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EFFECT OF TRADITIONAL PROCESSING METHODS ON THE NUTRITIONAL AND ANTINUTRITIONAL COMPOSITION OF TURMERIC (*Curcuma longa)*

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Abstract
Turmeric (*Curcuma longa*)in the past was consumed in small quantity as a spice, but in recent times, it's being consumed in large quantities because of the several reported health benefits associated with it. However, the presence of some antinutrients may pose health challenge and therefore prevent harnessing of the full nutritional benefits of turmeric. The research therefore, was conducted to determine the best method amongst the current traditional methods of processing turmeric practiced, that will reduce the antinutients and at the same time retain much of the macro and micronutrients. The commonly practiced processing methods evaluated were boiling plus sundrying, shade drying and sundrying alone. The elements evaluated include: antinutrients(oxalate, alkaloids, flavonoids, saponins, tannins and phenols), macronutrients (protein, fat, fibre and carbohydrate) and the micronutrients which include: vitamin C, vitamin A and mineral elements (calcium, magnesium, potassium and sodium). The results obtained showed that all processing methods significantly ($p<0.5$) reduced the antinutrient contents, but, boiling plus sundrying was most efficient, followed by shade drying. However, shade drying retained more of the micronutrients while sun drying alone showed the least efficiency in both antinutrient reduction and nutrient retention. Therefore, from the results obtained, boiling and shade drying is recommended as more efficient processing methods that will reduce the antinutrients and retain much of the macro and micronutrients.

Keywords: Turmeric, processing, antinutrient, and nutrient

Introduction

Turmeric (*Curcuma longa*) is a rhizomatous herbaceous perennial plant belonging to the ginger family *Zingiberaceae*. In the past, turmeric was consumed in small quantities as a spice because of the flavour and colour it added to food. However, with increasing knowledge of medicinal potentials of turmeric in recent times, turmeric is consumed in large quantities, sometimes as turmeric drink, as a composite of flour used for confectionaries, and as nutritional supplements. Curcumin (diferuloylmethane, demethoxycurcumin and bismethoxycurcumin) is responsible for turmeric biological activities (Chainani-Wu, 2003; Peter, 2000). Turmeric also possess some vital minerals and vitamins (Imoru *et al.*, 2018; Ikpeama *et al.,* 2014) that are critical for body metabolism and wellbeing. Sodium (Na), potassium (K), calcium (Ca) and magnesium (Mg) are among the vital minerals that reduce risk factors associated with cardiovascular diseases. Vitamin C, a co-factor in numerous physiological reactions, and β carotene are important antioxidants required for optimal functioning of the body. However, in addition to these beneficial nutrients in turmeric, turmeric also accumulates oxalate(Tang *et al*., 2008), tannins, phenols, flavonoids, alkaloids, saponins and other antinutrients (Imoru *et al.*, 2018; Ikpeama *et al.,*2014),which at high concentration can have negative effect on health, and thereby underscore the nutritional benefits in turmeric.

Antinutrients are chemicals in food that prevent the absorption of other nutrients; they are undesirable when consumed in large quantities because they reduce the bioavailability of essential minerals. For minerals to be absorbed by the body, it has to be in the ionic form, these antinutrients combine with the minerals in the body forming complexes with the mineral. Antinutrients such as oxalates, tannins and alkaloids interfere with the bioavailability of minerals and vitamins. Oxalate binds with calcium, forming calcium oxalates making Ca bio-unavailable (Park, 2013, Savage and Martensson, 2010). Calcium oxalate has been implicated in kidney stones with about 75% of kidney stones composing of calcium oxalate (Park, 2013; Tang *et al.*, 2008). Tannins

have ability to form complexes with metal ions and with macro-molecules such as proteins and polysaccharides (Lou *et al.,* 2019), making metal ion bio-unavailable and macro-molecules indigestible. Saponins have been reported to have haemolytic activity against red blood cells (Khalil and El-Adawy, 1994). In addition, saponins bind proteins to form saponin-protein complex reducing protein digestibility (Potter *et al*., 1993 and Shimoyamada *et al*., 1998). On the other hand, antinutrient consumed in controlled quantity have minimal effect, therefore, it is important to reduce these antinutrients to minimal level through various food processing methods. However, food processing also reduce the levels of nutritional content of food, therefore, this study evaluated the traditional methods of processing turmeric with the aim of determining the best method that effectively reduce the antinutrients without compromising much of the nutritious benefits in turmeric. The identified traditional methods used for processing turmeric are: boiling of the rhizomes up to boiling point, and thereafter, spread out under the sun for drying, shade drying (drying the rhizomes indoors) and sun drying of turmeric rhizomes.

