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PHYSICOCHEMICAL AND ANTIOXIDANT PROPERTIES OF TURMERIC (*Curcuma longa*) AND GINGER (*Zingiber officinale*)

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Abstract
The physicochemical properties of two spices, Curcuma longa and Zingiber officinale and the antioxidant activities of their oils were investigated. Proximate composition analysis revealed that the spices were rich in carbohydrates, followed by protein content of 10.68% for C. longa and 9.84% for Z. officinale. Twenty grams of the spices yielded percentage oil contents of about 13.0%. In addition, oils extracted from C. longa and Z. officinale had peroxide values of 7.01meqKOH/g and 6.25meqKOH/g and iodine values of 46.95I_2/100g and 44.95I_2/100g respectively. About 15.85% and 14.18% vitamin E were present in C. longa and Z. officinale respectively. The antioxidant activities of the extracted oils were examined by incorporating them into groundnut oil at varying concentrations and stored at 63°C for 20days. The results showed that antioxidant activities of the extracted oils were significantly lower than that of butylated hydroxytoluene (BHT) but significantly higher than that of the untreated sample, the control.

Keywords: antioxidant activity, *Curcuma longa*, physicochemical properties, proximate composition, *Zingiber officinale*

Introduction

Oxidation of lipids initiates other changes in food which affect its nutritional quality, wholesomeness, colour, flavour, texture and safety. The major cause of food quality deterioration during processing and storage is lipid peroxidation which has been implicated in carcinogenesis, mutagenesis and ageing (Knight, 2000; Devasagayam *et al.*, 2004). Oils are quite susceptible to oxidation during deep-fat frying process.The use of synthetic antioxidants to prevent free radical damage has been reported to involve toxic side effects (Shahidi and Wanasundara 1992), making attractive the search for natural compounds with antioxidant activity. Numerous researchers have demonstrated that plant extracts or their essential oils possessed high antioxidant activity and were used in many food applications (Jayathilakan *et al*., 2007; Juntachote *et al.*, 2007; Ifesan *et al*., 2009a, 2009b).

Curcuma longa (turmeric) and *Zingiber officinale* (ginger) are perennial herbs with a modified fleshy stem termed the rhizome, which occurs below ground. They belong to the family Zingiberaceae and many species have been extensively used as condiment for flavoring as well as for treating stomachache, carminative, diarrhoea, and dysentery (Voravuthikunchai, 2007). Ginger has been used as a spice for over 2000 years (Bartley and Jacobs, 2000). The roots and the extracts contain polyphenol compounds which have been reported to possess high antioxidant activity (Stoilova *et al*., 2007; Chan *et al*., 2008). Ginger is a common additive in a number of commercial foods and beverages and has been valued both for its aromatic volatile constituents and for its spicy, pungent smell. In addition to its aromatic contribution to a food, ginger tea is often used to improve circulation, aid digestion, and treat nausea from motion sickness, pregnancy or chemotherapy (Ernst and Pittler, 2000).

When the roots of *Curcuma longa* are dried and ground, the yellowish-orange powder obtained is called turmeric. It has found application as natural preservative in many foods such as canned beverages, baked products and biscuits, (Chatterjee *et al*., 1998). In addition, turmeric has been reported to decrease blood lipid peroxides in humans (Ramirez-Bosca *et al*., 1997), prevent ulcers (Prucksunand *et al*. 2001) and protects the liver from chemical injury (Song *et al*., 2001).

Regardless of the numerous studies carried out on these spices, studies of the physicochemical properties of the spices and antioxidant activities of the extracted oils are limiting in the literatures. The goal of the present study was to study the physicochemical properties of *C. longa* and Z. *officinale* and assess the antioxidant effectiveness of their oils in groundnut oil.

Materials and Methods

Sample Collection and Preparation

Samples of ginger and turmeric were purchased from a local market in Akure Ondo State, Nigeria. The spices were sorted, rinsed with potable water, sliced and dried in the oven at 50°C for 3days. Dried samples were milled using a hammer mill machine and allowed to pass through a 0.2mm sieve. The samples were packaged in polyethylene bags, sealed and stored for further analysis. All analyses were carried out in triplicates.

Proximate Composition Analysis

The powdered spices were subjected to proximate analysis following the procedure of AOAC (2000).

Determination of physicochemical properties

Analyses of specific gravity, refractive index, peroxide value and iodine value were carried out using the methods of AOAC (2000).

Extraction of Oil from the Spices

The powdered spices were subjected to antioxidant extraction following the modified method of Adegoke *et al*. (2003). Twenty five grams of the sample was extracted with 250ml of hexane in soxhlet extractor. The oil obtained was evaporated to dryness by drying in an oven at 50°C for 10min.

