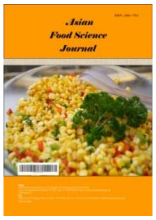

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Functional and Physicochemical Properties of Turmeric Powder as Affected by Processing Methods

Emelike, Nkechi-Juliet Tamuno[1*]

[1]*Department of Food Science and Technology, Rivers State University, Nkpolu Oroworukwo, P.M.B. 5080, Port Harcourt, Rivers State, Nigeria.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Turmeric rhizomes are exposed to a variety of conditions during processing such as boiling, cooking, blanching and drying before being utilized. In this study, the effect of processing methods on the functional properties and physicochemical properties of turmeric powder was investigated. Fresh turmeric rhizomes were processed into powder and five samples generated from the turmeric powder: Sample A (oven drying), sample B (blanching + oven drying), sample C (sun drying), sample D (cooking + oven drying). The processed turmeric powders were subjected to functional and physicochemical analysis using standard methods. Results obtained showed that cooking/oven drying resulted to a significant ($p<0.05$) improvement in the bulk density, water and oil absorption capacities and swelling power of the turmeric powders as compared to other processing methods. Dispersibility and solubility were greatly improved on sun drying/oven drying. Among the processing methods employed, blanching/oven drying exhibited significantly ($p<0.05$) higher colour value and curcumin content whereas decreases in TTA and pH was observed for cooked/oven dried sample. It is therefore recommended from the study that blanching/oven drying be used in the processing of turmeric powder for better nutrient retention. For better functionality of the turmeric powder, cooking/oven drying method should be employed.

**Corresponding author: Email: animityekpo@gmail.com;*

Keywords: Blanching; cooking; turmeric; oven drying; processing methods; sun drying.

1. INTRODUCTION

Spices occupy an essential part of agricultural commodities being used as seasoning or condiment and for medicinal purposes [1]. They are known to contain a significant amount of natural antioxidants and bioactive components (Dubey et al., 2015). Turmeric (*Cucumin longa* Linn) is a tropical perennial monocotyledonous herbaceous plant belonging to the Zingerberaceae family [2]. It has its origin from the South and South-eastern Asia but it is grown primarily in tropical regions of Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, Philippines and Nigeria [3]. The root or rhizome has a tough brown skin and bright orange flesh which is pungent and bitter [4]. The rhizomes of turmeric has been applied in folk medicine for the treatment of inflammations, cancerous symptoms, diabetics, abdominal pains, high cholesteromia, wounds and as a blood purifier [4].

The nutritional composition of turmeric was investigated by Ikpeama et al. [5] and it was reported to contain 8.92% moisture, 2.85% ash, 4.60% crude fibre, 6.85% fat, 9.40% crude protein and 67.38% carbohydrate. Gopinathan et al. [6] also reported the powdered rhizome to contain 70-76% curcumin. Curcumin which is a yellow coloured active ingredient is a potent antioxidant responsible for the biological activities of turmeric [7]. Curcumin also contains vital compounds such as vitamin C, beta-carotene, polyphenol, fatty acids and essential oil [5]. The rhizome of turmeric when dried and ground can be used as spice ingredient in cooking of foods. The use of turmeric powder in cooking gives the food a distinctive yellow colour and flavour. Tumeric powders have also been used in cosmetics and medicine.

The quality of any agricultural product is a function of the inherent quality of the material and the management during the processing condition it is subjected to [8]. In the same vein, the quality of turmeric powder is also determined by the processing methods employed. Turmeric rhizomes are exposed to a variety of conditions during processing which may have detrimental effect on the nutritional constituents. They are usually boiled and dried before being utilized. Other conventional processing of turmeric consists of slicing the rhizome, sun drying and grinding. However, sun drying has been reported to affect the colour of foods resulting to shrinkage of the product, which leads to a final unattractive product [9]. Blanching and the use of chemical treatments have been used prior to reduce nutrient losses [10]. In India, the common practice is to boil the rhizome in alkaline medium prior to dehydration.

Cooking also alters the nature of many food constituents such as proteins by changing their physical, chemical and nutritional characteristics. Suresh et al. [11] investigated the effect of heat processing on the bioactive compounds in turmeric, red and black pepper and reported diminished availability of spice active principles from cooked foods when the spice ingredients were subjected to either boiling or pressure cooking for few minutes. Bambirra et al. [12] also investigated the effect of peeling and cooking in water or alkaline media on the yield and quality of ground turmeric. It was reported that peel removal caused 30% mass loss but the powder obtained had higher intensity of yellow and red. Cooking was also reported to cause a reduction in dehydration time and provided a powder with lower moisture content and higher cucuminoid pigments. Therefore, suitable and better processing conditions are required for the production of turmeric powder which is of good quality and of added value. This study was taken to evaluate the effect of processing methods on the functional and physicochemical properties of turmeric. The specific objectives were to investigate the influence of oven drying, blanching, sun-drying and cooking on the functional and physicochemical properties of turmeric powders.