Materials and Methods

The harvested turmeric rhizomes used in the study were obtained from the Eastern farm of National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria and were identified by Genetic Resources Unit of NRCRI.

Processing of turmeric rhizome

I. Boiling + Sundrying: Rhizomes were immersed in water and heated up to boiling point, the water was drained off and the rhizomes spread out under the sun until properly dried. After which the dried rhizomes were milled into fine powder and sieved to remove particles.

ii. Shade drying: Rhizomes were spread out in a container and placed in a well ventilated room to dry. Thereafter, milled and larger particles sieved out.

iii. Sun drying: Rhizomes were spread out in a container and placed under the sun until well dried. The dried rhizomes were milled and sieved. All powdered samples were put in labeled polythene bags and stored at room temperature until required.

iv. Control: Fresh unprocessed rhizomes were put in polythene bag and stored in freezer until when required for use. Before using the frozen rhizomes for the experiment, the rhizomes were allowed to thaw, the bark was peeled out after which they were properly crushed to a fine paste.

The following analyses were carried out on all processed samples and the control (unprocessed rhizome).

Determination of proximate composition

The estimated amount of protein, lipids, moisture, ash, fibre and carbohydrates were determined by the Methods of Association of Official Analytical Chemists (AOAC, 2000). All analysis were duplicated and results reported in percentage. The Kjeidal's method was used for crude protein determination, the nitrogen content was determined and multiplied by 6.25 (conversion factor)to obtain the percentage protein. The total ash content was determined by furnace incineration, crude fibre content was determined by digestion method and the lipid content determined by soxhlet extraction method. The total soluble carbohydrate was estimated by difference of the sum of all the proximate compositions from 100%.

Determination of mineral content

Potassium, calcium, sodium and magnesium content of turmeric rhizome and powder were determined using flame photometry method as described by Udo *et al*. (2009).

Determination of vitamins

Vitamin A was determined using the method described by Pearson (1976) and vitamin C was analysed by the method described by Benderitter *et al.* (1998).

Determination of antinutrients

The tannin content of the sample was determined by Folin-Denms Colometric method as described by Nwosu *et al*., (2012), and flavonoids determined using the method described by Harbone (1973). Oxalate was estimated by method of Onwuka (2005), alkaloids and flavonoids determined by the method described by Haborne (1998). Saponin was determined by the method described by AOAC (2000). Tannins and phenols were determined by the method described by Person (1976).

Statistical analysis

The software package used for data analyses was SPSS Version 20.0 (IBM SPSS Inc, Chicago, IL) and level of significance estimated by One Way Analysis of Variance (ANOVA). Data were analyzed using Duncan Multiple Range Test and complemented with Student's t test for post-hoc test for comparisons of the means of the various doses and fractions. The probability level of less than 5% ($p<0.05$) was considered statistically significantly different between the test and control groups and among test groups for measured values.

Results and Discussion

Effect of processing on macronutrient content in turmeric

Table 1 shows the proximate nutritional composition of the fresh and processed rhizomes. The measured proximate nutrient compositions in all three processed dried samples were significantly ($P < 0.05$) higher than the nutrient composition of the raw rhizomes. This may be because the moisture was removed during drying thereby concentrating the nutrients in the dried samples. Moisture in food provides favourable environment for

