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PHYSICOCHEMICAL PROPERTIES OF FOUR SELECTED FOOD SPICES OF NIGERIAN ORIGIN: ALLIGATOR PEPPER, BLACK PEPPER, GINGER AND CLOVES

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ABSTRACT

Spices are largely used to enhance the physical, sensory and textural characteristics of foods being very beneficial to human health. Some physicochemical properties of alligator pepper, black pepper, ginger and cloves were investigated, following standard procedures. It was found that water and oil absorption capacity of the spices flour samples were in the range of 127.47-178.68 g of water per 100 g of flour and 106.66-219.18 g of oil per 100 g of flour, while angle of repose, tap bulk density, loose bulk density were in the range of 45.16-50.53°, 0.10-0.59 gcm^3, 0.07- 0.44 gcm^3, respectively. For each of the sieve mesh sizes considered, the flour samples indicated significantly different ($p<0.05$) particle sizes. The fat, crude fibre, ash and protein contents of the spices ranged from 4.17-7.5, 2.31-18.19, 2.84-5.7 and 1.91-13.01 g/100g of dry matter, respectively. Phytochemical screening shows that the spices contain alkaloids, flavonoids, phenols, tannins and saponins in the range of 8.81-51.60%, 4.45-7.54 mg GAE/g, 23.47-41.73 mg GAE/g, 0.68-2.66 mg TAE/100 g and 1.16-6.07 mg/100 g, respectively. These data find relevance in industrial processing of these spices into value added products and promises a boost in income obtainable from spices value chain.

Keywords: Spices, Alligator pepper, Black pepper, Clove, Ginger, Properties.

1. INTRODUCTION

Spices are aromatic vegetable substances used to change or enhance the physical, sensory and textural characteristics of foods. They are available in the form leaves, seeds, rhizomes, bark, root, flowers, seeds or fruits. The volatile oils and aromatic compounds that spices contain influence food aroma, colour and taste. Whether whole, broken or milled, spices can be purposively used as meat tenderizer, food seasoning, preservatives, antimicrobial agents or additives (Shan et al., 2005; Park, 2011; Fasoyiro, 2015). Owing to their hot, spicy, aromatic or pungent characteristics, Nigeria and many other countries in Africa and Asia have a long history in the use of spices as ingredient in local food systems and herbal medicine (Wohlmuth et al., 2005). In addition, many spices have also found application in the pastries, cosmetics, insect repellants, incense and alcoholic drinks industries (Kunnumakkara et al., 2009; Sung et al., 2012). Carlos and Harrison (1999) reported the use of ginger, nutmeg and cinnamon as meat tenderizers and antedote for some throat infections. Occasioned by their good antioxidant properties, alligator pepper, cloves, garlic and ginger have curative effect on certain gastro-intestinal ill-health conditions in African traditional medicine (Ajaiyeoba and Ekundayo, 1999; Ajav and Ogunlade, 2014). Fish/meat barbecue and spicy soup are choice delicacies usually taken with drinks as appetizers during cold weather conditions, ceremonies or evening recreation in many local drinking spots in Nigeria (Kallon, 2004).

Plate 1 shows samples of alligator pepper (*Aframomum melegueta*), ginger (*Zingiber officinale*), African black pepper (*Piper guineense*) and cloves (*Syzygium aromaticum*); all of which are obtainable in many local markets in Nigeria and other parts of West Africa. Alligator pepper (also called guinea pepper, grains of paradise) and ginger belong to the Zingiberaceae family of plants (Umukoro and Ashorobi, 2008). Alligator pepper is commonly served with kolanuts during some traditional rituals, divination and voodoo in Africa and Caribbean Islands. When eaten with alcohol, alligator pepper seeds are believed to lessen the effect of drunkenness in West Africa (Tropical diversity, 2014). Ginger is another tropical perennial monocot herb with rhizomes, usually consumed fresh (as paste) or dry (as powder) (Ravindran et al, 2002). Its active constituent, gingerol is a powerful anti-inflammatory substance associated with relief of arthritic pain (Organic facts, 2019) and it finds application in cosmetics, perfumery, flavoring of beverages and confectioneries (Wohlmuth et al., 2006). African black pepper (family: Piperaceae) is popularly known for its anti-oxidant, anti-inflamatory and aphrodisiac properties (Katzer, 2015) in herbal medicine.

