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IMPACT OF BOILING ON COMPOSITION OF OVEN-DRIED *CURCUMA LONGA LINN* RHIZOMES

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ABSTRACT: *The effect of boiling Curcuma longa Linn rhizomes prior to oven drying on its proximate, mineral and phytochemical composition was studied. Fresh turmeric rhizomes were sliced to 5 mm thickness and then divided into two parts. The first part was oven dried directly while the second part was boiled prior to oven drying. Both products were then pulverised and subjected to laboratory analysis following standard procedures of AOAC and spectrometry. Boiling had an impact on the proximate composition as there were significant (P<0.05) reductions in ether extract, crude fibre and crude protein. Sodium, calcium, potassium and phosphorus contents were significantly reduced with a significant increase in levels of magnesium, zinc and iron (P<0.05). Significant reductions in phytochemicals due to boiling prior to oven drying were also recorded (P<0.05). This experiment therefore shows that boiling Curcuma longa Linn rhizomes prior to oven drying could be of pharmacological importance.*

KEYWORDS: Phytochemicals, Mineral, Boiling, Turmeric, Pharmacology, Processing method.

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INTRODUCTION

Curcuma longa Linn commonly known as turmeric is a plant widely used as a spice in cooking and medicine in pharmacology. It belongs to the family Zingiberaceae and is cultivated in the tropics including China, India, Malaysia, Cambodia and Nigeria (Sawant & Godghate, 2013). The most commonly used part of the plant are the rhizomes which have a tough brown skin, are highly branched, cylindrical, aromatic and yellow to orange in colour (Igbokwe *et al.,* 2016; Abraham *et al.,* 2018). The powdered rhizome contains 88.2% dry matter, 9.40% crude protein, 11% ether extract, 2.5% crude fibre, 68.8% nitrogen free extract and 8.3% ash (Choudhury, 2019). It also has varying levels of water-soluble and fat-soluble vitamins. Apart from these nutrients, the presence of phytochemicals (alkaloids, saponins, tannins, phenols and flavonoids) in the rhizomes are responsible for their antimicrobial potentials (Hosea *et al.,* 2018).

In order to avoid postharvest deterioration, turmeric rhizomes are preserved through various drying methods which include sun drying, hot air oven-drying, fluidized bed drying, frying and microwave heating (Saha *et al.,* 2022). Pre-treatment processes such as boiling, blanching, slicing and grinding have also been applied to improve on the final product, although this is yet to be well understood (Saha *et al.*, 2022). While these postharvest processing methods have their advantages, they also have some disadvantages. For instance, a study by Zagorska *et al.*, (2023) showed that compared with microwave heating and frying, boiling had the best results for antioxidant activity of turmeric rhizomes. Boiling has also been shown to remove raw odour from turmeric and ensure a uniform colour is obtained for its powdered form. It also showed some level of reduction in drying time (Saha *et al.,* 2022). While some researchers have reported that boiling increased the curcumin percentage as a result of its uniform distribution (Venkateshwari *et al.,* 2021), the effects of boiling prior to oven drying on mineral, vitamin and proximate compositions have not been deeply researched into. This study therefore aimed to evaluate how boiling turmeric rhizomes prior to oven drying affects its composition.

MATERIALS AND METHODS

Sourcing of Curcuma Longa *L.* rhizomes

Mature, fresh Curcuma Longa *L.* rhizomes were purchased from three (3) different markets in Ado Ekiti, Ekiti state. The mature rhizomes comprised forms that were cylindrical, with a thin, slightly brown peel covering an orange-yellow flesh.

Processing of the rhizomes

The rhizomes were washed in clean water and peeled using a kitchen knife. Then they were sliced into 5mm thickness and subjected to two different processes as follows:

- Oven drying: the sliced rhizomes were arranged evenly in an oven tray for drying in a convection oven (Quincy Lab Inc. digital laboratory Gravity convection 10GCE oven) which was pre-heated to 60^{o}c. This was left in the oven for 12 hours. The product obtained was then pulverised using a BST-LB2S two-speed Bionics laboratory blender and stored in a dark glass jar under room temperature for further analyses.

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- Boiling and oven drying: Another portion of the sliced rhizomes were boiled in hot water (100^{o}c) for 30 minutes. The cooked slices were then taken out of the pan with a colander and spread evenly on an oven tray for oven drying in a Quincy Lab Inc. digital laboratory Gravity convection 10GCE oven preheated to 60^{o}c. This was left in the oven for 12 hours. Thereafter, it was blended with a BST-LB2S two-speed Bionics laboratory blender and kept for further analyses.

