

Research Article

Effects of heat treatment on the nutrient composition, phytochemical properties and indices of fat quality of fresh and dried leaves and seeds of *Piper guineense* (Uziza)

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Abstract - This study evaluated the effect of drying on the nutrient composition, phytochemical constituents, and indices of fat quality of fresh and dried leaves and seeds of *Piper guineense* (Uziza). The fresh and dried leaves and seeds of *P. guineense* were analyzed for phytochemical, vitamin, mineral, carotenoid, and quality indices. The results showed that fresh *P. guineense* leaves had the highest total phenol (1047.33 mg/100g), flavonoid (0.66 mg/100g), zinc (0.42 mg/100g), copper (0.10 mg/100g), vitamin C (2.49 mg/100g) and carotenoid contents while the dried *P. guineense* seeds had the lowest flavonoid (0.33 mg/100g), total phenol (975.87 mg/100g), iron (2.23 mg/100g) and vitamin C (1.85 mg/100g), but highest values for alkaloid (1.80 mg/100g), Magnesium (142.01 mg/100g) and the quality indices. The fresh *P. guineense* seeds had the highest tannins (3.55 mg/100g) and the B-vitamins, while the dried *P. guineense* leaves had the highest iron (3.14 mg/100g) and the lowest tannins (3.23 mg/100g). The seeds had significant amounts of crude fat. The study concluded

that fresh *P. guineense* leaves had the highest nutrient quality, making them a valuable resource for food and medicine. The study's findings have implications for the preservation and utilization of *P. guineense*, particularly in tropical regions where the plant is widely used. The study examined the effect of drying on the leaves and seeds of *P. guineense*, providing insights into the impact of drying on the properties of these two consumed plant parts.

Keywords: *Piper guineense* seeds, *Piper guineense* leaves, carotenoids, nutrients

1. Introduction

Various parts of plant likeleaves, seeds, and fruits, are being used as food spices and are also believed to contain some phytochemicals that serve different medicinal values. Plant materials are rich in nutrients such as vitamins and minerals, which are always needed by the human body for proper biochemical and metabolic activities (Arowora et al., 2017). There are different essential compounds present in spices, like oil and mixtures of complex organic compounds. The majority of these plant parts have been beneficial in herbal medicine, where they are used in the treatment and control of various health-related conditions. Leaves and seeds of *Piper guineense* are categorized in this class of plants, as their use is already increasing daily. The majority of these medicinal plants have been reported to perform important roles in the discovery of different drugs and are very vital for humans to treat different health-related ailments (Imo et al., 2015).

P. guineense, like all true pepper seeds, belongs to the family *Piperaceae*. They appear small and smooth and mainly bear a reddish tinge. It is known as uziza in Igbo and Iyere in Yoruba. Other common names are African black pepper and Benin pepper (Ogbedeagu et al., 2025a). *P. guineense* has a unique peppery taste and is a well-known spice used in many traditional recipes in West Africa and Nigeria in particular. It is mainly made up of proteins, carbohydrates, and some

levels of dietary fibre. Studies have shown various proportions (leaves, seeds, or fruits) depending on the plant parts being studied (Uzoekwe & Ezenwajiugo, 2023; Ojimekwe, 2023). According to work by Ojimekwe (2023), the level of nutrients, such as carbohydrates, proteins, and fibre, in different plant components ranged between 30% to 50%, 10% to 20%, and 5% to 15%, respectively. Vitamin C, vitamin A (as β -carotene), riboflavin (B_2), and niacin (B_3) were recorded in high quantities in *Piper guineense*. According to the work of Alagbe et al. (2021), both the leaves and seeds of *P. guineense* contain enough calcium and potassium. *P. guineense* is also known to contain some levels of minerals in different proportions. These include zinc, iron, and copper. These minerals have a major role to play in different metabolic processes and are also very vital in muscle activity, bone health, certain metabolic functions, and a valuable dietary supplement (Dingtsen et al., 2020; Evuen et al., 2022).

It has been reported that *P. guineense* leaves were found to be beneficial in the treatment of aftershave rash (Omorodion et al., 2017). The presence of these phytochemicals: tannins, alkaloids, saponins, and flavonoids has also been found to be present in the plant. It contains important vitamins, phytochemicals, as well as other nutrients (Aké et al., 2019). Studies have revealed that the components of the seed extracts of *P. guineense* have

been found to contain certain secondary metabolites like phenols, terpenes, carotenoids, steroids, and flavonoids (Ogunmefun et al., 2017). *P. guineense* has been used as a potential agent in controlling brain aging. This has been discussed due to its implications for practical brain function (Ademuyiwa et al., 2013). *P. guineense* is used as a vital ingredient in pharmaceuticals industries and could also be used to solve reproductive dysfunction. (Onwuka et al., 2022). It is also very important in the treatment of bronchitis, intestinal diseases, rheumatism, and cough. Studies have also shown that the plant contains anticonvulsant, neuropharmacological activities, anti-inflammatory and antioxidant properties (Oyemitan et al., 2014).

P. guineense seeds and leaves are used for preparation of soups and treatment of diverse ailments in southern Nigeria, including intestinal diseases, cough, bronchitis and rheumatism (Nwachukwu et al., 2010). It is also used for restoring fertility in women and low sperm count in men (Núñez et al., 2005).

P. guineense is a valuable spice and medicinal plant in Africa and Nigeria in particular, renowned for its nutritional and phytochemical properties. However, the plant's perishable nature poses challenges to its utilization and preservation. Drying is a common method used to preserve plant materials, but its impact on the nutritional and phytochemical properties of *P. guineense* leaves and seeds is not well understood. Understanding the effect of drying on the

nutritional and phytochemical properties of *P. guineense* leaves and seeds will help optimize drying methods to preserve these bioactive compounds, ensuring the plant's medicinal and nutritional value is retained. More so, the study compares fresh and dried leaves and seeds of *P. guineense*, allowing direct comparison of how drying differentially influences two widely used parts of the same plant. The study also considered the indices of fat quality of the plant, which has not been reported in *P. guineense*, and no prior work linked drying to oxidative stability or commercial fat quality. The study was done on samples sourced from local markets in Nigeria, enhancing relevance to West African food systems and addressing regional research gaps. By investigating the impact of drying on *P. guineense*, this study will contribute to the sustainable utilization of the plant, reducing post-harvest losses and promoting its year-round availability.

This study aimed to evaluate the effect of drying on the nutrient composition, phytochemical constituents, and indices of fat quality of fresh and dried leaves and seeds of *P. guineense* (Uziza).

2. Materials and methods

2.1 Sources of raw materials

The *P. guineense* leaves and seeds used for this research were harvested in one batch in Ahaba Oloko in Ikwuano L.G.A of Abia State, Nigeria, following both stipulated local and national guidelines.



Figure 1. Leaves and seed parts of *Piper guineense*.

2.2 Sample preparation

The leaves and the seeds were sorted by hand-picking to separate the healthy ones from the bad ones and washed with clean running water to remove debris. The freshly harvested leaves and seeds of *P. guineense* were divided into two portions each. One portion of the leaves and seeds was analyzed fresh on a fresh weight basis, and the other portion was dried on a dried weight basis. The leaves and seeds analyzed were oven-dried at 55 °C in an oven (model: KZ 760 4SS China) to a final moisture content of 5% and milled into powder using a mechanical grinder {model: BLG-595(MK2) China} according to the method of [Enyi et al. \(2025\)](#) and stored in an airtight container until needed for analysis. The fresh samples were taken to the laboratory immediately for analysis. The various samples obtained were subjected to compositional analysis to determine the nutrients, anti-nutrients, and quality indices of fat samples.

2.3 Preparation of extracts

The samples were prepared using the method described by [Kabiru et al. \(2012\)](#). Fifty (50 g) of the grounded samples were weighed into a round-bottom flask and extracted with 400 mL of absolute ethanol at 60°C for 2 hours by reflux. The filtrates

were slowly evaporated to dryness using a hot air oven at 37°C. The crude extracts were weighed, and the yield was kept in a refrigerator at a temperature of 4°C until used.

2.4 Determination of phytochemical properties

Alkaloids were determined and calculated using the method of [Herborne \(2000\)](#). One (1 mg) of the sample was dispersed in 10 mL of 10 % acetic acid solution in ethanol to form a ratio of 1:10 (10%). The mixture was allowed to stand for 4 hours at 28 °C. It was later filtered with a Whatman No 42-grade filter paper. The filtrate was concentrated to one quarter of its original volume by evaporation and treated with dropwise addition of concentrated aqueous NH_4OH until the alkaloid was precipitated. The alkaloid precipitated was filtered, received in a weighed filter paper, washed with 1% ammonia solution, and dried in the oven at 80°C for 30 minutes.

$$\% \text{Alkaloid} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

W = weight of sample, W1 = weight of empty filter paper, W2 = weight of paper + alkaloid precipitate.