Determination of Vitamin E Content

Modified method of Association of Vitamin Chemist (1987) was used to carry out this experiment. About 0.5g of oil extracted from the spices was weighed into a 100ml beaker containing 40ml of petroleum ether. The mixture was shaken to obtain uniformity and filtered through a whatman filtered paper and made up to mark with petroleum ether. Standard vitamin E (á-tocopherol) were prepared ranging from 25 to 200µg/ml in petroleum ether and treated as standards. Two milliliter of sample and standard petroleum ether were each treated with 10ml of iron dipyridyl in glacial acetic acid and made up to 100ml volume with glacial acetic acid in 100ml volumetric flask. The absorbance of the standards were read on a spectrophotometer at a wavelength of 460nm. Vitamin E in mg/100g was calculated using the formula:

$$\frac{\text{absorbance of sample} \times \text{gradient factor} \times \text{dilution factor}}{\text{Weight of sample}}$$

Application of Oil and Assessment of the Antioxidant Activities

Oil samples from the spices were incorporated into groundnut oil by direct addition and were thoroughly mixed to achieve a uniform dispersion. In order to examine the efficacy of the oil from spices as antioxidants, the inoculated oil samples and the control were subjected to accelerated stability test. The minimum concentration of the oil added was 100ppm while the maximum was 300ppm and BHT was used as control. All the treatments were stored in transparent, uncovered glass jars which were incubated at 63°C in an oven for 20days. Samples were shaken twice daily during storage and monitored for the peroxide value every 5day. Decrease in the rate of formation of peroxides were used as a measurement of the antioxidant activity of the spices.

Results and Discussion

Table 1 shows the proximate composition of *Z. officinale* and *C. longa*. It revealed that the spices have very high carbohydrate contents of 55.15% for ginger and 49.55% for turmeric. The result is comparable with the carbohydrate content of *Aframomum melegueta* (Adegoke *et al*., 2003). This may be an indication that both ginger and turmeric are good sources of carbohydrate. The low percentage yield of oil from ginger and turmeric may be due to their low fat content of 9.63% and 11.12% respectively. Many researchers have reported the chemical composition of ginger but no toxic effect was found.

Table 1. Proximate composition of *Curcuma longa* and *Zingiber officinale*

Characteristics (%)	*Curcuma longa*	*Zingiber officinale*
Ash	13.33 ± 0.01	16.96 ± 0.01
Carbohydrate	55.15± 0.01	49.55 ± 0.01
Crude fibre	2.13 ± 0.01	1.69 ± 0.01
Fat	11.12 ± 0.01	9.63 ± 0.02
Moisture content	7.61 ± 0.01	12.25 ± 0.01
Protein	10.68 ± 0.01	9.84 ± 0.06

The results of the physicochemical analysis of the spices shows that they possess low iodine values of 46.95I_2 /100g and 44.95I_2 /100g for turmeric and ginger respectively (Table 2). The greater the degree of unsaturation the higher the iodine value. The iodine values obtained is lower than that reported for *A. melegueta* (Adegoke *et al.*, 2003). Low level of unsaturation of oil can be of good advantage and such is preferable in cooking (Ogungbenle, 2003). Ginger and turmeric oils possess low iodine values which may imply a high level of saturated fatty acids. This may explain why they are used as component of many food aditives since they are less liable to oxidative rancidity. Apart from the ability of ginger and turmeric to keep foods stable against oxidation, they can also be effective in controlling microbial growth (Stoilova *et al.*, 2007; Voravuthikunchai, 2007). The peroxide values obtained from the spices used in this study were higher compared to that of *A. melegueta* which also belong to the same Zingiberaceae family. However, the peroxide values of ginger and turmeric were lower than the minimum acceptable value of 10meqKOH/kg set by the Codex Alimentarius Commission for oil seed (Abayeh *et al.*, 1998).

Table 2. Physicochemical properties of oil extracted from *Curcuma longa* and *Zingiber officinale*

Characteristics	*Curcuma longa*	*Zingiber officinale*
Colour	Yellow	Brown
Iodine value (I_2 /100g)	46.95 ± 0.1	44.95 ± 0.2
pH	7.30 ± 0.01	7.10 ± 0.01
Peroxide value (meqKOH/g)	7.01 ± 0.2	6.25 ± 0.2
Refractive index	1.45 ± 0.02	1.43 ± 0.01
Specific gravity (g/cm^3)	1.10 ± 0.01	1.05 ± 0.01

Ginger and turmeric oils were found to contain vitamin E content of 14.18% and 15.85% respectively (Table 3). Vitamin E is the most abundant lipid soluble antioxidant and protects the lipid portions of the cell, especially cellular membranes. Tocopherol scavenges free radicals by reacting with lipid peroxyl radicals to produce a tocopheroxyl radical (Kaur and Kapoor, 2001). About 13% of crude oil was obtained from ginger and turmeric. The low fat content of the spices may be responsible for the low yield of oil obtained from the spices.