Both samples were analysed in triplicates.

Proximate composition of the pulverised Curcuma Longa *L.* rhizomes

Determination of ash

2g of each of the oven-dried powdered samples were weighed into separate crucibles of known weight using an electronic balance (OHAUS, USA). These were ignited in a muffle furnace (MXBAOHENG, China) for 8 hours at 550^{o}c. Then the crucible was cooled to room temperature in a desiccator and ash content was calculated as:

$$\% \text{ Ash}_{(\text{wet basis})} = \text{Mass}_{(\text{ash})}/\text{Mass}_{\text{wet}} \times 100$$

Ether extract determination

The lipid content was determined by extracting the fat from 10g of the samples using petroleum ether in a soxhlet apparatus as described by Jae-min and Seun-Kook (2015). This was achieved by weighing the extraction flask, adding 85ml of petroleum ether and extracting for 4 hours. The leftover ether evaporated in a steam bath. Thereafter, the flask was oven dried at 100^{o}c till a constant weight was attained. The weight of the lipid obtained from the extract gave the weight of the ether extract in the sample and it was calculated as the difference between the original sample and the ether extract residue.

Determination of carbohydrate

Carbohydrate was calculated by the method of difference by subtracting the sum of percentage moisture, ash, crude protein, crude fibre and ether extract from 100% on a dry basis.

Determination of crude fibre

2.0g of each sample was weighed into separate beakers, the samples were then extracted with petroleum ether by stirring, settling and decanting 3 times. The samples were then air dried and transferred into a dry 100ml conical flask. 200cm^3 of 0.127M sulphuric acid solution was added at room temperature to the samples. The first 40cm^3 of the acid was used to disperse the sample. This was heated gently to boiling point and boiled for 30 minutes. The contents were filtered to remove insoluble materials, which was then washed with distilled water, then with 1% HCI, next with twice ethanol and finally with diethyl ether. Finally, the oven-dried residue was ignited in a furnace (MXBAOHENG, China) at 550^{o}C. The fibre contents were measured by the weight left after ignition and were expressed in terms of the weight of the sample before ignition.

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Determination of crude protein

The protein content was determined with the Kjeldahl method using a Kjeldahl analyser (DK8 Kjeldahl digestion unit, Switzerland). The protein nitrogen in 1g of the dried samples were converted to ammonium sulphate by digestion with sulfuric acid in the presence of $CuSO_4$ and Na_2SO_4. These were heated and the ammonia that evolved was steam distilled into boric acid solution. The nitrogen from ammonia was deduced from the titration of the trapped ammonia with 0.1M HCl with Tashirus indicator (double indicator) until a purplish pink colour was obtained. Crude protein was then calculated by multiplying the value of the deduced nitrogen by the factor 6.25.

MINERAL DETERMINATION

Calcium, Magnesium, Potassium, Sodium, Iron, Zinc and Manganese were determined using the atomic absorption spectrophotometer (AAS-Buck 205), as described by the methods of the Association of Official Analytical Chemists (AOAC, 2010). Phosphorus was determined colorimetrically as described by AOAC, 2010. The values of calcium, magnesium and potassium were reported in percentage while iron and zinc were reported in parts per million (ppm).

Magnesium, Manganese, Iron, Zinc and Copper were determined using AAS BUCK SCIENTIFI 211 AAS VGP, USA as follows:

The digest of the ash of each sample above as obtained in calcium and potassium determination was washed into 100 ml volumetric flask with deionized or distilled water and made up to mark. These diluents were aspirated into the Buck 211 Atomic Absorption Spectrophotometer (AAS) through the suction tube. Each of the trace mineral elements was read at their respective wavelengths with their respective hollow cathode lamps using appropriate fuel and oxidant combination.

Phosphorus content was determined using a spectrophotometer wherein the ash of each sample obtained was treated with 2 MHCL solution as described for calcium determination above. 10ml of the filtrate solution was pipetted into 50 ml standard flask and 10ml of vanadate yellow solution was added and the flask was made up to mark with distilled water, stoppered and left for 10 minutes for full yellow development. The concentration of phosphorus was obtained by taking the optical density (OD) or absorbance of the solution on a Spectronic 20 spectrophotometer at a wavelength of 470 nm.