enzyme activity and effective functioning of organs in the human body. On the other hand, moisture reduces the shelf life of produce because it provides a conducive environment for microbial growth, leading to food spoilage. Therefore, the low moisture in all three processed turmeric rhizome is desirable and indicative of longer shelf life. Moreover, the sun dried sample in this experiment had the least moisture content, implying sun drying to be a more efficient means of removing moisture from turmeric. The levels of protein, fibre and fat content was observed to be lowest in the boiled+sundried samples compared to the other processed samples. The lower protein value could be due to the solubilisation of protein and leaching out of nitrogenous substance during the boiling process (Reid *et al*., 2017). The low ash content may be due to leaching out of minerals during the boiling process, while denaturation of lipids and breakdown into glycerol and fatty acid by heat (Reid *et al.,* 2017) could have been the reason for the observed lower value observed for fat. Carbohydrate value was obtained by difference, therefore, the reason for the high carbohydrate value observed in the boiled + sundried sample. Meanwhile, the highest macronutrient content was observed in the shade dried sample while the highest energy value was observed in the sundried sample.

Comparatively, the result of the proximate analysis of the processed turmeric rhizomes is in agreement with what was obtained in other studies. The value obtained in this experiment for the shade dried sample for protein, fat, fibre, ash, moisture and carbohydrate was 9.67%, 6.49%, 4.86%, 2.86%,8.62% and67.50 respectively, while Imoru *et al.* (2018) indicated values for processed air dried samples as: 10.07%, 6.64%, 4.87%, 2.76%, 8.91%, and 66.76%. Also, the proximate nutritional content of the boiled + sundried samples was 9.12% protein, 6.35% fat, 4.51% fibre, 3.01% ash, 7.21% moisture and 69.80% carbohydrate. This is comparable with the result of Ikpeama *et al.,* (2014), for turmeric powder processed by boiling + oven drying processed; 9.40% protein, 6.85% fat, 4.60% fibre, 2.85% ash, 8.92% moisture and 67.38% carbohydrate. The difference could be because of the cooking time which incidentally was not recorded in both studies.

Effect of processing on micronutrient contents in raw and processed turmeric

The amounts (ppm) of Ca, Mg, K and Na in the various processed samples of *Curcuma longa* are as represented in Table 2. Ca values in the samples were as follows: raw (1.202), boiled + sundried (0.002), shade dried (1.102) and sun dried (1.402). Mg content in the samples were as follows: raw (0.424), boiled + sun dried (0.364), shade dried (0.789) and sun dried (0.624). K content were also as follows: raw (0.74), boiled + sun dried (3.075), shade dried (2.042) and sun dried (3.325). Na content is as follows: raw (0.028), boiled + sun dried (0.097), shade dried (0.032) and sun dried (0.112). The results showed that the mineral nutrients were retained best by sun drying technique. This observation is in agreement with that of Liman *et al.,* (2014) on spinach (*Spinaceaoleraceae*) and ability to retain Na, K, Ca, Mg better by sun drying technique. Also observed was that the minerals were in smaller concentration in the samples subjected to boiling + sun drying. Nerdy (2018) showed a decrease in the sodium, potassium, magnesium, and calcium mineral levels in boiled broccoli and cauliflower compared with fresh broccoli and cauliflower. A possible explanation to the observed low retention of the minerals in the boiled + sun dried sample could be that some of the minerals leached into the boiling water following the studies of Bethke, and Jansky, (2008) and Avola *et al.,*(2012).

The result of vitamin C and β-carotene levels in the processed and unprocessed samples are represented in Table 3. Both vitamin C and β-carotene are strong antioxidants scavenging free radicals in the body. The β-carotene level was observed to be reduced significantly ($P < 0.05$) by the three evaluated processing methods when compared with the level in the raw rhizome. This could be because of oxidation of the conjugate double bonds in the β-carotene by molecular oxygen during drying, thereby producing compounds with no β-carotene activity. This observation is in line with report of Burton *et al*., (2014) on β-carotene autoxidation by oxygen producing a non-vitamin A product but with immunomodulatory potential. However, shade drying of samples retained more β-carotene than sun drying method which could be because oxidation is accelerated by heat, light and oxygen (Oulai *et al.*, 2015). Also, the higher β-carotene level in the boiled+sundried sample could be because of release of protein-bound β-carotene by cooking. Moderate cooking method is reported to increase β-carotene availability in vegetables due to the breakdown of the plant cell walls and the release of protein-bound β-carotene, while repeated cooking at high temperature destroys some of the provitamins (Musa and Ogbadoyi, 2012).