Figure 1. A collection of the spices selected for this study.

Apart from being an excellent source of lycopene, carotene and vitamin B complex, African black pepper contains a lot of minerals (Waard and Anunciado, 1999) and is widely used in native food systems given its strong and pungent flavor (Ukeh et al., 2009). Cloves are the aromatic flower buds of a tree in the *Myrtaceae* family of plants. It is popular in Asian, African and Middle East as food spice, preservative and nutraceutical due to its antioxidant and antimicrobial activities in human nutrition (Organic facts, 2019). Although some studies have been carried out on spices generally, the physicochemical properties of most spices grown in Nigeria have rarely been reported.

Based on the foregoing, the physicochemical properties of alligator pepper, ginger, black pepper and cloves of Nigerian origin were investigated in this work with the view to providing data that may assist industrial processors, promote value addition and boost income obtainable from spices value chain.

2. MATERIALS AND METHODS

2.1. Source of Material and Samples Preparation

About 5 kg each of dry alligator pepper pods, black pepper, cloves and fresh ginger rhizomes were purchased from Oja tuntun, Saabo, Ile-Ife, Nigeria. Alligator pepper seeds were extracted from the pods by hand. Black pepper and cloves were cleaned to remove all extraneous and spoilt materials. The fresh ginger rhizomes were sliced and sun-dried under ambient temperature and humidity conditions (average of 34°C and 74%, respectively) for seven days during the dry season in Ile Ife, Nigeria (between February and March, 2019). This brought the moisture content of ginger from an initial value of 79.83 to 8.69% wet basis which conforms with the moisture content of dried ginger obtainable in the local market (Hassan *et al*., 2007); The dried materials were processed into flour in an attrition mill as shown in Figures 2 (a, b and c).

2.2. Experimental Procedures

Particle size analysis: Flour sample of known weight was subjected to particle size analysis using mechanical sieve shaker with sieve mesh sizes 600, 500, 425, 300, 212 and 150 μm. The mechanical sieve shaker was operated for 5mins.

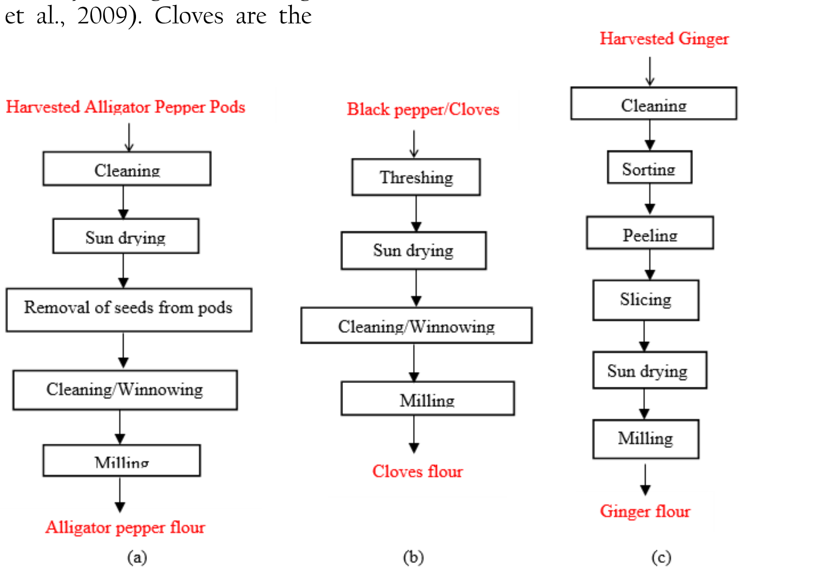

Figure 2: Flow charts for processing the spices into flour Alligator pepper, (b) Black pepper and Cloves (c) Ginger rhizome

and the material retained on each sieve mesh was weighed and estimated as a percentage of the input (Ogunsina et al., 2016).

$$\text{Particle size distribution, PSD} = \frac{W_{sr}}{W_f} \times 100 \quad (1)$$

where, W_{sr}=weight of sample retained; W_f=total weight of flour sample.