The percentage phosphorus was then calculated from using the formula:

$$\%\text{Phosphorus} = \frac{\text{Absorbance} \times \text{Slope} \times \text{Dilution factor}}{\text{Wt. of sample}}$$

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PHYTOCHEMICAL DETERMINATION

Determination of Phenols

The amount of total phenolics in extracts was determined according to Xu and Chang (2007) with slight modifications. After adding Folin-Ciocalteu reagents and sodium carbonate to aliquots of samples, the mixtures were set in 40^0C water bath for 20 minutes. The absorbance was measured at 740 nm using a spectrophotometer and the total phenolic content was expressed as milligrams of gallic acid equivalents (GAE) per gram of defatted sample.

Determination of Tannins

Tannins were extracted into boiling distilled water for one hour. Colour development was done with Folin-Denis reagent and sodium carbonate solution. Absorbance was measured at 750 nm spectrophotometrically. The tannic acid concentrations were calculated from the tannic acid standard curve.

Determination of Alkaloids

5g of the samples was weighed into 250 ml beaker and 200 ml of 10% acetic acid in ethanol was added and covered and allowed to stand for 4hrs.This was filtered and the extract was concentrated on a water bath to one quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitate was collected and washed with dilute ammonium hydroxide and filtered. The residue is the alkaloids which were dried and weighed.

Determination of Saponin

Saponin was extracted for 2 hours in a reflux condenser containing pure acetone. Exhaustive re- extraction over the heating mantle with methanol in the Soxhlet apparatus was done for 2 hours. Extract was weighed after allowing methanol to evaporate. The saponin content was calculated as percentage of the sample.

Flavonoid determination

The total flavonoids contents were estimated using the procedure described by Zhichen *et al*. (2019) total of 1 ml of sample were diluted with 200µl of distilled water separately followed by the addition of 150 µl of sodium nitrate (5%) solution. This mixture was incubated for 5 minutes and 15 µl of ammonium chloride (10%) solution was added and allowed to stand for 6 minutes, then 2 ml of Sodium hydroxide (4%) solution was added and made up to 5 ml with distilled water. The mixture was shaken well and left for 15 minutes at room temperature. The absorbance was measured at 510 nm. The appearance of pink colour showed the presence of flavonoids content. The total flavonoids content was expressed as rutin equivalent mg RE/100g extract on dry weight basis using standard curve.

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STATISTICAL DATA ANALYSIS

Completely Randomised Design was used for this experiment with three (3) replicates per treatment. Data collected were subjected to analysis of variance using SPSS IBM version 26.0 while means were separated using Tukey's Honest Significant Difference Test at $p<0.05$.

RESULTS AND DISCUSSION

Proximate composition of *Curcuma longa Linn* rhizomes

The results in Table 1 show the approximate composition of oven-dried and boiled oven-dried *Curcuma longa Linn* rhizomes. Both methods gave significantly different results with boiled oven dried rhizomes having higher dry matter, ash, and Nitrogen-free extracts (91.0800%, 3.5100%, and 68.2900%) but lower crude fibre, ether extract and crude protein contents (5.9900%, 4.5100% and 8.5600% respectively). Although Dhami *et al.,* (2023) reported significantly lower dry matter (91.37%) in cooked oven-dried turmeric rhizome as compared with oven dried (95.25%), the lower moisture content obtained in this study could be due to moisture loss during boiling and subsequent drying. This therefore implies longer shelf life and stability. Boiling also yielded a significant decrease in the ether extract content which suggests losses due to oil extraction into the boiling water. The reduction in protein content of boiled oven dried rhizomes could be attributed to denaturation and solubilization of amino acids while the reduced the crude fibre content could be attributed to breakdown and solubilization of fibre (Kumar *et al., 2017;* Singh *et al.,* 2018; Torres *et al.,* 2018).

Dhami *et al.* (2023) also reported that boiling significantly reduced the ash content in turmeric rhizomes. This contrasts the results of this study which showed that boiled oven dried turmeric had higher ash content than the oven dried one. This increase may be due to concentration of minerals, especially non-water-soluble minerals (USDA, 2020).