2. MATERIALS AND METHODS

2.1 Sample Collection

Turmeric rhizome (*Curcuma longa* L.) was purchased from Mile 3 Market in Port Harcourt, Rivers State. All reagents used were of analytical grade and were obtained from the Department of Food Science and Technology, Rivers State University.

2.2 Processing of Turmeric Powder

The turmeric rhizomes were sorted thoroughly to separate the damaged ones from the good ones and thereafter, they were washed thoroughly in clean water to remove soil particles on them and then divided into four portions.

Portion A: This portion was peeled and thinly sliced (0.02 mm in diameter) and was sun dried for 10 days.

Portion B: This portion was blanched in hot water (100°C) for 10 mins and thereafter it was peeled and thinly sliced.

Portion C: This portion was peeled and thinly sliced without any form of heat treatment which served as the control.

Portion D: This portion was cooked for 30 min until the aroma became very strong, it was strained, peeled and thinly sliced.

All the portioned turmeric was oven dried in a DT 104 Gemo hot Air Oven at 60°C for 24 hr apart from the potion which was sun dried. After drying, they were ground into powder and stored in air tight containers which were labelled appropriated and then they were subjected to further analysis.

2.3 Determination of Functional Properties

2.3.1 Dispersibility

Dispersibility was determined by the method of Kulkarni et al. [13]. The turmeric sample (10 g) was weighed into 100 ml measuring cylinder and distilled water was added to a volume of 100 ml. the set up was stirred vigorously and allowed to settle for three hours (3 hours). The volume of the settled sediment was recorded as shown on the measuring cylinder and value subtracted from 100. The difference was reported as percentage dispersibility.

