	8.029^{a}±0.10	2.315^{a}±0.01	2.390^{a}±0.02
Control	0.00	0.489^{e}±0.01	1.773^{c}±0.05	0.579^{c}±0.01	1.106^{b}±0.04
PORK					
M. myristica	10	1.438^{d}±0.01	5.376^{c}±0.09	0.257^{d}±0.00	1.186^{b}±0.05
	30	9.014^{a}±0.02	7.429^{a}±0.11	0.772^{b}±0.02	1.076^{c}±0.01
O. viride	10	0.884^{e}±0.03	4.236^{cd}±0.10	0.243^{d}±0.03	0.768^{d}±0.01
	30	2.239^{c}±0.10	4.856^{cd}±0.03	0.772^{b}±0.01	0.774^{d}±0.03
T. tetrapetra	10	1.42^{d}±0.02	3.557^{d}±0.07	0.257^{d}±0.01	1.838^{a}±0.06
	30	4.136^{b}±0.10	5.635^{c}±0.02	1.543^{a}±0.01	1.816^{a}±0.00
M. tenuifola	10	1.914^{d}c±0.01	1.5824^{e}±0.01	0.772^{b}±0.02	0.170^{b}±0.01
	30	4.673^{b}±0.05	6.155^{b}±0.04	0.514^{c}±0.02	1.140^{b}±0.01
Control	0.00	0.003 ^{f}±0.00	0.023^{f}±0.00	0.514±0.03	0.064e±0.00
RICE					
M. myristica	10	1.084^{b}±0.00	2.593^{b}±0.00	0.510^{c}±0.02	1.897^{c}±0.11
	30	1.562^{b}±0.02	7.015^{a}±0.03	0.772^{b}±0.04	2.224^{b}±0.10
O. viride	10	1.691^{b}±0.10	1.558^{c}±0.01	0.257^{d}±0.01	1.962^{c}±0.04
	30	2.168^{b}±0.11	5.456^{a}±0.31	0.772^{b}±0.07	2.937^{a}±0.01
T. tetrapetra	10	10.295^{a}±0.20	2.598^{b}±0.07	0.772^{b}±0.03	2.156^{b}±0.05
	30	12.194^{a}±0.31	6.353^{a}±0.21	1.713^{a}±0.08	2.560^{b}±0.03
M. tenuifolia	10	1.350b±0.02	1.132c±0.08	0.257d±0.02	1.988c±0.10
	30	2.943b±0.02	3.377b±0.10	1.543a±0.03	2.384b±0.30
Control	0.00	0.466c±0.04	1.015c±0.00	0.529c±0.01	1.330d±0.07

Values are means of three determinations ± standard deviations, N.D. = Not determined.

4. CONCLUSION

The four Nigerian spices possess varying levels of phytochemicals. Spices and solvent extracts of spices differed significantly ($p < 0.05$) in phytochemical contents and the amounts of phytochemicals extracted were influenced by the solvent systems used. Methanol or methanol in combination with other solvents seems was the best extracting solvent for these phytochemicals. However, none of the solvent systems was consistently best in extracting a particular phytochemicals from the spices; suggesting that spice morphology and composition might have influenced extracting capacity of the solvents. Amount of phytate extracted was not significantly ($p > 0.05$) affected by solvent types used. *M. tenuifolia* had the highest alkaloid (6.54 mg/100g), oxalate (7.0 mg/100g) and phytate (5.5 mg/100g) contents, and *M. myristica* the highest saponin (0.719mg/100g) content. The individual phytochemicals should be isolated and characterized, using the best extracting solvents, for biochemical activities.

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