The vitamin C level was observed to be significantly lower in all three processed samples compared to the control, however, the shade dried sample retained more vitamin C than the sun dried and the boiled + sundried samples (Table 4). Vitamin C is water soluble and temperature sensitive vitamin (Lee and Kader, 2000; Igwemmar *et al.,* 2013), hence, the observed greater loss caused by boiling and drying processing methods. The obtained vitamin C level in the raw turmeric (56.12mg/100g) was lower than 84mg/100g observed by Imoru *et al.,* (2018). This could be because of variation in the mineral content of the planting soils. Abanto-Rodriguez *et al*., (2016), reported inorganic mineral content of the planting soil affected the vitamin C content of *Myrciriadubia* which was observed to be negatively related to the concentration of aluminium, but positively to the concentration of magnesium and phosphorus. Genotypic differences could be another possible cause of differences in vitamin C content.

Effect of processing on antinutrient contents in raw and processed turmeric

The result of the antinutrient content in the processed

and unprocessed rhizomes is presented on Table 3 and Fig. 1. The results show that the three processing methods (boiling+sundrying, shade drying and sundrying) significantly ($p<0.05$) reduced the concentrations of the evaluated antinutrients contents in all processed samples when compared with the level in the control. Comparing the effectiveness of the evaluated processing methods on antinutrient reduction, boiling + sundrying processing method was observed to be most effective in reducing the antinutrients in turmeric. This observation can be attributed more to boiling as several reports validates the effectiveness of boiling in reducing antinutrients content in food (Musa and Ogbadoyi, 2012; Ogbadoyi *et al.*, 2006; Adeboye and Babajide, 2007). An important observation is the high oxalate content in the unprocessed turmeric sample(1257 mg/100g), however, there were significant reduction in the value by the evaluated processing methods: boiling + sundrying (33.18%), shade drying (24.31%) and sun drying (17.25%). This result is in agreement with those of other studies on oxalate content of fruits and vegetables, where it was reported that high levels of soluble oxalate could be reduced by cooking (Vanhanen *et al*., 2011; Juajun *et al.,*2012).Oxalates react with calcium to precipitate calcium oxalate which is the main cause of kidney stone (Park, 2013, Savage and Martensson, 2010). Besides, accumulation of oxalates in the body prevents the absorption and utilization of calcium; which in turn may cause calcium imbalance, rickets and osteomalacia.

Table 1: Proximate analysis of processed and unprocessed turmeric rhizomes

Sample	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)	Carbohydrate (%)	Energy value (Kcal)
Boiling + Sundrying	8.75±0.02^{b}	5.78±0.01^{a}	4.69±0.01^{c}	2.73±0.00^{c}	7.85±0.01^{c}	70.20 ±0.07^{a}	367.82±0.06^{c}
Shade drying	9.67±0.02^{d}	6.49±0.40^{b}	4.86±0.00^{d}	2.86±0.00^{b}	8.62±0.02^{b}	67.50±0.04^{c}	367.17±0.03^{c}
Sun drying	9.12±0.01^{c}	6.35±0.02^{b}	4.51±0.02^{b}	3.01±0.00^{a}	7.21±0.02^{d}	69.80±0.00^{b}	374.09±0.01^{a}
Control(unprocessed)	8.35±0.01^{a}	5.63±0.02^{a}	4.34±0.01^{a}	2.57±0.00^{c}	15.75±0.02^{a}	63.36±0.03^{d}	337.56±0.01^{b}

Table 2: Constituents of the mineral nutrients observed in processed and unprocessed turmeric rhizomes

Treatment	Ca (ppm)	Mg (ppm)	K (ppm)	Na (ppm)
Boiling + Sundrying	0.002	0.364	3.075	0.097
Shade drying	1.102	0.789	2.042	0.032
Sun drying	1.402	0.624	3.325	0.112
Control (unprocessed)	1.202	0.424	0.74	0.028
T-prob	0.002	0.028	0.030	0.054
SD	0.208	0.229	1.176	0.043