% Dispersibility = 100 –Dispersibility

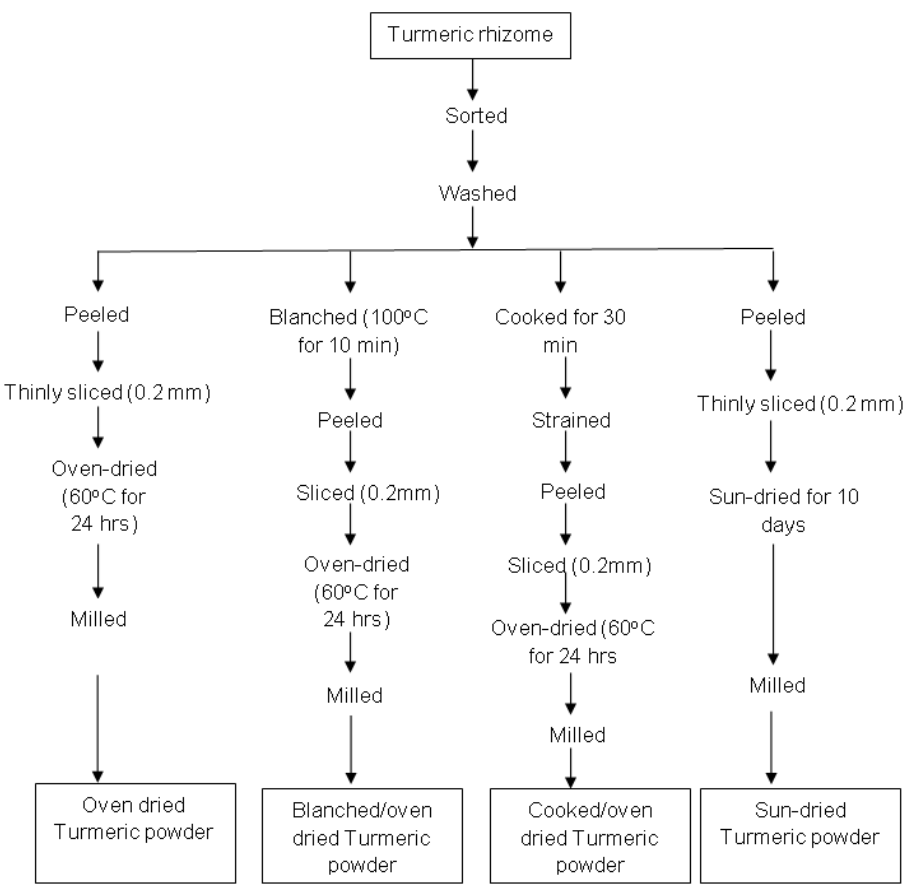

Fig. 1. Flow chart for the processing of turmeric rhizome into powder

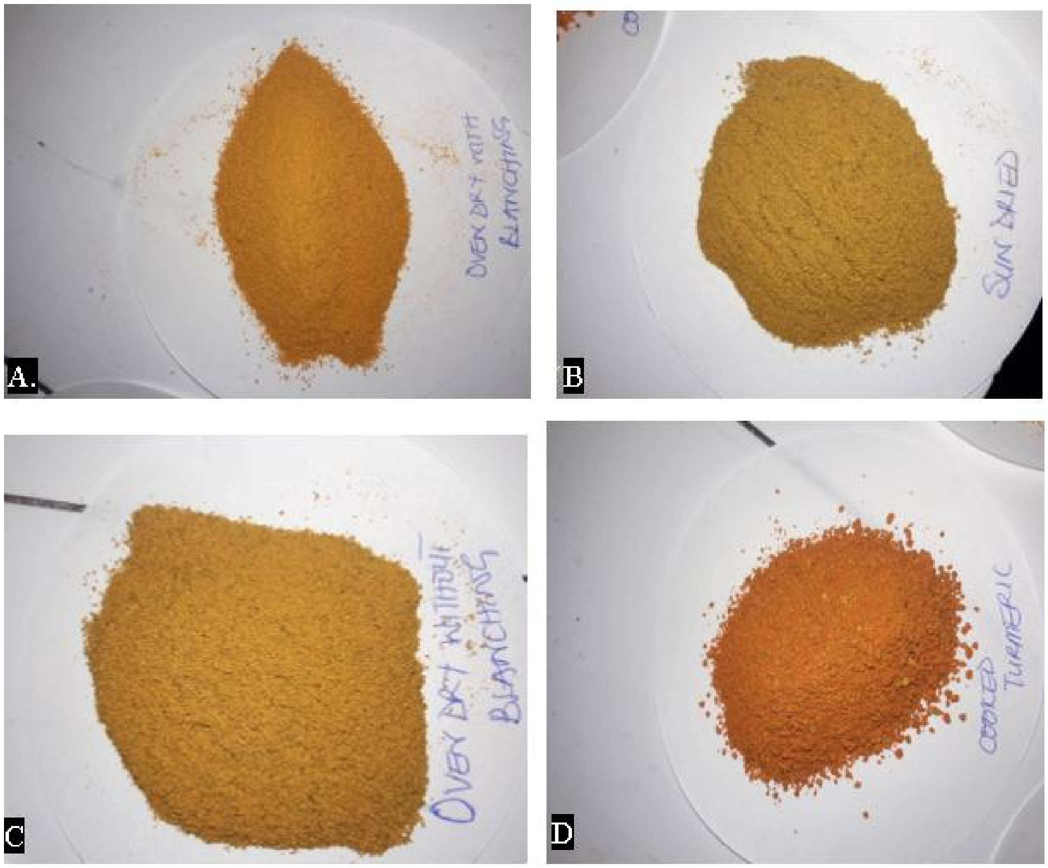

Fig. 2. Oven dried (A), Sun dried (B), Blanched/oven dried (C), Cooked/oven dried (D)

2.3.2 Relative bulk density

The relative bulk density was determined by the method described by Narayana and Narasinya [14]. The sample was poured into a calibrated sample tube. The sample was added till it gets to the 5 ml mark on the tube and then weight was taken. The tube with the sample was tapped while more samples were added. This continued till the sample is steady at the 5 ml mark of the tube and then the final weight taken:

> Bulk density (g/g) = Sample weight after tapping – Sample weight before tapping / 5 ml of centrifuge tube ×100

2.3.3 Water absorption capacity

The water absorption capacity was determined using the method by Sosulski [15]. One gram of sample was added to 15 ml of distilled water in a pre-weighed centrifuge tube. The centrifuge tube was agitated and centrifuged for 30 minutes at 3000rpm. The clear supernatant was discarded and the volume taken and the tube absorbed water was weighed. The retained water is computed as water absorbed per gram of the sample.