Table 1: Proximate composition of processed *Curcuma longa Linn* rhizomes

Processing method	Parameters (%)					
	Dry matter	Ash	Ether extract	Crude fibre	Crude protein	Nitrogen-free extract
OD	90.7200^{b}	2.6200^{c}	4.7300^{a}	6.6100^{b}	9.1300^{a}	67.8800^{b}
BOD	91.0800a	3.5100^{a}	4.5100^{b}	5.9900^{c}	8.5600^{b}	68.2900^{a}
SEM±	0.0279	0.0110	0.0428	0.0228	0.519	0.1175

Means with different superscript on the same column are significantly different ($p<0.05$)

OD - Oven dried; BOD – boiled oven dried

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Table 2: Mineral composition of processed *Curcuma longa Linn* rhizomes

Processing method	MAJOR MINERALS (%)					TRACE MINERALS (ppm)	
	Na	Ca	K	Mg	P	Zn	Fe
OD	0.0036[b]	0.0173[b]	0.0775[b]	0.0011[c]	0.0024[b]	0.6600[c]	2.2800[b]
BOD	0.0029[c]	0.0129[c]	0.0671[c]	0.0012[b]	0.0021[c]	0.8700[a]	2.4100[b]
SEM±	0.2505	16.8280	0.5215	0.1639	0.4751	0.0468	0.1429

Means with different superscripts on the same column are significantly different ($p<0.05$).

OD - Oven dried; BOD – boiled oven dried

Table 2 shows the mineral composition of oven-dried and boiled oven-dried *Curcuma longa Linn* rhizomes. The results show significant differences among all the minerals tested for. The sodium, calcium, potassium and phosphorus contents (0.0029%, 0.0129%, 0.0671% and 0.0021%) of the boiled rhizomes were significantly lower than that of the directly oven-dried ones (0.0036%, 0.0173%, 0.0775% and 0.0024%. This reduction may be attributed to leaching of water-soluble minerals during boiling (Lavelli *et al.,* 2007). Zinc and iron contents however were significantly higher (0.8700ppm) in the boiled rhizomes than in the directly oven-dried ones (0.6600ppm). This is most likely because these are non-water-soluble minerals so they are concentrated during boiling and oven-drying (Kumar *et al.,* 2017).

Studies have been conducted on the effects of boiling on the colour, water holding capacity, swelling power, solubility and essential oil contents of turmeric rhizomes but literature is scarce on its effect on mineral composition (Jayashree and Zachariah, 2016; Emelike, 2020; Dhami *et al., 2023*). This study therefore contributes to the growing body of research on this subject.

Table 3: Phytochemical composition of processed *Curcuma longa Linn* rhizomes

PROCESSING METHODS	**(PHYTOCHEMICALS mg/100g)**				
	Alkaloids	Tannins	Saponins	Flavonoids	Phenols
OD turmeric powder	58.2800[b]	17.1833[a]	4.2147[a]	2.1263[a]	1.2333[a]
BOD turmeric powder	46.4937[c]	15.1937[b]	2.3553[b]	1.3800[b]	0.6497[c]
SEM ±	0.1013	0.0613	0.0192	0.7256	00.0843

Means with different superscript on the same column are significantly different ($p<0.05$)

OD - Oven dried; BOD – boiled oven dried

The phytochemicals contained in processed turmeric rhizomes are shown in Table 3. The results show that boiling had significant effects on oven-dried turmeric powder. The boiled oven-dried turmeric powder contained 46.4937, 15.1937, 2.3553, 1.3800 and 0.6497 mg/100g of alkaloids, tannins, saponins, flavonoids and phenols respectively while oven-dried turmeric powder contained 58.2800, 17.1833, 4.2147, 2.1263 and 1.2333mg/100g. Phytochemicals, when in large quantities, have been known to interfere with the digestion and absorption of food, thus having adverse effects on growth when found in high levels in the diet (Nath *et al.,* 2022). On the other hand, they are also useful in the diet as they possess some antifungal,

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antioxidant and antimicrobial properties. It therefore becomes imperative to reduce their concentrations in the diet for optimal benefits to be attained (Singh *et al.,* 2023). One way of doing this is by boiling (Kemboi *et al.,* 2023). Results of this study have further proven this by showing a significant reduction in the concentrations of phytochemicals in boiled turmeric powder. Saponins have been shown to contribute to the bitter taste and aroma of turmeric rhizomes. Boiling therefore reduces this and may alter its flavour profile. Patterson *et al.* (2017) also gave a similar report that boiling reduced the tannin content in pulses. A reduction in the levels of alkaloids in foods also have beneficial effects such as antibiotic and anti-hyperglycaemic physiochemical activities, thereby aiding their optimal utilisation (Cushnie *et al.,* 2014; Qiu *et al.,* 2014; Singh *et al.*,2017).

CONCLUSION

Boiling turmeric rhizomes before oven-drying significantly increases shelf life, reduces the level of its phytochemicals and slightly alters its mineral composition. However, the reduction in quantity of phytochemicals increases the absorption and availability of minerals and vitamins for growth and development. Further studies may also be conducted to ascertain if similar results will be obtained with varied boiling time.

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