Flavonoids were determined and calculated using the method of [Meda and Lamien \(2005\)](#). Five (5 g) of each sample was boiled in 50 mL of 2 M HCl solution for 30 minutes under reflux. It was allowed to cool and then filtered using Whatman No 42-filter paper. A known volume (5 mL) of the extract was treated dropwise with an equal volume of ethyl acetate. The flavonoid precipitate was recovered by filtration using weighed filter paper. The weight difference gave the weight of flavonoid in the sample.

$$\text{Flavonoids} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

W = weight of sample, W1 = weight of empty paper, W2 = weight of paper + flavonoid precipitate.

Tannins were determined and calculated using the method of [Kirk and Sawyer \(1991\)](#). Five (5g) weight of each sample was dispersed in 50 mL of distilled water, shaken, and allowed to stand for 30 minutes at 28 °C before it was filtered through Whatman No.42 grade filter paper. Two (2 mL) volumes of each sample extract were dispensed into a 50 mL volumetric flask and mixed with 2 mL standard reagent and 2.5 mL of saturated Na₂CO₃ solution. After mixing, the content of each flask was made up to 50 mL with distilled water and allowed to incubate at 28 °C for 90 minutes. The respective absorbance was measured in a spectrophotometer at wave length of 260 nm. The reagent blank was used to calibrate the instrument, while the absorbance values of the samples were plotted to determine tannin content against the weight of the sample. Tannin content was calculated as:

$$\% \text{ Tannin} = \frac{100}{W} \times AU \times \frac{C}{AS} \times C \times \frac{Vf}{1000} \times D/Va$$

W = weight of sample analyzed, AU = Absorbance of the test sample, AS = Absorbance of the standard solution in mg/mL, C = Concentration of standard solution in mg/mL, Vf = Total volume of extract, Va = Volume of extract analyzed, D = Dilution factor

Phenol was determined using the method of [Singleton et al. \(1999\)](#). A known weight (0.2 g) of the various samples was treated with 10ml of concentrated methanol in order to extract the phenol and the filtrate. The resultant mixture was thoroughly mixed for 30 minutes at room temperature (28°C). The mixture was then centrifuged at 500rpm for 15 minutes, and the supernatant was recovered and used for the analysis. One (1 mL) of the extract obtained from each sample was treated with an equal volume of Folin-Ciocalteu's reagent. This was followed by the addition of 2 mL of 2 % Na₂CO₃ solution. The phenol solution was prepared to standard and diluted to a desired concentration. One (1 mL) of the standard solution was also treated with Folin-ciocalteu reagent and Na₂CO₃ solution.

2.5 Determination of mineral contents

Magnesium, iron, copper, and zinc contents of the samples were all determined using the method described by [AOAC International \(2000\)](#) as reported by [Verma and Srivastav \(2017\)](#). A di-acid mixture, which is made up of 2 parts: nitric acid and perchloric acid, was used to digest 2 g each of the samples. The digested samples were recovered and transferred to a volumetric flask (100 mL), and distilled water was used to make it up to the volume. The samples and the

standards of elements were analyzed using an atomic absorption spectrophotometer (AAS) (Thermo Fisher Scientific CE FIOS Atomic absorption Spectrometer). The concentrations of respective elements were also determined.

2.6 Determination of vitamin contents

Thiamine (B_1) was determined and calculated using the method described by [Okwu and Josiah \(2006\)](#). Two (2 g) of the sample was ground in a mortar and 75 mL of 0.2N HCl added. It was heated in a water bath for 30 minutes and cooled. Five (5 mL) of enzyme solution was added and incubated at 37°C overnight. The material was placed in a 100 mL flask and made up with water. It was filtered and the filtrate purified by passing through a silicate column. Five (5 mL) of acidic KCl, 3 mL of alkaline Ferricyanide solution, and 15 mL of isobutanol were added in a conical flask and shaken for 2 minutes. It was allowed to separate, and the alcohol layer was taken. Three (3 g) of anhydrous Na_2SO_4 was added to the isobutanol extract, and 5 mL of thiamine solution was taken to another flask. Oxidation and extraction of thiochrome from the sample was carried out. The sample and standard blank were prepared, and 5 mL from each was taken. Three (3 mL) of 15% NaOH was added. The fluorimeter was set at an excitation wavelength of 360 nm and an emission wavelength of 435 nm. The instrument was adjusted to zero deflection with 0.1N H_2SO_4 against the standard. The fluorimeter was read with the sample and the blank. Thiamine was calculated as:

$$\text{Thiamin (mg/100g)} = \frac{100}{W} \times \frac{Au}{As} \times C \times \frac{V_f}{V_a}$$

W = weight of sample, Au = absorbance of the test sample, as = absorbance of standard solution, V_f = total volume of

filtrate, V_a = volume of filtrate analyzed, C = concentration of standard, D = dilution factor, where applicable.

Riboflavin (B_2) was determined and calculated using the method described by [Onwuka \(2018\)](#). The sample was ground, and 5 g of it was mixed with 50 mL of 0.2N HCl in a 100 mL conical flask, boiled for 1 h, and cooled under tap water. The pH of the mixture was adjusted to 6.0 using 0.5 M NaOH solution and then readjusted to 4.5 using 1N HCl to facilitate precipitation of all interfering materials. It was diluted to the 100 mL mark of the flask and then filtered through a double-fold filter paper. Ten (10 mL) of the filtrate was added to each of four separate test tubes. To each of the first two test tubes was added 1 mL of distilled water, while to each of the remaining two test tubes was added 1 mL of riboflavin standard (0.5 μg / mL). One (1.0 mL) of glacial acetic acid and 0.5 mL of 3% $KMnO_4$ were added to each of the tubes, and the tubes were shaken vigorously. Fluorescence was measured at 440 nm excitation and at 565 nm emission for the sample tube containing water, and then repeated on the same sample after mixing with 20 mg of $Na_2S_2O_4$. Fluorescence of the standard at the same 440 nm excitation and 565 nm emission was also measured. Riboflavin concentration was calculated with the expression:

$$\text{Riboflavin mg/100m} = \frac{100}{W} \times \frac{Au}{As} \times C \times \frac{V_f}{V_a} \times D$$

W = weight of sample analyzed, Au = absorbance of the test sample, as = absorbance of standard solution, V_f = total volume of filtrate, V_a = volume of filtrate analyzed, C = concentration of the standard, D = dilution factor where applicable

Niacin (B_3) was determined using the method described by Okwu and Josiah (2006). Fifty (50 g) of the grounded samples were mixed with 200 mL of 1N H_2SO_4 in order to extract niacin. The extracts were autoclaved at 121 for 30 min, cooled to room temperature ($28^\circ C$), and the pH adjusted to 4.5 before diluting to the 250 mL mark. The mixtures were all purified by mixing 40 mL of filtrate into a 50 mL volumetric flask containing 17 g $(NH_4)_2SO_4$ and shaking before filtering. One (1 mL) of each filtrate and standard solution was added into two separate test tubes. A known weight of 0.5 mL of 2% aqueous NH_4OH , 2.0 mL of 2% H_2SO_4 solution, and 0.5% dilute HCl were all added to each tube and mixed thoroughly. About 5.0 mL of H_2O was added to the filtrate, while 5.0 mL of CNBr was added to the niacin standard, and both were shaken thoroughly. The mixtures were allowed to stand for 2 min, and the absorbance was read against a standard at 430 nm.

Vitamin C (ascorbic acid) was determined and calculated using the method described by Okwu and Josiah (2006). Five (5 g) of the samples were diluted with 10% trichloroacetic acid (TCA) to the 100.0 mL mark of a 100 mL volumetric flask. 2,6-dichlorophenolindophenol was titrated to 10.0 mL of the vegetable filtrate. Ascorbic acid was calculated as:

$$\text{Ascorbic acid (mg/kg)} = (A-B) \times C \times 100/s \times (100/10)$$

Where A = Volume in mL of indophenol solution used in the sample, B = Volume in mL of indophenol solution used for the blank, C = Mass in mg of ascorbic acid equivalent to 1 mL of standard indophenol solution, S = weight of the sample taken (g), $100/10$ = total extraction volume/volume of titrated sample

2.7 Determination of quality indices of fat

The free fatty acid (FFA), peroxide, iodine and saponification values were all determined using the methods described by Onwuka (2018). Twenty-five (25 mL) of diethyl ether with 25 mL of alcohol (ethanol) were mixed, and 1mL of 1 % phenolphthalein in solution added. Two (2 g) of sample was weighed into a clean conical flask of known weight and dissolved in the neutralized solvent mixture. It was boiled for 5 minutes, after which it was titrated with aqueous 0.1 mL of NaOH solution, shaken constantly until a pink color was obtained. Free fatty acid content was calculated as:

$$FFA \frac{mg}{KOH} / g = \frac{V \times 0.0282 \times 100}{\text{weight of sample}}$$

Where V is the sample titre; 1 cm³ of 0.1M NaOH contains 0.0282 of oleic acid.