> Water absorption capacity (g/ml) = (initial volume water added – volume of water decant) / sample weight

2.3.4 Swelling power and solubility

The swelling Power and Solubility was determined using the method by Takashi and Sieb [16]. One gram of the sample was weighed and transferred into a flask and 15 ml of distilled water was added to the sample in the conical flask and shake thoroughly, it was sent to the water bath at a set temperature of 100°C for 1 hour. After heating, it was cooled under running water; it was transferred into a previously dried and weighed centrifuge tube and centrifuge for 30 minutes at 2000 rpm. After centrifuge, the swollen volume was read directly from the tube. The clear portion was transferred into a previously ignited weighed metal can, it was dried in the oven at 105°C for 1 hour after which it was cooled in the dessicator and weighed.

$$\text{Solubility} = \frac{\textit{weight of solute}}{\textit{sample}\ \text{weight}} \times \frac{10\ 0}{1}$$

Swelling power= (Weight of tube +sediment)- weight of empty tube)/ (Sample weight)

2.3.5 Determination of physico-chemical properties curcumin content and colour value

The Curcumin content of the turmeric powders was determined using the method by Soni et al. [17]. 0.1 g of the powdered sample was dissolved in 25 ml of ethanol; this solution was filtered and made up to 100 ml. Then 10 ml of above solution was taken into volumetric flask and again made up to 100 ml with ethanol. The absorbance was measured using spectrophotometer at 425 nm. Percentage (%) curcumin and colour value were determined.

A standard curcumin 0.25 g/lit give absorbance at 425 nm = 0.42

Absorptive of curcumin (A)

= 0.42/1 × 0.025 =16.8
% curcumin =a×100/L×A×W
Colour value = a ×1000

Where,

a = absorbance of sample at 425 nm
L= path length (1cm)
A = absorptivity.

2.3.6 Total titratable acid

The Total titratable acid was determined using the method by AOAC [18]. One gram of sample was weighed into the beaker and 10 ml of distilled water was added. Two drops of phenolphthalien was added. It was titrated against 0.1N NaOH to have a pink colour.

% TTA= (Sample titre ×Normality of base ×Equivalent ml of predominant acid) / (Sample weight) ×100

2.3.7 pH determination

One gram of turmeric powder was weighed into a beaker and 10 ml of distilled water was added and allowed to stand for 30 minutes. pH electrode was dipped into the sample and reading was taken.

2.4 Statistical Analysis

Data obtained from the analysis was subjected to analysis of variance (ANOVA) using the Statistical Product for the Service Solution (SPSS) version 23.0. All analysis was done in duplicate using Duncan Multiple Range Test (DMRT) for means separation at 5% probability level (p>0.05).

3. RESULTS AND DISCUSSION

3.1 Effect of Processing Methods on the Functional Properties of Turmeric Powder

Table 1 shows the functional properties of turmeric powder as affected by different processing methods. Bulk density of the turmeric powders ranged from 0.46 g/ml in oven dried sample to 0.67g/ml in cooked/oven dried sample. Processing methods was observed to have a significant (p<0.05) increase in the bulk density of the turmeric powders. Bulk density depends on the particle size and initial moisture content of flours [19]. This could explain why cooking/oven drying and blanching methods resulted to a significantly high bulk density as the turmeric powders absorbed moisture during these processes thereby resulting to increased bulk density. Similar increase was also reported by Igbokwe et al. [20] for *D. Bulbifera* flour on blanching. High bulk density of the turmeric powders on processing with cooking/oven drying and blanching indicates their heaviness and also suggests their suitability for use in food preparations. Bulk density of flours is an indication of their relative volume of packaging material required. According to Udensi and Eke [21], flours with higher bulk densities are desirable for greater ease of dispersibility and reduction of paste thickness.

Water absorption capacity of the turmeric powders ranged from 2.05-6.90 g/ml with the sundried sample as lowest and cooked/oven dried sample as highest. Cooking/oven drying was observed to significantly (p<0.05) improve the water absorption capacity of the turmeric powders. This could be due to denaturation of proteins during cooking. Khalid et al. [22] reported that heat treated flours tends to absorb more water due to gelatinizaton of carbohydrate and heat dissociation of proteins. In a similar study, Obatolu et al. [23] reported that increased cooking time caused yam bean protein to denature, thus increasing the water absorption capacity. Flours with high water absorption capacity can be used as a food thickener in a food system indicating that cooked/ oven dried turmeric powder will serve this purpose.

Oil absorption capacity ranged from 1.60-2.80 g/ml with sun dried and blanched/oven dried sample as lowest while cooked/oven dried sample was highest. Similarly, cooking/oven drying resulted to a significant ($p<0.05$) improvement in the oil absorption capacity of the turmeric powder while that of blanched/oven dried and sun dried samples were significantly ($p<0.05$) similar. Increase in fat absorption on cooking/oven drying is also attributed to heat dissociation of the proteins and denaturaton which results in the unmasking of non polar residue from the interior of the protein molecules [24]. Similar increase was also reported by Obatolu et al. [23]. Oil absorption is an important property in food formulation because fat acts as a flavour retainer and enhances the mouth feel of foods [25]. This implies that the cooked/oven dried turmeric powder will improve the mouth feel and flavour retention when used in food formulation and production.