Bulk density of each flour sample was determined following Beuchat's method (Ogunsina et al., 2016). About 25 g of flour sample was placed in a 50 mL graduated cylinder, and the loose bulk density was calculated as a ratio of the weight of sample to the loose volume. The cylinder was tapped gently 10 times on a wooden table until there was no further diminution and tap bulk density was calculated as a ratio of the weight of sample to the tap volume. The values reported were averages of five determinations.

Angle of repose: Flour sample of known weight was allowed to flow through a conical funnel having a spout diameter of 20 mm. The angle of repose was calculated from the base angle formed by the heap of the flour using equation (2).

$$\text{Angle of repose, } \theta = \tan^{-1}\frac{2H}{D} \quad (2)$$

where H= height of the cone, and D = diameter of the cone. The procedure was replicated five (5) times.

Water and oil absorption capacities of the flour samples were determined following standard procedure (Ogunsina *et al*., 2010). One gram of the sample was mixed with 10 ml of distilled water for water absorption capacity and 10 ml of pure vegetable Oil-Gino oil(R) for oil absorption capacity. In each case, the mixture was allowed to stand for 10 min at room temperature (about 27 °C) and centrifuged at 4000 × g for 30 min. Afterwards, the supernatant was carefully decanted; the tube was allowed to drain at a 45° angle for 10 min and weighed again. Water and fat absorption capacities were expressed as grams of water or oil bound per 100 g of flour.

Proximate analysis: Protein, fat, ash and crude fibre content were determined according to standard procedures (AOAC, 2002). Percent nitrogen was estimated by micro-Kjeldhal method using a nitrogen distiller and protein content was calculated by multiplying the nitrogen value by 6.25. Carbohydrate content was obtained by difference.

Phytochemicals analyses: Alkaloid content of the flour samples was determined following the method of Harborne (1973). The saponin content was determined following the method described by Okwu (2005). The phenol content was determined using Folin-Cio Cateau's method (Singleton et al., 1999). The method of Lamaison and Carnet (1990) was used to determine the total flavonoid contents in the spice extracts while Price and Butler (1977) approach was used to determine the condensed tannin content.

2.3. Statistical Analysis

The data obtained were subjected to analysis of variance and means were separated using Duncan multiple range tests.

3. RESULTS AND DISCUSSION

Table 1 shows the particle size distribution of the four food spices that were investigated. For the six (6) sieves mesh that were considered, PSD for alligator pepper, black pepper, cloves and ginger were in the range of 1.40 – 44.17, 4.20 – 34.33, 1.97 – 47.43 and 1.75 - 41.45%, respectively. The results show that the fractions differ significantly from one another ($p<0.05$). The least and the highest fractions of samples retained by sieve mesh 600 μm were 1.97 and 21.13% for cloves and alligator pepper, respectively. The fractions retained on sieves 500 and 425 μm ranged from 3.21 - 6.90 and 1.40 - 4.20%, respectively. On sieve mesh 300 μm, the highest fractions retained were 44.17 and 41.45%, for alligator pepper and ginger, respectively; and these values are not significantly different. On sieve mesh 212 μm, clove has the highest fraction retained (47.43%) while alligator pepper was the least (21.41%). Alligator pepper had the least fraction (5.67%) retained on sieve mesh 150 μm while clove had the highest (13.32%). Particle size distribution affects the swelling index, sensory attributes, stability, pasting characteristics and functional properties of flours to a very large extent. In addition, (Ogunsina et al., 2016) reported that properties such as bulk density, compressibility and flowability of food flours depend on PSD and particle shape.