A quantity of the sample was weighed into a dry conical flask, and 1g of powdered Potassium Iodide and 20mL of solvent mixture (Acetic acid/chloroform, 2:1 w/v) were added. The flask was placed in a hot bath set at $100^\circ C$ for 30 minutes. After which the mixture was transferred into a titrating flask containing 20 mL of Potassium Iodide (5%), and the flask was washed twice with 25 mL of water and added to the titrating flask. The mixture was titrated with 0.002 N sodium thiosulphate solution as indicator. The blank titration was also performed. Peroxide value was calculated as:

$$\begin{aligned} \text{Peroxide value meq/kg} \\ = \frac{1000 \times (b - a)N}{\text{weight of sample}} \end{aligned}$$

Where 1000 is the conservation factor, b is the titre value for the blank, a is the titre value for the sample, N is the normality of the titrant = 0.002

One (1 g) sample was weighed into a glass stopper bottle of 250 mL capacity, and 10 mL of Carbon tetrachloride was added to dissolve the sample. Twenty (20 mL) of Wiji solution was added with the aid of a pipette. The mixture was placed in the dark for 30 minutes, after which 25 mL of 10% potassium iodide solution was added and shaken thoroughly. The bottle was washed down with 100 mL of distilled water. The mixture was titrated with standard 0.1 N Sodium thiosulphate solution using starch as an indicator. The reagent was added with constant shaking until a yellow color of iodine appeared slightly before adding 2 mL of 1% starch solution (newly prepared), and titration continued until a blue color was obtained. Blank determination with an equal portion of Wiji's reagent was also carried out. Iodine value was calculated as:

$$\text{Iodine value Wiji's} = \frac{12.69 \times (b - a)N}{\text{weight of sample}}$$

Where 12.69 is the constant for iodine value, a is the titre value for the sample, b is the titre value for the blank, and N is the normality of the titrant = 0.1N. Fifty (50mL) of 0.5N ethanol Potassium hydroxide was added to 0.5 mL of the sample. It was heated for 30 minutes and cooled. Two drops of 1% phenolphthalein indicator were added and titrated with 0.5 N hydrochloric acid. A blank titration was also performed. Saponification value was calculated as:

$$\begin{aligned} \text{Saponification value} &= \frac{\text{mg}}{\text{KOH}} / \text{g} \\ &= \frac{56.1 \times (b - a)N}{\text{weight of sample}} \end{aligned}$$

Where 56.1 is the molecular weight of KOH, N is the normality of HCl = 0.5, a is the titre value for the sample, and b is the

titre value for the blank. The method described by [Andina et al. \(2014\)](#) was used to determine the anisidine value of the sample. The samples were all blended in methanol (1:1 w/v). The extracts were also mixed in ethanol (1:3). The extracts obtained were evaporated at 70°C. Anisidine value was determined using a spectrophotometer. Fat content of the samples was determined and calculated using the method described by [AOAC International \(2016\)](#). One (1 g) of sample was weighed into a fat-free thimble, plugged lightly with cotton wool and extracted with petroleum ether in soxhlet apparatus set up for 5 hours at a boiling point of 70. The ratio of the quantity of fat sample to petroleum ether used was 1:4. The residue was evaporated in an air oven at 100 for 30 minutes, cooled and weighed. The fat content was calculated as:

$$\text{Crude fat} = \frac{\text{weight of fat extract}}{\text{weight of sample}} \times \frac{100}{1}$$

2.8 Determination of carotenoid content

2.8.1 Sample extraction

The method described by [Kimura and Rodriguez-Amaya \(2002\)](#) was used to determine the carotenoid content. A known weight (10 g) of the sample was thoroughly mixed with 3 g of Hyflosupercel (celite) and 50 mL of cold acetone. The mixture was filtered with filter paper.

2.8.2 Partition to petroleum ether

The extracts were transferred into a chromatographic open column and were wetted with petroleum ether. The recovered parts were transferred to a 500 mL separator funnel. Twenty (20 mL) of petroleum ether (PE) and 300 mL of distilled water were added and allowed to separate while discarding the aqueous lower phase. About 200 mL of distilled

water was used to wash and remove any residual acetone. The PE phase was recovered in a 25 mL volumetric flask while passing through a small funnel containing anhydrous Sodium sulphate. The volume was made up to the mark using PE. The carotenoid content of the extract was determined using a spectrophotometer. The total carotenoids (TC) content was calculated using the formula:

$$\text{TC } (\mu\text{g/g}) = \frac{A \times \text{volume (mL)} \times 10^4}{A_{1\%1\text{cm}} \times \text{sample weight (g)}}$$

Where A= absorbance, Volume = total volume of extract: 25 mL, $A_{1\%1\text{cm}}$ = absorption coefficient of carotene in PE (2592)

2.8.3 High-performance liquid chromatography (HPLC)

The carotenoids in samples were separated using Waters e2695 HPLC systems equipped with a Photodiode Array (PDA) Detector. The PE extract was concentrated and dried down under nitrogen gas and reconstituted in 1 mL of dichloromethane: methanol (50:50) and filtered through a 0.22 mm PTFE syringe filter (Millipore) directly into injection vials, and 10 μL was injected into the system. Chromatographic conditions were performed using a mobile phase consisting of 50 % methyl-tert-butyl ether (MTBE) and 50 % methanol. Separation was achieved on a polymeric YMC C₃₀ column (5 μm particle size, 4.6 mm $\times$ 250 mm dimensions). The system operated under isocratic elution for a duration of 10 minutes. A flow rate of 1 mL/min was maintained throughout the run. After each analysis, the column was equilibrated for 10 minutes. The injection volume was set to 10 μL . Standards for β -carotene (cis and trans isomers) were purchased from

CaroteNature, GmbH (Lupsingen, Switzerland) and used for qualitative and quantitative determination of carotenoids in the samples. Chromatograms were generated at 450nm and identification of β -carotene (cis and trans isomers) was determined using external standards based on a calibration curve from pure standards and verification of the absorption spectrum and co-elution with available authentic standards.

2.9 Statistical analysis

All experiments were conducted in triplicate, with results reported as mean values $\pm$ standard deviation (SD). Statistical significance between groups was evaluated using a one-way analysis of variance (ANOVA), followed by Duncan's Multiple range test. Differences were considered statistically significant at p -values ≤ 0.05 . These analyses were performed using statistical software (SPSS version 22).

3. Results and discussion

3.1 Phytochemical properties of fresh and dried leaves and seeds of *Piper guineense* (uziza)

The phytochemical properties of fresh leaves and seeds of *Piper guineense* are shown in Table 1. The phytochemical properties of the plant showed the presence of flavonoids, alkaloids, tannins, and total phenol. The total phenol content of the fresh uziza leaves (1047.33 mg/100g) had the highest value, which was significantly ($p < 0.05$) higher than that of the seeds (984.73 mg/100g). The alkaloid content of the fresh uziza seeds (1.66 mg/100g) had the highest value, which was significantly ($p < 0.05$) higher than that of the leaves (1.53 mg/100g). The tannin content of the fresh uziza seeds (3.55 mg/100g) had the highest value, which was significantly ($p < 0.05$) higher

than that of the leaves (3.42 mg/100g). Flavonoid content of the fresh uziza seeds recorded the lowest value (0.39 mg/100g), which was significantly ($p < 0.05$) lower than that of the leaves (0.66 mg/100g). Total phenol of the fresh uziza seeds recorded the lowest value (984.73 mg/100g), which was significantly ($p < 0.05$) lower than leaves (1047.33 mg/100g). These findings suggest that both fresh uziza leaves and seeds are rich in phytochemicals, but with varying compositions. The significant differences in phytochemical properties between leaves and seeds may imply different potential uses or bioactive effects.