Significance level = 0.05

Table 3: Levels of carotenoids and vitamin C in processed and unprocessedturmeric rhizomes

Treatment	Carotenoid	Vitamin C
Boiling + Sundrying	5.13±0.04^{b}	35.58±0.03^{b}
Shade drying	8.68±0.02^{c}	47.85±0.04^{c}
Sun drying	4.50±0.03^{a}	30.64±0.03^{a}
Control (unprocessed)	10.25±0.02^{d}	56.12±0.03^{d}

Table 4: Constituents of the anti-nutrients observed in raw and processed rhizomes of *Curcuma Longa*

Treatment	Oxalate (mg/100g)	Tannins (mg/100g)	Alkaloids (mg/100g)	Flavonoids (mg/100g)	Saponins (mg/100g)	Phenols (mg/100g)
Boiling + Sun drying	852.5±45^{a}	1.17±0.03^{a}	0.48±0.02^{a}	0.64±0.02^{a}	0.35±0.03^{a}	0.20±0.02^{a}
Shade drying	965±21^{b}	1.26±0.03^{b}	0.56±0.02^{b}	0.92±0.02^{b}	0.42±0.02^{a}	0.31±0.01^{b}
Sun drying	1070±00^{c}	1.43±0.02^{c}	0.62±0.03^{b}	1.16±0.03^{c}	0.51±0.02^{b}	0.64±0.02^{c}
Unprocessed	1257±21^{d}	1.54±0.02^{d}	0.77±0.03^{c}	1.28±0.03^{d}	0.64±0.04^{c}	0.79±0.02^{d}

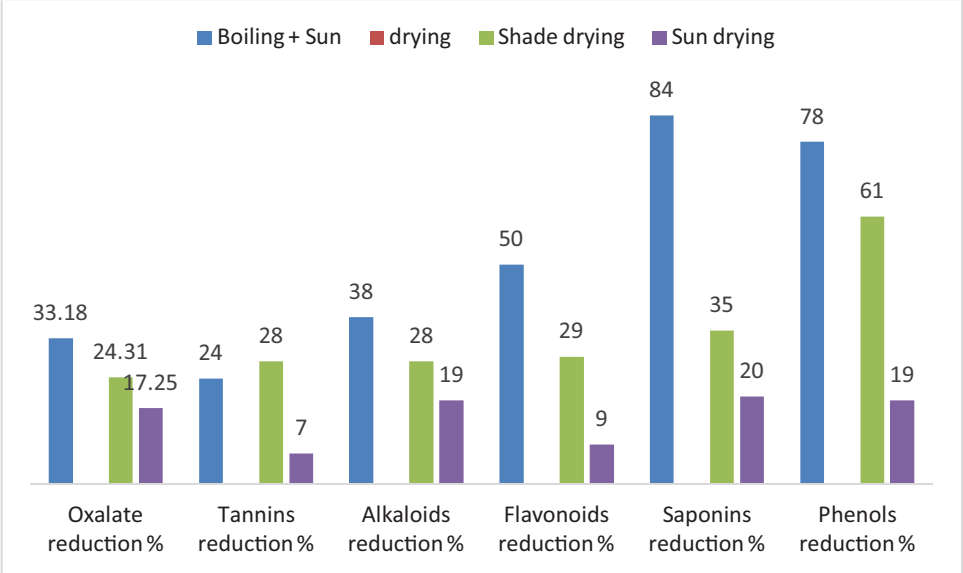

Fig. 1: Effect of processing on antinutrent reduction

Conclusion

The study analysed the effect of traditional processing methods on the nutritional and antinutritional composition of turmeric (*Curcuma longa*).Processing of turmeric by shade drying retained more of the macro and micronutrients in turmeric, while, boiling+sundrying was most effective in reducing the antinutrients. Among the evaluated antinutrient contents in turmeric, oxalate content was observed to be high. Compared with other evaluated processing methods, Boiling+sundrying was most effective in reducing the oxalate level by 33% followed by shade drying. There is still need to investigate and compare various boiling time that will be most effective on oxalate reduction and evaluate the effect of boiling + shade drying will have on oxalate reduction.

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