Table 3. Vitamin E content and % yield of oil extracted from *Curcuma longa* and *Zingiber officinale*

Samples	Vitamin E content (mg/100g)	Yield of extract (%)
Curcuma longa	15.85 ± 0.01	13.01 ± 0.01
Zingiber officinale	14.18 ± 0.02	13.19 ± 0.01

The antioxidant effectiveness of the oil from the spices in groundnut oil at 100ppm is shown in Table 4, while Table 5 revealed the activity of the oil when it was added at 300ppm. The result shows that as the concentration of the oil increases there were decreases in peroxide values. At day 15, addition of ginger oil at 100ppm was able to reduce the peroxide formation from 9.01meqKOH/g in control (sample without antioxidant) to 5.30meqKOH/g in treated groundnut oil.

Table 4. Effect of *Curcuma longa* and *Zingiber officinale* oil (100ppm) on peroxide formation in groundnut oil

Number of days	Control	*Curcuma longa*	*Zingiber officinale*	Butylatedhydroxytoluene
0	6.76 ± 0.02^{a}	6.76 ± 0.02^{a}	6.76 ± 0.02^{a}	6.76 ± 0.02^{a}
5	8.60 ± 0.20^{d}	5.16 ± 0.08^{c}	4.93 ± 0.03^{b}	2.86 ± 0.03^{a}
10	8.80 ± 0.11^{d}	5.43 ± 0.15^{c}	5.06 ± 0.11^{b}	2.95 ± 0.00^{a}
15	9.01 ± 0.11^{d}	5.83 ± 0.03^{c}	5.30 ± 0.15^{b}	3.13 ± 0.03^{a}
20	9.40 ± 0.05^{d}	6.10 ± 0.05^{c}	5.66 ± 0.03^{b}	3.20 ± 0.00^{a}

Values are means ± SD from triplicate determinations, different superscript in the same row are significantly different ($p<0.05$).

Table 5. Effect of *Curcuma longa* and *Zingiber officinale* oil (300ppm) on peroxide formation in groundnut oil

Number of days	Control	*Curcuma longa*	*Zingiber officinale*	Butylatedhydroxytoluene
0	6.76 ± 0.02^{a}	6.76 ± 0.02^{a}	6.76 ± 0.02^{a}	6.76 ± 0.02^{a}
5	8.60 ± 0.20^{d}	4.56 ± 0.03^{c}	4.10 ± 0.05^{b}	2.02 ± 0.00^{a}
10	8.80 ± 0.11^{d}	4.76 ± 0.03^{c}	4.30 ± 0.05^{b}	2.16 ± 0.02^{a}
15	9.01 ± 0.11^{d}	5.00 ± 0.05^{c}	4.56 ± 0.06^{b}	2.24 ± 0.02^{a}
20	9.40 ± 0.05^{d}	5.33 ± 0.03^{c}	4.90 ± 0.05^{b}	2.35 ± 0.02^{a}

Values are means ± SD from triplicate determinations, different superscript in the same row are significantly different ($p<0.05$).

As the concentration of the antioxidant increased to 300ppm, the peroxide value of the treated sample dropped to 4.56meqKOH/g. At both concentrations it was observed that the antioxidant activity demonstrated by BHT was significantly higher than that of the spices. Antioxidant activity demonstrated by ginger in this study is lower when compared to that of ginger reported by Stoilova *et al.* (2007), where the antioxidant effect of ginger ethanolic extract exceeded that of BHT. The difference in origin, climatic conditions, time of harvest and extraction processess and solvent used could have been responsible for the differences in antioxidant effectiveness of the spices. Since the ability to prevent oxidation increased along with increase in concentration of the extracted oil, it may be suggested that further increase in oil concentration beyond the level tested may be able to compete with the antioxidant activity demonstrated by BHT.

Conclusion

Oils extracted from *Z. officinale* and *C. longa* could be good sources of antioxidants in diets since they are locally available. However, further study may focus on purification of the oil since the colours of ginger and turmeric oils are brown and yellow respectively.

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