The phytochemical properties of dried leaves and seeds of *Piper guineense* are shown in Table 2. The results also showed the presence of flavonoids, alkaloids, tannins, and total phenol. The alkaloid and tannin contents of the dried uziza seeds (1.80 mg/100g) and (3.37 mg/100g) were significantly ($p < 0.05$) higher than those of dried leaves (1.71 mg/100g) and (3.23 mg/100g), respectively. The total phenol and flavonoid contents of the dried uziza leaves (1035.77 mg/100g) and (0.55 mg/100g) were significantly higher than those of dried seeds (975.87 mg/100g) and (0.33 mg/100g), respectively. These findings suggest that dried uziza leaves and seeds have distinct phytochemical profiles, which may influence their potential uses and bioactive effects.

The alkaloid content of the *Piper guineense* leaves (fresh weight (FW) basis and dry weight (DW) basis) was slightly lower than the value (1.72 mg/g) reported by Chinwendu et al. (2016) but much lower than 4.48 mg/g reported by Dibulo et al. (2017) for leaves of *P. guineense*. The *P. guineense* seeds (fresh weight (FW) basis and dry weight (DW) basis) were slightly lower than the value 1.58 mg/g reported by Ezenobi et al. (2016) for the

phytochemical composition of *P. guineense* seeds. The differences in these values could be attributed to genetic variety, part of the plant, and type of soil. The alkaloid values for the leaf and seed increased during the drying process. According to Stafford et al. (2005), during drying, cell membranes rupture and degrade, thereby releasing compounds during extraction. Alkaloids work on the nervous system and are used as analgesics because they are capable of relieving pain (Okeke & Elekwa, 2003), and it plays some metabolic roles and control development in living organisms (Edeoga et al., 2006).

The flavonoid contents of the *P. guineense* leaves (fresh weight (FW) basis and dry weight (DW) basis) were lower than the values 1.44 mg/g reported by Chinwendu et al. (2016) and 7.86 mg/g reported by Dibulo et al. (2017) for leaves of *P. guineense*. The *P. guineense* seeds (fresh weight (FW) basis and dry weight (DW) basis) were higher than the value 0.26 mg/g reported by Ezenobi et al. (2016) for phytochemical composition of *P. guineense* seeds. The differences in these values could also be attributed to genetic variety, part of the plant, and type of soil. The flavonoid values for the leaves and seed decreased during the drying process. The decrease in the flavonoid content of the sample could be a result of the processing methods adopted. According to Müller and Heindl (2006), post-harvest processes like drying take authoritative impact on the quality of the product, influencing its value, which is mostly shown in its appearance. Flavonoids are a distributed group of polycyclic compounds characterized by a common benzopyrone ring structure that has been reported to act as antioxidants in many biological systems (Emeziem & Iwu, 2024). They possess free radical scavenging activities, having multiple biological activities including

vasodilatory, anti-carcinogenic, anti-allergic, antiviral, estrogenic effects, as well as being inhibitors of phospholipase H-2, cyclooxygenase, glutathione reductase, and xanthine oxidase (Emeziem & Iwu, 2024). They possess anti-inflammatory and analgesic effects as well as anti-cancer properties (Iwu et al., 2019).

The phenol contents of the *Piper guineense* leaves (fresh weight (FW) basis and dry weight (DW) basis) were higher than the values of 1.32 mg/g reported by Chinwendu et al. (2016) and 0.56 mg/g reported by Dibulo et al. (2017) for leaves of *Piper guineense*. The *Piper guineense* seeds (fresh weight (FW) basis and dry weight (DW) basis) were higher than the value of 0.01 mg/g reported by Ezenobi et al. (2016) for the phytochemical composition of *Piper guineense* seeds. The phenol values for the leaves and seed decreased during the drying process. The decrease could also be as a result of the processing methods adopted. According to Müller and Heindl (2006), post-harvest processes like drying take authoritative impact on the quality of the product, influencing its value, which is mostly shown in its appearance. Phenolic compounds detected in this plant might be responsible for the antioxidant property. Phenols are important plant-derived bioactive compounds because of their ability to scavenge free radicals due to their hydroxyl groups, and they may directly contribute to their antioxidant potential and antibacterial activities (Chandran et al., 2013).

The tannin contents of the *Piper guineense* leaves (fresh weight (FW) basis and dry weight (DW) basis) were higher

than the values 2.38 mg/g reported by Chinwendu et al. (2016), 0.183 mg/g reported by Ajayi et al. (2014), 0.34 mg/g reported by Ojinnaka et al. (2016), and slightly higher than 3.20 mg/g reported by Dibulo et al. (2017) for leaves of *P. guineense*. The *P. guineense* seeds (fresh weight (FW) basis and dry weight (DW) basis) were higher than the value 1.30 mg/g reported by Ezenobi et al. (2016) for the phytochemical composition of *P. guineense* seeds. The differences in the tannin contents could also be attributed to genetic variety, part of the plant, and type of soil. The decrease in the tannin content of the samples may also be as a result of the processing methods adopted. The losses observed in the tannins during drying are in line with the findings of Okafor (1983), who reported that tannins account for the astringent bitter taste of vegetables and have been associated with binding and precipitation of proteins, which also decreased with drying. Tannins are a type of polyphenol that has several therapeutic and medical uses. Their pharmacological qualities include: the ability to heal wounds, prevent dysentery, fight bacteria, and reduce inflammation; being anti-toxic, anti-cancerous, antiallergic, and anti-inflammatory (Ghosh, 2015).

There were decreases in the phytochemical contents of the dried samples. These phytochemicals are naturally occurring bioactive compounds which are susceptible to heat and light (Bonnie & Choo, 2000). At room temperature above 30°C, phytonutrients break up (Hidalgo et al., 2009).

Table 1. Phytochemical properties of fresh leaves and seeds of *Piper guineense* (Uziza)

Samples	Alkaloid (mg/100g)	Flavonoid (mg/100g)	Total phenol (mg/100g)	Tannin (mg/100g)
Fresh uziza leaves	1.53 ^b ±0.03	0.66 ^a ±0.02	1047.33 ^a ±1.04	3.42 ^b ±0.01
Fresh uziza seeds	1.66 ^a ±0.02	0.39 ^b ±0.02	984.73 ^b ±0.94	3.55 ^a ±0.02

Note: Values show the mean of triplicate analysis and ± standard deviation. Figures with different superscripts down the column are significantly different (p<0.05).

Table 2. Phytochemical properties of dried leaves and seeds of *Piper guineense* (Uziza)

Samples	Alkaloid (mg/100g)	Flavonoid (mg/100g)	Total phenol (mg/100g)	Tannin (mg/100g)
Dried uziza leaves	1.71 ^b ±0.02	0.55 ^a ±0.01	1035.77 ^a ±0.50	3.23 ^b ±0.02
Dried uziza seeds	1.80 ^a ±0.01	0.33 ^b ±0.02	975.87 ^b ±0.15	3.37 ^a ±0.02

Note: Values show the mean of triplicate analysis and ± standard deviation. Figures with different superscripts down the column are significantly different (p<0.05).

3.2 Mineral compositions

The mineral compositions of the fresh leaves and seeds of *P. guineense* are shown in Table 3. The iron, zinc and copper contents of the fresh uziza leaves (3.09 mg/100g), (0.42 mg/100g) and (0.10 mg/100g) were significantly (p<0.05) higher than the fresh seeds (2.24 mg/100g), (0.32 mg/100g) and (0.06 mg/100g) respectively, while the fresh uziza seeds (141.25 mg/100g), was significantly (p<0.05) higher than leaves (137.01 mg/100g).

The mineral compositions of the dried leaves and seeds of *P. guineense* are shown in Table 4. The iron, zinc and copper contents of the dried uziza leaves (3.14 mg/100g), (0.39 mg/100g) and (0.09 mg/100g) were significantly (p<0.05) higher than the dried seeds (2.23 mg/100g), (0.34 mg/100g) and (0.07 mg/100g), respectively. The dried uziza seeds (142.01 mg/100g) recorded the highest magnesium, while the dried leaves recorded the lowest value (138.40 mg/100g). The dried uziza seeds differ significantly (p<0.05) from the dried leaves. The drying process has minimal impact on the mineral composition compared to fresh samples (Table 3).

