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Comparative Evaluation of Physicochemical, Phytochemical and FTIR Analysis of Pure and Leached Ginger Rhizome (*Zingiber officinale*)

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The emerging global significance and faster rate of increase in interest on herbal drugs for treating various illnesses cannot be underestimated. This research is aimed to evaluate physicochemical, phytochemical and FT-IR spectroscopy to identify leached ginger with pure ginger. The physicochemical parameters were determined using standard analytical methods, phytochemical screening was determined using standard method and the FT-IR analysis was conducted using an agilent microlab 4000 (Agilent Technology). The results shows that fat contents is 3.97% and 0.00%, moisture contents 11.40% and 2.40%, ash value 8.20% and 2.50% and acid-insoluble ash 11.30% and 2.20%. Moisture contents, ash value and acid-insoluble ash of leached ginger suggested some level of adulteration, and that of pure ginger were found to be of acceptable limits for powdered medicinal plants prescribed by European pharmacopoeia. The results also revealed the presence of phytochemicals tested in pure ginger but only flavonoids and alkaloids were present in the leached ginger. The results of FT-IR revealed different characteristic peak values with various functional compounds such as alcohols, alkanes, carbonyl, and aromatic ring. The research has suggested that, the result of physicochemical and phytochemical analysis indicated that pure ginger is a good source of micronutrients and it could be useful in medicinal herb.

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1. Introduction

The contribution of ginger to herbal product in modern medicine is well known and life in most parts of Africa begins and ends with herbal medicine. About 65-80% of world's population relies on traditional medicine for their health care needs (Calixto, 2000). According to the United Nations Conference on Trade and Development, 33% of total modern drugs produced by industrialized countries are plant based (Raskin, *et al.*, 2002). In Nigeria, thousands of plant species such as ginger are known to have medicinal values and the use of different parts of several medicinal plants to cure specific ailments has been in vogue since ancient times (Rios, *et al.*, 2005). As a result of better cultural acceptability and fewer side effects herbal medicine still remains the mainstay of 75-80% of the whole population in the developing countries for primary health care (Ghasi, *et al.,* 2000).

In recent years, the ginger, soft drinks and jams industry have received great attention because of their biological activities and sensory quality, and have become very important agricultural product in the world (Gurdeniz *et al,* 2007). The adulteration of food products is of primary important for consumers, food processors and industries. From the legislative point of view, the quality standards were established through the requirement of quality labels that specify the chemical composition of each product (Gallardo, *et al*, 2009). The adulteration frequently involves the replacement of high-cost ingredients with cheaper substitutes (Flores, *et al*, 2007). Although the adulteration is done for economic reasons, the action can affect the chemical composition and quality parameters of food (Christy, *et al*, 2004).

Several analytical techniques have been developed for detection and quantification of adulteration and authentication of food products, such as mass spectrometry using new type of ion source, direct analysis in real time (Vaclavik *et al,* 2009), nuclear magnetic resonance (NMR) spectroscopy (Jafari, *et al,* 2009), Raman spectroscopy (Heise, *et al,*2005), fluorescence

(Poulli, *et al,*2007), gas chromatography (Jafari, *et al,* 2009), high performance liquid chromatography (HPLC) (Flores, *et al*, 2007) and differential scanning calorimetry (Chiavaro, *et al*, 2009). Some of these methods are time consuming, expensive, generally destructive of the sample material, and require a high degree of technical knowledge when interpreting the data. Optical spectroscopy techniques have the potential to replace or at least complement some of the classical laboratory methods. In many cases, they allow for a reliable analysis in quality control during production where speed and simplicity of analysis are crucial advantages. FT-IR spectroscopy has shown to be useful for a range of adulteration problems in food sector (Kemsley, *et al.,* 1996). There is a demand for new and rapid analytical methods for assessing quality attributes. Recently, Fourier-Transform Infrared Spectroscopy (FT-IR) has become a well-accepted method for the determination of food constituents since it achieves high analysis speed and requires little or no sample preparation. FT-IR spectroscopy often coupled with chemometrics has been used to study different quality attributes in many food samples including fruits, vegetables or beverages (Veraverbeke, *et al,* 2005).