From Table 2, loose and tap bulk densities were 0.44 and 0.59, 0.39 and 0.53, 0.38 and 0.50, and 0.07 and 0.1 g/cm^3 for black pepper, cloves, alligator pepper and ginger, respectively. These values indicated significant differences ($p<0.05$) except alligator pepper and clove. Bulk density is often affected by the chemistry of flour, PSD, processing methods and handling history. It has implication in food mixing, sorting, packaging as well as transportation of particulate food products (Owuanam et al., 2010). The angle of repose of the flour samples ranged from 45.16 to 50.73° for black pepper and ginger, respectively. Black pepper forms a flatter heap than that of other spices. Angle of repose characterizes the flow behavior of flours or granular materials (Zhou, et al., 2002) and is one of the simplest parameters for rough estimation of inter-particulate cohesion of flours and bulk solids (Ruales, et al., 1993). It is important in the design of hoppers and discharge chutes. Furthermore, the results show that water and oil absorption capacities were 153.28 and 132.84, 127.47 and 106.66, 178.68 and 115.49 and 219.18 (g of water/100 g of sample) and 138.69 (g of oil/100 g of sample); for alligator pepper, black pepper, cloves, and ginger, respectively. Ginger indicated the highest values in both cases. Water and oil absorption capacities are indices of the ability of a material to absorb and retain water or oil, which in turn influences their behaviour in food products development.

This is important for flours intended for baked or aqueous foods in which hydration and shortening is desirable. While water absorption capacity is important for flours intended for use in viscous foods like soups, curries, dough and baked products, oil absorption capacity particularly affects texture and mouth feel of food products (Ogunsina et al. 2010).

The proximate composition of the spices that were investigated is presented in Table 3. The results show that fat, crude fibre, ash and protein contents of the spices under study ranged from 4.17 – 7.5, 2.31 – 18.19, 2.84 – 5.7 and 1.91

– 13.01 g/100g of dry matter. Cloves indicate the highest fat and crude fibre contents; while the highest values of ash and protein were obtained for ginger and alligator pepper, respectively. Generally, the proximate composition of the samples differs significantly ($p<0.05$) except for crude fibre of alligator pepper and pepper and carbohydrates of black pepper and ginger. The samples generally exhibited high carbohydrates contents. Although, drying depletes the nutritional constituents of foods, spices are seldom eaten fresh; most spices are consumed in flour form. Proximate composition plays a crucial role in the nutritional value and functional behavior of foods, but the minute quantities of spices often used in food preparations switch emphasis to their phytochemical contents for which they are utilized as food ingredients. While, their usage is common in one form or the other in every household, their demand in the food processing industry is increasing rapidly all over the world because they are real delight to the senses, making foods more palatable, tasty and easily digestible. Thus, demand will continue to increase.

TABLE 1: Percent Particle Size Distribution of the Spices Under Study

Sieve mesh number(μm)	Alligator Pepper	Black Pepper	Clove	Ginger
600	21.13 ± 0.57[a]	7.59±0.51[c]	1.97±0.32[d]	9.29±0.93[b]
500	3.21 ± 0.23[b]	6.14± 0.81[a]	4.30±1.17[b]	6.90± 0.10[a]
425	1.40 ± 0.39[c]	4.20± 0.59[a]	3.09±0.60[b]	1.75± 0.55[c]
300	44.17± 1.41[a]	26.77±3.48[b]	23.94±5.10[b]	41.45± 1.04[a]
212	21.41± 0.25[d]	34.33±4.02[b]	47.43±3.38[a]	28.56± 1.31[c]
150	5.67± 0.27[b]	12.28±4.97[ab]	13.32±5.01[a]	7.37± 0.61[ab]

Each value represents the mean± standard deviation of three replicates;
Means followed by the same superscript on a row are not significantly different ($p<0.05$).

TABLE 2: Some Physical Properties of the Spices

Property	Alligator Pepper	Black Pepper	Clove	Ginger
Loose Density (g/cm^3)	0.38±0.00[b]	0.44±0.01[a]	0.39±0.02[b]	0.07±0.00[c]
Tap Density (g/cm^3)	0.50±0.00[c]	0.59±0.01[a]	0.53±0.01[b]	0.10±0.00[d]
Angle of Repose (°)	49.40±0.92[ab]	45.16±2.77[c]	47.13±1.81[bc]	50.73±0.15[a]
Water Absorption Capacity (g of water/100 g of sample)	153.28± 2.40[c]	127.47±2.89[d]	178.68±1.84[b]	219.18± 1.29[a]
Oil Absorption Capacity (g of oil/100 g of sample)	132.84±2.05[b]	106.66±2.1[d]	115.49±1.9[c]	138.69±3.39[a]

Each value represents the mean ±standard deviation of three replicates;
Means followed by the same superscript on a row are not significantly different ($p<0.05$).