The iron contents for both the fresh weight (FW) and dry weight (DW) bases of the leaves and seeds vary from the values 3.12 mg/g reported by [Ojinnaka et al. \(2016\)](#) for the seeds and leaves of uziza (*P. guineense*), 2.48 mg/g reported by [Ezenobi et al. \(2016\)](#) for phytochemical composition of *P. guineense* seeds and 3.82 - 6.34 mg/g reported by [Ogbedeagu et al. \(2025b\)](#) for three Nigerian spices. The deficiency of iron has been described as the most prevalent nutritional deficiency, and iron deficiency anemia is estimated to affect more than one billion people worldwide ([D'Mello, 2003](#)). The Iron content of the dried uziza leaves increased when compared with the fresh leaves. The iron content of the uziza seeds decreased with drying. High iron content in the dried uziza leaves could be attributed to the loss of moisture. It is known that the loss of moisture increases nutrient density in foods with Iron inclusive ([Adejumo et al., 2012](#)). The drying temperature had varied effects on mineral concentrations such that the drying temperature employed caused lower iron concentration in the dried uziza seeds when compared with the fresh uziza seeds. According to [Amaechi et al. \(2020\)](#), increased oven

temperature resulted in a gradual decrease in mineral concentrations, which could be attributed to a higher oxidation rate of minerals with an increase in oven temperature.

The zinc contents of the *P. guineense* leaves and seeds (fresh weight (FW) basis and dry weight (DW) basis) were lower than the value 0.63 mg/g reported by Ogbuji et al. (2016) for green leafy vegetables consumed in South Eastern Nigeria. The samples (fresh weight (FW) basis and dry weight (DW) basis) were higher than 0.085 and 0.210 mg/g reported by Onyeka et al. (2018) from different localities and lower than 0.75 mg/g reported by Ezenobi et al. (2016). There were variations in the zinc contents. According to Chikwendu and Nmalubuikeibe (2014), variation in minerals could be due to changes in environmental factors or the laboratory used for the analysis. The differences in the zinc contents of the samples may be as a result of the processing methods adopted and also the breakdown of the nutrients. According to Hidalgo et al. (2009), at normal room temperature, phyto nutrients would be able to break down. Zinc has been reported to exhibit catalytic and modulatory activities on over 300 enzymes. It also aids in the maintenance of a healthy immune system and enhances sperm development, ovulation, and fertilization (Umedum et al., 2013). The zinc content of the dried uziza leaves decreased when compared with the fresh leaves. This indicates that drying was not effective in retaining and improving the zinc content of the dried leaves. This observation agrees with the work of Morris et al. (2004). While the zinc content of the uziza seeds increased with drying. This might be because of the loss of moisture, as loss of moisture tends to increase nutrient density in food (Adejumo, 2012).

The magnesium contents of the *P. guineense* leaves and seeds (fresh weight (FW) basis and dry weight (DW) basis) were higher than the values 0.46 mg/g reported by Ogbuji et al. (2016) for green leafy vegetables consumed in South Eastern Nigeria, 25.16 mg/g reported by Ezenobi et al. (2016) for phytochemical composition of *Piper guineense* seeds and 0.14, 0.015 and 0.086 mg/g reported by Onyeka et al. (2018) for uziza (*P. guineense*) seeds from different localities. According to Onyeka et al. (2018), the disparity in the mineral compositions of *P. guineense* leaves and seeds for the fresh weight (FW) and dry weight (DW) bases could be attributed to factors such as effects of processing, stage of maturity of the seeds before harvesting, and climatic influences. It can also be due to soil compositions and the rate of uptake of minerals by the vegetable (Anjorin et al., 2010). Magnesium is essential in glucose and insulin metabolism, chiefly by enhancing tyrosine kinase activity of the insulin receptor. The activity of phosphorylase b kinase is also activated by magnesium, thereby bringing about the release of glucose-1-phosphate from glycogen (Ramadass et al., 2015). Thus, it could be deduced that *P. guineense* may be a better candidate for the formulation of chemotherapeutic agents for diabetic conditions associated with dysfunctional insulin. The magnesium contents of the dried uziza leaves and seeds increased when compared with the fresh ones. This might be because of the loss of moisture, as loss of moisture tends to increase nutrient density in food (Adejumo et al., 2012).

The copper contents of the *Piper guineense* leaves and seeds (fresh weight (FW) basis and dry weight (DW) basis) vary from the values 0.06 and 0.03 mg/g reported by Ojinnaka et al. (2016) for seeds and leaves of uziza (*P. guineense*) and 0.15 mg/g reported by Ogbuji et al.

(2016) for green leafy vegetables consumed in South Eastern Nigeria. According to Bolanle et al. (2014), minerals like copper are vital for mental and physical well-being and are an important constituent of tissues, muscles, blood and nerve cells. The copper content of the dried uziza leaves decreased when compared with the fresh leaves. This indicates that drying

was not effective in retaining and improving the zinc content of the dried leaves. This observation also agrees with the work of Morris et al. (2004). Also, the copper content of the uziza seeds increased with drying. This might be because of the loss of moisture, as loss of moisture tends to increase nutrient density in food (Adejumo, 2012).

Table 3. Mineral compositions of fresh leaves and seeds of *Piper guineense* (Uziza).

Samples	Iron (mg/100g)	Zinc (mg/100g)	Magnesium (mg/100g)	Copper (mg/100g)
Fresh uziza leaves	3.09 ^a ±0.02	0.42 ^a ±0.02	137.01 ^b ±0.20	0.10 ^a ±0.01
Fresh uziza seeds	2.24 ^b ±0.04	0.32 ^b ±0.02	141.25 ^a ±0.65	0.06 ^b ±0.02

Note: Values show the mean of triplicate analysis and ± standard deviation. Figures with different superscripts down the column are significantly different (p<0.05).

Table 4. Mineral compositions of dried leaves and seeds of *Piper guineense* (Uziza).

Samples	Iron (mg/100g)	Zinc (mg/100g)	Magnesium (mg/100g)	Copper (mg/100g)
Dried uziza leaves	3.14 ^a ±0.05	0.39 ^a ±0.02	138.40 ^b ±0.49	0.09 ^a ±0.03
Dried uziza seeds	2.23 ^b ±0.02	0.34 ^b ±0.02	142.01 ^a ±0.91	0.07 ^b ±0.02

Note: Values show the mean of triplicate analysis and ± standard deviation. Figures with different superscripts down the column are significantly different (p<0.05).

3.3 Vitamin contents

The vitamin contents of the fresh leaves and seeds of *P. guineense* are shown in Table 5. The vitamin C contents of the *P. guineense* ranged from 1.91 mg/100g to 2.49 mg/100g. Fresh uziza leaves had the highest value while fresh uziza seeds had the least value. There were significant (p<0.05) differences between the samples. The vitamins B₁, B₂ and B₃ ranged from 0.03 mg/100g to 0.83 mg/100g, 0.03 mg/100g to 2.07 mg/100g and 0.70 mg/100g to 0.90 mg/100g, respectively. Fresh uziza seeds had the highest value, while fresh uziza leaves had the least value. There were significant (p<0.05) differences between the samples. The vitamin profiles suggest different nutritional potentials for uziza

leaves and seeds.

The vitamin contents of the dried leaves and seeds of *P. guineense* are shown in Table 6. The vitamin C contents of the *P. guineense* ranged from 1.85 mg/100g to 2.16 mg/100g. Dried uziza leaves had the highest value, while dried uziza seeds had the lowest value. There were significant (p<0.05) differences between the samples. The vitamins B₁, B₂ and B₃ ranged from 0.03 mg/100g to 0.78 mg/100g, 0.03 mg/100g to 1.093 mg/100g and 0.70 mg/100g to 0.88 mg/100g. Dried uziza seeds had the highest value, while dried uziza leaves had the least value. There were significant (p<0.05) differences between the samples. The drying process had minimal impact on the vitamin composition compared to fresh

samples (Table 5).

Drying affected the vitamin C contents of the dried samples, as the vitamin C contents of the fresh leaves and seeds of *P. guineense* were reduced due to drying. This explains why vitamins are heat-sensitive. According to [Bonnie and Choo \(2000\)](#), vitamins are naturally occurring bioactive compounds that are susceptible to heat and light. The vitamin C contents of the dried *P. guineense* leaves and seeds were lower than the values 2.51 and 1.94 mg/g, respectively, reported by [Ojinnaka et al. \(2016\)](#) for leaves and seeds of uziza (*Piper guineense*), but higher than the values 1.40 – 1.84 mg/g reported by [Ogbedeagu et al. \(2025b\)](#) for three Nigerian spices. These differences in the vitamin C values could be attributed to genetic variety and type of soil. According to [Chun et al. \(2006\)](#), the amount of vitamins in fruits and vegetables is affected by species, variety, maturity, growing conditions, and time and manner of harvesting. The differences in the vitamin C content of the samples are attributed to the processing methods adopted. The vitamin C content of the samples could enhance non-heme iron absorption from the fortified complementary foods, hence reduce the prevalence of anemia in the infants consuming it ([Attaugwu & Uvere, 2017](#)).