2. Materials and Methods

2.1 Collection and identification of plant materials

Fresh samples of ginger *(Zingiber officinale)* were purchased from Marina market in Sokoto metropolis. The sample of the plant materials were authenticated at herbarium unit, Department of Pharmacognosy and Ethnopharmacy, Faculty of pharmaceutical Science, Usmanu Danfodiyo University, Sokoto where a specimen was prepared and a voucher number (PCG/UDUS/ZING/0002) was issued.

2.2 Preparation of the plant material

Fresh ginger was thoroughly washed with tap water to remove earthly materials, and then cut into small pieces and allow to dry at 55^{0}C for 24 hours in an oven (Nuve oven FN-055). The dried samples were weighed with electronic balance (Model: MT-2000) and then dry again for another 1 hour and record the mass, until no change in the weight of ginger and then pulverized to powder and kept for use.

2.3 Extraction of Ginger

Ginger rhizome (35 g) was extracted with (350 cm^3) of n-hexane using Soxhlet extractor to obtained the ginger oil. The marc of ginger extracted from the n-hexane was cold macerated with water-ethanol (50:50) and the mixture was kept for 72 hrs with occasional shakings to afford hydro-ethanol extract. The mixture was filtered with Whatman No.1 filter paper and the filtrate was oven dried at 40^{o}C (*Mohammadi*, *et al.,* 2014).

2.4 Determination of Fat Contents

The fat content of the sample was determined by adapting the AOAC method (AOAC, 2000). About 3 g of sample was weighed, paper filter and wrap, the sample was taken to extraction thimble and Soxhlet apparatus was connected and heat for about 14 hours, the solvent was evaporated by using the vacuum condenser. The bottle was incubated at 90^{o}C until solvent is completely evaporated and bottle is completely dry.

$$\text{Fat contents} = \frac{w_1 - w_2}{w_1} \times 100\% \quad \text{------------} 1$$

Where: W_1 = initial weight (g) of the sample

W_2 = weight (g) of the sample after extraction

2.5 Determination of Moisture Content

The moisture content of the sample was determined by adapting the AOAC method (AOAC, 2000). A clean dried petric dish was weighed empty and 3 g of the sample was put on it. The petric dish containing the sample was then placed in the oven at 105^{O}C for 24 hours. This was done in triplicate.

$$\text{Moisture (\%)} = \frac{w_2 - w_3}{\text{weight of sample}} \times 100\% \quad \text{- - - -}2$$

Where: W_1 = weight (g) of empty crucible
W_2 = weight (g) of empty crucible + sample before drying
W_3 = weight (g) of empty crucible + sample after drying

2.6 Determination of Ash Content

The ash content was determined according to the method described by (AOAC, 2000). A clean dried crucible was weighed and 3 g of sample was placed on the empty crucible. The sample was heated in a Muffle furnace at 600^{o}c for 7 hours and the procedure was carried out in triplicate.

$$\text{Ash value (\%)} = \frac{w_3 - w_1}{w_2 - w_1} \times 100\% \quad \text{----- -----} 3$$

Where: W_1 = weight (g) of empty crucible

W_2 = weight (g) of empty crucible + sample before burning

W_3 = weight (g) of empty crucible + sample after burning

2.7 Determination of Acid-Insoluble Ash

The crucible with the ash was transferred to a beaker containing 25 cm^3 of dilute hydrochloric acid and boiled for five minutes and filter through an ash-less filter paper, the beaker and crucible was washed with water and the washing was pass through the filter paper. The washing was repeated for three times and the residue was collected in the tip of the cone of filter paper, the funnel and filter paper was then dried in an oven at 105ºC (AOAC, 2000).

Acid-insoluble ash (%) =

$$\frac{\text{weight } (w_2) - \text{weight } (w_3)}{\text{weight of sample}} \times 100\% \text{ - - - - - - } 4$$

2.8 Phytochemical Screening of the Plant Extract

The preliminary phytochemical screenings were performed on the pure and leached ginger samples according to the standard procedures to identify the presence of some secondary metabolites (Trease and Evans, 1996).