TABLE 3: Proximate Composition of the Spices Samples

Property (g/100 g of dry matter)	Alligator Pepper	Black Pepper	Clove	Ginger
Fat	7.50±0.05[b]	4.17±0.03[d]	10.72±0.03[a]	4.62±0.03[c]
Crude fibre	4.78±0.12[b]	4.60±0.03[b]	18.19±0.15[a]	2.31±0.06[c]
Ash	2.84±0.12[d]	3.44±0.08[c]	5.49±0.03[b]	5.70±0.11[a]
Protein	13.01±0.21[a]	10.97±0.11[b]	1.91±0.04[d]	9.56±0.04[c]
Carbohydrate	71.86±0.35[b]	76.82±0.02[a]	63.69±0.17[c]	77.81±0.56[a]

Each value represents the mean ±standard deviation of three replicates;
Means followed by the same superscript on a row are not significantly different ($p<0.05$).

In Table 4, the phytochemical content of the samples include alkaloids, flavonoids and phenols in the range of 8.81 – 51.60%, 4.45 – 7.54 mg GAE/g and 23.47 – 41.73 mg GAE/g. Low amounts of tannins (0.68 – 2.66 mg TAE/100g) and saponins (1.16 – 6.07 m/100g) were generally observed. The phytochemicals exhibited significant differences ($p<0.05$) except for the saponins content of alligator pepper and clove which showed no significant difference. Purified alkaloids as well as their synthetic derivatives are reported as having analgesic, antimalarial, antiseptic and anti-bactericidal properties (Trease and Evans 2002). Saponins are plants' natural antibiotics which act as defense mechanism against pathogens (Okwu and Emenike, 2006). They have also been documented as having cholesterol lowering effects and the ability to kill or inhibit cancer cells (Okwu, 2005). Flavonoids protect against allergies, inflammation, platelet aggregation and microbial infection (Okwu and Omodimiro, 2005). Tannins are dietary antinutrients that are responsible for the astringent taste of foods and drinks (Chikezie et al., 2008). Their presence can cause browning or other pigmentation problems in both fresh foods and processed products. Phenols are associated with antioxidant properties and are believed to lower the risk of heart disease and cancer and possess the ability to prevent certain diseases (Okwu, 2005). Karsha and Lakshmi (2010) reported that the presence of phenolic compounds in spices may be responsible for their antimicrobial activity by which bacteria membrane gets damaged and their growth retarded. It must be remarked that since drying has been reported to cause depletion of nutrients and bioactive compounds in plant materials (Barimah et al., 2017), further studies on the effect of drying on the quality characteristics of the spices under study should arouse future research interest.

TABLE 4: Phytochemical Screening of the Spices Samples

Property	Alligator Pepper	Black pepper	Clove	Ginger
Saponins (mg/100 g)	2.59±0.16[b]	6.07± 0.81[a]	2.27±0.33[b]	1.16 ±0.16[c]
Tannins (mg TAE/100 g)	1.01±0.08[c]	1.66± 0.12[b]	0.68±0.07[d]	2.66±0.06[a]
Alkaloids (%)	51.60 ±0.41[a]	15.73±0.81[d]	8.81±0.24[c]	13.52±0.71[b]
Flavonoids (mg GAE/g)	5.74±0.06[c]	6.43±0.49[b]	4.45±0.38[d]	7.54±0.18[a]
Phenols (mg GAE/g)	35.52±0.38[b]	41.73±0.85[a]	25.63±0.29[c]	23.47±0.07[d]

Each value represents the mean ±standard deviation of three replicates;
Means followed by the same superscript on a row are not significantly different ($p<0.05$).

4. CONCLUSIONS

The physicochemical properties of four common food spices grown in Nigeria alligator pepper, black pepper, clove and ginger have been investigated. The spices exhibited major differences in their physical properties and proximate components. Phytochemicals screening of these spices indicated that they contain significant amounts of alkaloids, flavonoids and phenols but low in tannins and saponins. For these spices, this study provides basic information that may promote processing, value addition and trade; thereby boosting obtainable income via various food and industrial applications.

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