The vitamin B₁ contents of the leaves were not affected after the drying process, while that of the seed was slightly reduced. This could be as a result of the leaves having a more robust matrix structure, providing natural protection to the vitamins, whereas seeds have higher lipid contents, making them more susceptible to degradation ([Carsono et al., 2022](#)). Moreover, seeds contain more polyunsaturated fatty acids, which can lead to oxidative degradation of vitamins ([Carsono et al., 2022](#)). Leaves, with higher antioxidant content, may protect vitamins

from oxidation. The vitamin B₁ content of fresh and dried leaves were same as the values 0.03 mg/g reported by [Ojinnaka et al. \(2016\)](#) for leaves of uziza (*P. guineense*) while the dried seed was in line with 0.82 mg/g reported by [Ojinnaka et al. \(2016\)](#) for seeds of uziza (*P. guineense*) but higher than 0.02 mg/g reported by [Ezenobi et al. \(2016\)](#) for vitamin composition of *P. guineense* seeds. The differences observed in the thiamine content of the samples may be attributed to the processing methods adopted. According to [Eitenmiller and Lee \(2004\)](#), after harvest, variation in the vitamin values is caused by many factors including processing procedures, storage time and conditions, sample preparation, and variation in analytical methods. Aqueous solutions of thiamine itself are acidic, and at pH below 5.0, they are even stable to autoclaving at 120 °C and 130 °C and not susceptible to oxidation ([Trang, 2013](#)).

The vitamin B₂ contents of the leaves were not affected after the drying process, while that of the seed was slightly reduced. This also could be as a result of the leaves having a more robust matrix structure, providing natural protection to the vitamins, whereas seeds have higher lipid contents, making them more susceptible to degradation ([Carsono et al., 2022](#)). Moreover, seeds contain more polyunsaturated fatty acids, which can lead to oxidative degradation of vitamins ([Carsono et al., 2022](#)). Leaves, with higher antioxidant content, may protect vitamins from oxidation. The vitamin B₂ content of fresh and dried leaves were same as the values 0.03 mg/g reported by [Ojinnaka et al. \(2016\)](#) for leaves of uziza (*P. guineense*) while the dried seed was slightly lower than 2.06 mg/g reported by [Ojinnaka et al. \(2016\)](#) for seeds of uziza (*P. guineense*) but higher than 0.09 mg/g reported by [Ezenobi et al. \(2016\)](#) for vitamin composition of *P. guineense* seeds.

Riboflavin (B₂) is responsible for maintaining healthy blood cells. It plays an important role in the conversion of food into energy and in fat and protein metabolism. Hence, infants consuming complementary food containing *P. guineense* will have healthy blood cells, healthier vision and skin as well as improved fat and protein metabolism (Attaugwu & Uvere, 2017).

The vitamin B₃ contents of the leaves were not affected after the drying process, while those of the seed were slightly reduced. This also could be as a result of the leaves having a more robust matrix structure, providing natural protection to the vitamins, whereas seeds have higher lipid contents, making them more susceptible to degradation (Carsono et al., 2022). Moreover, seeds contain more polyunsaturated fatty acids, which can lead to oxidative degradation of vitamins (Carsono et al., 2022). Leaves, with higher antioxidant content, may protect vitamins from oxidation. The vitamin B₃ content of fresh and dried leaves were higher than the values 0.07 mg/g reported by Ojinnaka et al. (2016) for leaves of uziza (*P. guineense*) while the dried seed was similar to 0.90 mg/g reported by Ojinnaka et al. (2016) for seeds of uziza (*P. guineense*)

but higher than 0.08 mg/g reported by Ezenobi et al. (2016) for vitamin composition of *P. guineense* seeds. Severe deficiency of niacin in the diet causes the disease pellagra, which is characterized by diarrhea, dermatitis, and dementia, as well as hyperpigmentation, thickening of the skin, inflammation of the mouth and tongue, digestive disturbances, amnesia, delirium, and eventually death, if left untreated (Prakash et al., 2008).

These vitamins are naturally occurring bioactive compounds which are susceptible to heat and light (Bonnie & Choo, 2000). Domínguez et al. (2014) observed that drying loss of vitamins depends on mass transfer during thermal treatment, leading to drying losses of vitamins. Different drying methods affect losses in different ways. Also, the drying process affected the B vitamins in seeds but not in leaves. This could be as a result of differences in the tissue structure. The seeds are dense with a high lipid matrix, but with thin cell walls and a high moisture diffusion path, while the leaves are thicker and porous with more vacuoles, intact membranes, and better protection of B-vitamins (Carsono et al., 2022).

Table 5. Vitamin contents of fresh leaves and seeds of *Piper guineense* (Uziza).

Samples	Vitamin C (mg/100g)	Vitamin B ₁ (mg/100g)	Vitamin B ₂ (mg/100g)	Vitamin B ₃ (mg/100g)
Fresh uziza leaves	2.49 ^a ±0.24	0.03 ^b ±0.00	0.03 ^b ±0.00	0.70 ^b ±0.00
Fresh uziza seeds	1.91 ^b ±0.04	0.83 ^a ±0.02	2.07 ^a ±0.03	0.90 ^a ±0.02

Note: Values show the mean of triplicate analysis and ± standard deviation. Figures with different superscripts down the column are significantly different (p<0.05).

Table 6. Vitamin contents of dried leaves and seeds of *Piper guineense* (Uziza).

Samples	Vitamin C (mg/100g)	Vitamin B ₁ (mg/100g)	Vitamin B ₂ (mg/100g)	Vitamin B ₃ (mg/100g)
Dried uziza leaves	2.16 ^a ±0.01	0.03 ^b ±0.00	0.03 ^b ±0.00	0.70 ^b ±0.00
Dried uziza seeds	1.85 ^b ±0.04	0.78 ^a ±0.04	1.93 ^a ±0.03	0.88 ^a ±0.03

Note: Values show the mean of triplicate analysis and ± standard deviation. Figures with different superscripts down the column are significantly different (p<0.05).

3.4 Quality indices

The quality indices of the fresh leaves and seeds of *P. guineense* are shown in Table 7. The crude fat content of the fresh uziza seeds (3.18%) had the highest value, which was significantly ($p < 0.05$) higher than that of the leaves (1.25%). The free fatty acid (FFA) value of the fresh uziza seeds (6.64 mg KOH/g) was significantly ($p < 0.05$) higher than the fresh leaves (0.86 mg KOH/g). The iodine value of the fresh uziza seeds (10.96 g/100g) was significantly ($p < 0.05$) higher than the fresh leaves (0.37 g/100g). The saponification value of the fresh uziza seeds (158.37 mg KOH/g) was significantly ($p < 0.05$) higher than that of the fresh leaves (129.70 mg KOH/g). The peroxide value of the fresh uziza seeds (2.75 meq/kg) was significantly ($p < 0.05$) higher than that of the fresh leaves (2.67 meq/kg). The anisidine value content of the fresh uziza seeds (0.20) was significantly ($p < 0.05$) higher than the fresh leaves (0.07). Fresh uziza seeds had higher crude fat, FFA, iodine value, saponification value, peroxide value, and anisidine value compared to leaves, indicating differences in oil quality and composition.

The quality indices of the dried leaves and seeds of *P. guineense* are shown in Table 8. The crude fat content of the dried uziza seeds (3.18%) was significantly ($p < 0.05$) higher than the dried leaves (2.41%). The FFA value of the dried uziza seeds (8.50 mg KOH/g) was significantly higher than that of the dried leaves (1.25 mg KOH/g). The iodine value of the dried uziza seeds (12.98 g/100g) was significantly ($p < 0.05$) higher than that of the dried leaves (6.52 g/100g). The saponification value of the dried uziza seeds (170.00 mg KOH/g) was significantly higher than that of the dried leaves (136.30 mg KOH/g). The anisidine

value of the dried uziza seeds (0.27) was significantly higher than that of the leaves (0.10). The dried uziza seeds have higher crude fat, FFA, iodine value, saponification value, and anisidine value compared to leaves, indicating differences in oil quality and composition.