2.9 FT-IR Analysis

FT-IR (Agilent Technology) analysis of the samples was conducted at Central Advanced Science Research and Analytical Services (CasRas), Usmanu Danfodiyo University, Sokoto. The frequency was set at range of 4000-650 cm^{-1} at resolution of 4.0cm^{-1}.

3. Results and Discussion

The result of the analyses is presented in tables 1, 2 and 3. The results in table 1 show the fat content, moisture content, ash content and acid-insoluble ash of the samples. It can be seen that, there was no fat detected in leached ginger while it is present in pure ginger (3.97%), this shows that pure ginger is an important source of energy in addition to other essential nutrients (Kim, *et al*., 2020). The moisture content of leached ginger (11.40%) was higher significantly than pure ginger (2.40%), this shows that the leached ginger can easily be prone to spoilage than pure ginger due to higher moisture content, while the value of moisture of pure ginger indicates that it can be stored for a longer time without spoilage (Kim, *et al*., 2020). The low value of moisture content could prevent bacterial, fungal and yeast growth (African Pharmacopoeia, 1986). The result of moisture content is within and in agreement with the 10% maximum limits moisture content in powdered medicinal plants prescribed in European pharmacopoeia (2007).

The ash content of pure ginger was found to be (8.20%) which is higher significantly than leached ginger (2.50%), which were within the 14% maximum limit for total ash value in powdered medicinal plants (European Pharmacopoeia, 2007). The ash content is an indication of the total inorganic mineral elements content; the results obtained indicate that the pure ginger has more mineral composition than leached ginger. The ash content is a measure of the amount of specific inorganic components present within a plant, such as Ca, Na, and K. Higher ash content indicates high mineral elements while lower ash content indicates low mineral elements (Leung, *et al*., 2005).

The Acid-insoluble ash of pure ginger (11.30%) is significantly higher compare to the leached ginger (2.20%) which were within the 14% maximum limit for acid insoluble ash value in powdered medicinal plants (European Pharmacopoeia, 2007). this shows that the pure ginger has more inorganic materials like silica, sand and other types of minerals that are difficult for acid to dissolve in or not easily soluble in acid than leached ginger. The purity and quality of food products, including cereals, animal feed and other agricultural products are determined by using the acid-insoluble ash content as a quality control standard. (Musa, 2006).

Table 1: Result of physico-chemical analysis of pure ginger and leached ginger samples

S/No	Parameters	Pure Ginger	Leached Ginger
1	Fat Content	3.97 ± 0.551	0.00 ± 0.000
2	Moisture Content	2.40 ± 0.173	11.40 ± 0.173
3	Ash Value	8.20 ± 0.346	2.50 ± 0.173
4	Acid-Insoluble Ash	11.30 ± 0.300	2.20 ± 0.346

Table 2: Result of the phytochemical screening of pure ginger and leached ginger samples

Test/Phytochemical	Pure Ginger	Leached Ginger
Tannins		
Ferric chloride test	+	-
Flavonoids		
Shinoda's test	++	-
Alkaline test (NaOH)	+++	+
Alkaloid		
Meyer's test	+	-

Wagner's test	++	+
Steroid		
Salkowki's test	+	-
Protein		
Xanthoproteic test	+	-
Carbohydrate		
Molich's test	++	-
Fehling's test	+	-
Saponins		
Frothing test	++	-
Phenols		
Ferric chloride test	+	-

Key: **-** = absent, **+** = present (trace amount), **++** = present (moderate amount), **+++**= present (High amount), PG = Pure ginger, LG = leached ginger

Table 3: Results of FT-IR Spectroscopic studies of Pure Ginger and Leached Ginger samples