The seeds recorded higher fat contents when compared with the leaves. This could be as a result of the seed containing more lipids to provide energy for the developing seedling (Imo et al., 2018). There was an increase in the fat content of the dried leaves when compared with the fresh leaves. This is possible as drying can break down cell walls, making them more extractible and contributing to the apparent increase in fat content (Adum & Inyang, 2024). No change was observed in the fat content of the dried seeds when compared with the fresh seeds. This could be because the seeds have a more stable lipid composition, with fewer polyunsaturated fatty acids, making them less prone to oxidation and degradation. The fresh and dried *P. guineense* leaves were lower than the value of 2.45%, while the fresh and dried seeds were slightly higher than 3.16% reported by Ojinnaka et al. (2016) for leaves and seeds of uziza (*Piper guineense*). Ekeanyanwu et al. (2010) reported that fat is a high-energy nutrient and does not add to the bulk of the diet. The crude fat contents of the seeds of *P. guineense* obtained in this study were significantly less than 17.30 % reported by Bolanle et al. (2014) for the plant seeds from Ekiti State in Southern Western Nigeria.

The free fatty acid (FFA) contents of the samples differ from the values 5.14-6.54 mg KOH/g reported by Enyi and Ojmelukwe (2021) for quality of palm oil. According to Codex Alimentarius/ FAO/ OMS, free fatty acid content is the most used measure for determining the quality of oil and must not exceed 5%. Fatty acids

are in general present in oils as part of triacylglycerol molecules. The presence of free fatty acid residues is an indication of poor oil quality (Agbaire, 2012). The high FFA level reported in the seed could be linked with the postharvest handling practices. FFA content of edible oil is an indicator of deterioration through the action of lipases in the fruit following cell disruption (Hiol et al., 2000). Therefore, the high FFA reported in the fresh and dried seeds could be attributed to the postharvest handling practices. The lower the free fatty acid level, the better the quality of the oil. Thus, the oil samples from fresh and dried leaves were suitable for nutritional purposes. The increase in the FFA contents of the dried samples could be a result of hydrolysis, as drying breaks down triglycerides into glycerol and free fatty acids. Also, high temperature and O₂ can oxidize fatty acids, forming short-chain FFAs (Enyi & Ojmelukwe, 2021).

The iodine values of the samples were lower than the value of 13.66 g/100g reported by Ogbonna et al. (2015) for *P. guineense* and *Xylopia aethiopica* seed oils. Iodine value is the quantity of iodine absorbed by one gram of the oil to saturate the sigma bond. It is a sign of the level of unsaturation and susceptibility of oil to oxidation and rancidity (Agbaire, 2012). The iodine values of the fresh and dried seed oils indicated a higher degree of unsaturation than that of the leaves. From the iodine values of the oil samples, they could be classified as non-drying oils. Non-drying oil is that which does not harden when exposed to air. This is opposed to drying oil, which hardens completely, or semi-drying oil, which partially hardens when exposed to air (Ogbonna et al., 2015). Oils less than 115 g/100g are considered non-drying, and those above 130 g/100g are considered drying. In between are the semi-drying

types. According to Ogbonna et al. (2015), the higher the iodine value, the less stable the oil and the more vulnerable it is to oxidation and production of free radicals. The increase in the iodine value contents of the dried samples could be as a result of unsaturation exposure and conjugation effects, as drying can rupture cell walls, releasing embedded unsaturated fatty acids (e.g., linoleic, linolenic). Also, heat may promote formation of conjugated dienes/trienes, which react with iodine (Ogunka-Nnoka et al., 2015).

The saponification values of the samples were lower than the values 194.48-196.82 mg KOH/g reported by Enyi and Ojmelukwe (2021). Saponification value is inversely related to the molecular weights of triglycerides of oils. A high saponification value indicates a high proportion of low fatty acids since saponification value is inversely proportional to the average molecular weight or length of fatty acids (Amin et al., 2019). Saponification value is a unique and reliable means of characterizing fat and oil. Its value depends on the growing conditions of the oil-bearing plants and the method of extraction (Ogunka-Nnoka et al., 2015). The increase in the iodine value contents of the dried samples could be a result of short-chain FA formation and release of bound lipids. Thermal degradation or hydrolysis produces more short-chain fatty acids, which have higher saponification numbers (more KOH mg/g fat). Also, drying breaks down phospholipids or glycolipids, increasing total saponifiable fat (Mgbeahuruike et al., 2018).

The peroxide values of the samples were lower than the value of 0.92 reported by Ogbonna et al. (2015). The peroxide value gives early evidence of rancidity in oils, which is mostly referred to as lipid peroxidation or oxidative degradation.

The peroxide value is also used to evaluate the stability of fats by measuring the amount of lipid peroxides and hydroperoxides formed during the initial stages of oxidation and thus estimate the extent of spoilage of the oil (Ogunka-Nnoka et al., 2015). The saponification values for the samples were lower than the maximum limit of 10 mEqKOH/Kg set by the Codex Alimentarius Commission for nuts and seed oils, suggesting that the oils are stable to oxidation. Peroxide value is an index of rancidity; a low peroxide value indicates resistance of oil to peroxidation during storage (Alademeyin & Arawande, 2016). The increase in the peroxide value contents of the dried samples could be as a result of primary oxidation. Reaction of heat and oxygen leads to the formation of hydroperoxides (ROOH), the first stage of lipid peroxidation.

Anisidine value represents the content of secondary oxidation products such as β -alkenals. These compounds are able to react with *p*-anisidine reagent. AV is particularly appropriate for heated oils,

because most of the peroxides are destroyed during thermal oxidation using high temperature (Guillen & Cabo, 2002). The *p*-anisidine values were higher than 0.08 reported by Ouilly et al. (2017) for *Lannekerstingii* seeds and seed oil, except for fresh uziza leaves, which are lower. According to the standard of ISO, a desirable *p*-AV for fresh oil is <4.0, with an upper limit of 6.0. At a *p*-AV above 6, the oil would be highly oxidized. According to the findings from this research, the *p*-AV of the samples was well below the upper limit standard; therefore, it cannot result in higher oxidation. Determination of *p*-AV is considered to be the most accurate and reliable method to assess the oxidative state of oils (Sebastian et al., 2014). The increase in the anisidine values of the dried samples could be a result of secondary oxidation. Hydroperoxides decompose into aldehydes (e.g., hexanal, malonaldehyde). Also, heat accelerates the breakdown of unstable peroxides to these carbonyl compounds, which react with *p*-anisidine.

Table 7. Quality indices of fresh leaves and seeds of *Piper guineense* (Uziza).

Samples	Crude fat (%)	FFA (mg KOH/g)	Iodine value g/100g	Saponification value (mg KOH/g)	Peroxide value (meq/kg)	Anisidine value
Fresh uziza leaves	1.25 ^b ±0.03	0.86 ^b ±0.02	0.37 ^b ±0.02	129.70 ^b ±0.36	2.67 ^b ±0.03	0.07 ^b ±0.01
Fresh uziza seeds	3.18 ^a ±0.01	6.64 ^a ±0.02	10.96 ^a ±0.03	158.37 ^a ±0.23	2.75 ^a ±0.03	0.20 ^a ±0.01

Note: Values show the mean of triplicate analysis and $\pm$ standard deviation. Figures with different superscripts down the column are significantly different ($p < 0.05$).

Table 8. Quality indices of dried leaves and seeds of *Piper guineense* (uziza).

Samples	Crude fat (%)	FFA (mg KOH/g)	Iodine value g/100g	Saponification value (mg KOH/g)	Peroxide value (meq/kg)	Anisidine value
Dried uziza leaves	2.41 ^b ±0.01	1.25 ^b ±0.02	6.52 ^b ±0.06	136.30 ^b ±0.26	3.45 ^a ±0.03	0.10 ^b ±0.01
Dried uziza seeds	3.18 ^a ±0.02	8.50 ^a ±0.23	12.98 ^a ±0.02	170.00 ^a ±0.32	2.90 ^b ±0.01	0.27 ^a ±0.01

Note: Values show the mean of triplicate analysis and $\pm$ standard deviation. Figures with different superscripts down the column are significantly different ($p < 0.05$).

3.5 Carotenoid content

The carotenoid contents of the fresh leaves and seeds of *P. guineense* are shown in Figure 3. The 13-cis beta-carotene contents of the fresh uziza leaves (15.22 µg/g) had the highest value, which was significantly ($p < 0.05$) higher than the fresh seeds (6.99 µg/g). The Trans beta-carotene contents of the fresh uziza leaves (60.33 µg/g) had the highest value, which was significantly ($p < 0.05$) higher than the fresh seeds (16.1 µg/g). The 9-cis beta-carotene contents of the fresh uziza leaves (26.17 µg/g) had the highest value, which was significantly ($p < 0.05$) higher than the fresh seeds (3.82 µg/g). The Total beta-carotene contents of the fresh uziza leaves (101.71 µg/g) had the highest value, which was significantly ($p < 0.05$) higher than the fresh seeds (27.09 µg/g). The carotenoid contents of the dried leaves and seeds of *P. guineense* are shown in Figure 3. The 13-cis beta-carotene contents of the dried uziza leaves (7.21 µg/g) had the highest value, which did not differ significantly ($p > 0.05$) from the dried seeds (6.94 µg/g). The Trans beta-carotene contents of the dried uziza leaves (52.96 µg/g) had the highest value, which was significantly ($p < 0.05$) higher than the dried seeds (15.96 µg/g). The 9-cis beta-carotene contents of the dried uziza leaves (18.23 µg/g) had the highest value, which was significantly ($p < 0.05$) higher than the dried seeds (3.51 µg/g). The Total beta-carotene content of the dried uziza leaves (75.94 µg/g) had the highest value, which was significantly ($p < 0.05$) higher than that of the dried seeds (26.40 µg/g).