Sample	Wave no. cm^{-1} (Reference article) (Hong e*t al*., 2019)	Wave no. cm^{-1} (Test sample)	Assignment	Functional Group
Pure Ginger	3200-3500	3283 (m)	O-H	Alcohol
	2800-3000	2926 (m)	C-H	Alkanes
	1630-1680	1634 (m)	C=O	Carbonyl
	1400-1550	1517 (w)	C-C	Aromatic ring
	1000-1320	989 (s)	C-O	Alcohol
Leached Ginger	3200-3500	3283 (m)	O-H	Alcohol
	2800-3000	2926 (m)	C-H	Alkanes
	1630-1680	1634 (m)	C=O	Carbonyl
	1320-1370	1319 (w)	C-H	Bonded with Alkyl group
	1000-1320	1012 (s)	C-O	Alcohol

Key: Where (S)=strong peak, (M)medium peak, (W)=weak peak, (b)=broad peak, and (sh)=sharp peak

The result in table 2 show the phytochemical screening of pure ginger and leached ginger samples. The result of phytochemical screening tested for pure ginger sample revealed the presence of tannins, flavonoids, alkaloids, steroids, proteins, carbohydrates, saponins and phenols, but only flavonoids and alkaloids showed presence in the leached ginger sample, which is due to the extraction process it undergone. The quantitative phytochemical analysis on the potency of pure ginger sample corroborates the findings of it should be noted that the plants are rich in medicinal and immune stimulating phytochemicals which will be beneficial to health. Plants generally contain chemical compounds (such as saponins, tannins, alkaloid, flavonoids, steroids, phenols, proteins, carbohydrates, and glycosides) known as secondary metabolites, which are biologically active (*Azu, et al*., 2007). Secondary metabolites may be applied in nutrition and as pharmacologically-active agents. Plants are also known to have high amounts of essential nutrients, vitamins, minerals, fatty acids and fiber.

The results in table 3 demonstrate the presence of various functional groups recognized from the pure ginger and leached ginger samples of *Zingiber officinale* rhizome. The medium and broad peak observed at 3283 cm^{-1} is the characteristics absorption for O-H (alcohol) functional group in the pure ginger and the O-H is associated with intermolecular bonding, the medium and sharp peak observed at 2926 cm^{-1} is assigned to C-H stretching vibration of alkane, the medium and sharp peak observed at 1634 cm^{-1} is the characteristics absorption for C=O of carbonyl compound frequency vibration, which means some carbonyl compounds are present in the pure sample of *Zingiber officinale*, the weak peak observed at 1517 cm^{-1} is assigned to C-C for aromatic ring, the strong and sharp peak obtained at 989 cm^{-1} are the characteristics absorption for C-O of alcohol. These peaks were in consistent with the FT-IR of Zhang et al., (2021). In the case of leached ginger, the medium and broad peak at 3369 cm^{-1} is the characteristics absorption for free O-H (alcohol) functional group, the weak peak at 2918 cm^{-1} is assigned to C-H stretching vibration of alkane, the strong and sharp peak observed at 1630 cm^{-1} is the characteristics absorption for C=O of carbonyl compound frequency vibration, the peak observed at 1319 cm^{-1} is the characteristics absorption for C-H bonded with alkyl group, the medium peak obtained at 1012 cm^{-1} is assigned to C-O for alcohol functional group. These peaks were similar with the findings of Zhao *et al*., (2020).

4. Conclusion

Physicochemical analysis of *Zingiber officinale* was determined and the results indicate that pure ginger has more mineral composition and has more inorganic materials like silica, sand and other minerals. In phytochemical assessment of ginger, the known phytochemicals tested showed presence in pure ginger sample but only flavonoids and alkaloids showed presence in the leached ginger sample. By using FT-IR analysis we confirmed the various functional groups observed in the different ginger samples such as alcohols, alkanes, alkenes, aldehydes, aromatics, aromatic ring, aromatic amines and aliphatic amines, which showed major peaks. The FT-IR analysis confirmed the various functional groups observed in the different ginger samples such as alcohols, alkanes, alkenes, aldehydes, aromatics, aromatic ring, aromatic amines and aliphatic amines, which showed major peaks. The research has suggested that pure ginger has good secondary plants metabolites which justify its therapeutic utility and a source of medicinal herb.

Conflict of interest

The authors declare no conflict of interest.

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