The 13-cis beta-carotene contents of the samples were higher than the values of 2.12 µg/g reported for Okra and 0.32 µg/g for Tomato by [EL-Qudah \(2009\)](#). The Trans beta-carotene contents of the leaf samples were higher than the values

of 50.8 µg/g for tomato; 38.6 µg/g for pumpkin; 27.7 µg/g for squash, but lower than 203.0 µg/g for carrot; and 128.5 µg/g for spinach, while the seed samples were lower as reported by [Sahabi et al. \(2012\)](#). The 9-cis beta-carotene contents of the samples were higher than the values of 0.43 µg/g reported for Okra, 0.12 µg/g reported for green beans, and 0.09 µg/g for eggplant as reported by [EL-Qudah \(2009\)](#). The Total beta-carotene contents of the samples were lower than the values 231.0 µg/g for tomato; 135.2 µg/g for pumpkin; 156.7 and 397.8 µg/g for carrot, but higher than 25.3 µg/g for punk leaf and 20.3 µg/g for squash as reported by [Sahabi et al. \(2012\)](#). The results from these findings were in contradiction with reports from other researchers, probably due to changes in stage of maturity, growing conditions, season, and agricultural and post-harvest handling practices according to [de Sá and Rodriguez-Amaya \(2004\)](#).

Carotenoids are involved in the oxidative stability of the oil and have a protective role against cancer and cardiovascular diseases ([Yoshida et al., 2003](#)). More than 700 carotenoids have been identified in 89 plant foods and in the human body, but the overwhelming majority in the human diet is represented by β -carotene, α -carotene, lycopene, lutein, cryptoxanthin, and zeaxanthin ([Gimeno et al., 2000](#)). Carotenoid accumulation in plant tissue appears to be shaped by the physiological, genetic, and biochemical attributes of a plant species, as well as by environmental growth factors such as light, temperature, and fertility. Significant differences in carotenoid accumulation among different vegetable crop species have been reported. The accumulation of carotenoids in plant foods is also influenced by environmental growing conditions. Carotenoid accumulations have been shown to

increase and decrease in response to environmental manipulations, with different results for different plant species (Kopsell & Kopsell, 2006). The decrease in the carotenoid contents of the dried samples when compared with the fresh samples when compared with the fresh samples could be a result of the heat

treatment. Carotenoids are heat-sensitive, and at room temperature, phytonutrients break up. Also, heat accelerates thermal isomerization (cis and trans forms) and promotes oxidative breakdown and cleavage to apocarotenoid and aldehydes (Bonnie & Choo, 2000).

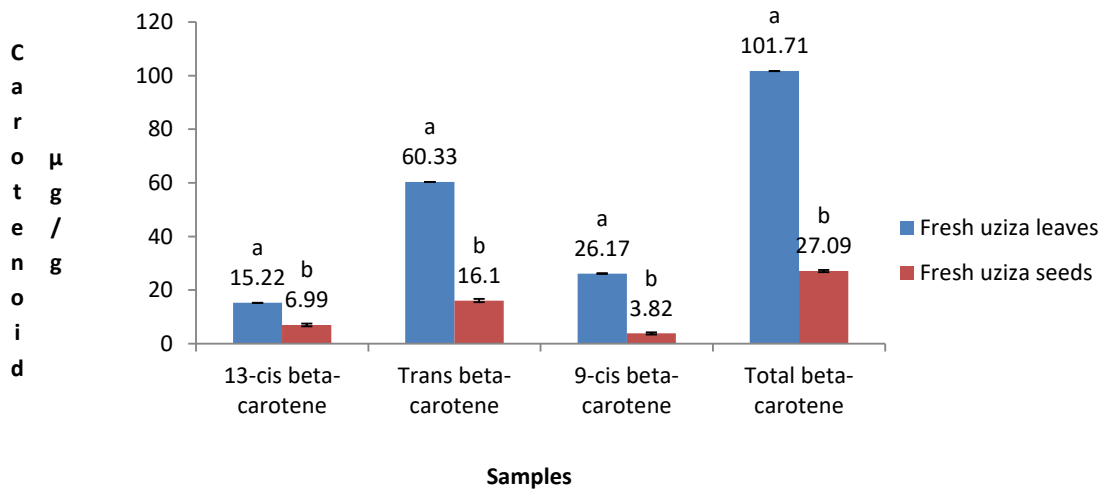


Figure 2. Total carotenoid (determined using spectrophotometer) with individual carotenoid (determined using HPLC) of fresh leaves and seeds of *Piper guineense* (Uziza).

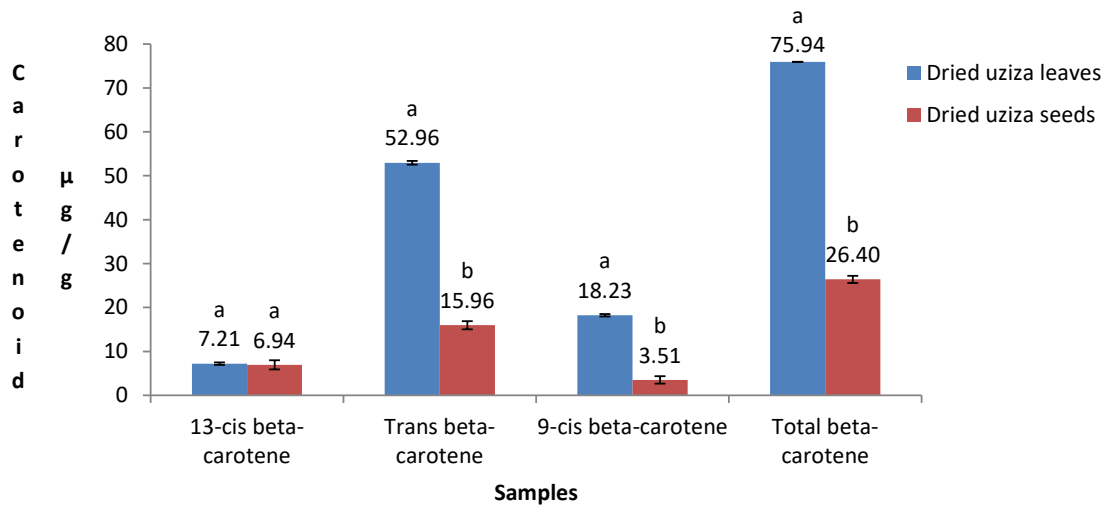


Figure 3. Total carotenoid (determined using spectrophotometer) with individual carotenoid (determined using HPLC) of dried leaves and seeds of *Piper guineense* (Uziza).

5. Conclusion

This study evaluated how drying impacts the nutrient composition, phytochemical and fat quality indices of fresh and dried leaves and seeds of *Piper guineense* (uziza). The fresh leaves exhibited the highest levels of total phenols, flavonoids, zinc, copper and vitamin C, while the dried seeds recorded the lowest flavonoids, total phenols, Fe and vitamin C. Drying boosted concentrations of alkaloids, magnesium and fat quality indices in seeds, and iron in dried leaves. The B-vitamins were highest in fresh seeds but declined on drying, whereas the leaves' B-vitamins showed little change. The observed differences align with moisture-loss concentration effects and heat-sensitivity/oxidation mechanisms. It is evident from this research that the leaves tolerated drying better than seeds, retaining most of their micronutrients and phytochemicals. This has shown that dried leaf powder can still serve as a nutrient-dense functional ingredient, whereas seeds are better consumed fresh or minimally processed to preserve their bioactive compounds and fat quality. Future work should optimize low-temperature drying and evaluate combined pre-treatments such as blanching to protect heat-labile vitamins and phytochemicals, especially in seeds. Emphasis should also be placed on in vivo bioavailability studies to confirm whether the observed nutrient losses translate to reduced physiological benefits.

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