Dispersibility ranged from 17.00% in oven dried sample to 51.00% in sun dried sample. Blanching/oven drying and sun drying was observed to have significant ($p<0.05$) improvement on the dispersibility of the turmeric powders while oven dried and cooked/oven dried samples were significantly ($p<0.05$) similar. Dispersibility determines the tendency of flour to move apart from the water molecules [26]. Higher dispersibility has been indicted with better reconstitution properties [27]. The high dispersibility of sun dried turmeric powder indicates better reconstitution properties.

Swelling power ranged from 5.76-10.96 g/g with sun dried sample as lowest and cooked/oven dried sample as highest. There was a significant ($p<0.05$) difference in the swelling power values. Cooking/oven drying significantly improved the swelling power of the turmeric powders. This could be attributed to reduction of fat during cooking. Tsado et al. [28] reported that high heat during cooking result to melting of fat thereby causing a reduction in the fat content. Igbokwe et al. [20] also added that high levels of fat leads to the formation of amylase-lipid complexes which restricts swelling. On heating, some of the intermolecular hydrogen bonds are disrupted and swelling becomes noticeable [29].

Solubility of the turmeric powders ranged from 14.00% in cooked/oven dried sample to 25.00% in oven dried sample. Significant ($p<0.05$) differences were observed in these values. Cooking/oven drying, blanching/oven drying and sun drying resulted to a significant reduction in the solubility of the turmeric powders while that of oven drying alone was improved. Falade and Okafor [30] stated that solubility is the ability of solids to dissolve or disperse in aqueous solution (mostly water). The high temperatures used in the oven drying process might have weakened the starch granules resulting in increased solubility.

3.2 Effect of Processing Methods on the Physicochemical Properties of Turmeric Powder

The physicochemical properties of turmeric powder from different processing methods are presented in Table 2. Colour is an indispensible sensorial attribute used in turmeric powder resulting from the desirable yellow component. In this study, colour value of the turmeric powders ranged from 184.50-278.00 with blanched/oven dried sample as highest while sun dried sample was lowest. Processing had a significant ($p<0.05$) effect on the colour values of the turmeric powders. Colour value of the blanched/oven dried powder was significantly ($p<0.05$) improved on processing and this could be due to the potential of blanching to retard both enzymatic and non-enzymatic reactions in the turmeric powder [31]. Oven dried turmeric powder were better in colour than the sun dried powder. The oven drying temperature of the sample also might be responsible for this since higher temperature have been reported to inactivate phenolase enzyme [32]. Similar finding was also reported by Ngoma et al. [33] who stated that colour values of sweet potato were improved on blanching with sulphite and salts.

Table 1. Functional composition of turmeric powder from different processing methods

Treatments	Bulk Density (g/ml)	Water Absorption (ml/g)	Oil Absorption (ml/g)	Dispersibility (%)	Swelling Power(g/g)	Solubility (%)
OD	0.46±0.02[c]	4.65±0.07[b]	1.60±0.00[b]	17.00±0.00[c]	6.94±0.00[b]	25.00±1.14[a]
BOD	0.54±0.01[b]	3.85±0.07[c]	1.20±0.00[c]	37.00±0.00[b]	6.84±0.02[c]	19.00±1.14[b]
SUN	0.50±0.00[bc]	2.05±0.07[d]	1.20±0.00[c]	51.00±0.00[a]	5.76±0.00[d]	18.00±0.00[bc]
COD	0.67±0.00[a]	6.90±0.14[a]	2.80±0.00[a]	16.00±0.00[c]	10.96±0.00[a]	14.00±0.00[c]

Values are expressed as mean ± standard deviation of duplicate determination. Means with the same letters along the same column are not significantly different (p>0.05); KEY: OD – oven dried; BOD – Blanched + Oven Dried turmeric powder; SUN – Sun Dried turmeric powder; COD – Cooked + Oven Dried turmeric powder

Table 2. Physicochemical results of turmeric powder from different processing methods

Treatments	Colour value	% Curcumin	pH	%TTA
OD	225.50±2.12[c]	27.00±0.00[c]	6.40±0.00[b]	1.61±0.01[a]
BOD	278.00±2.83[a]	33.00±0.00[a]	6.30±0.00[c]	1.59±0.00[b]
SUN	184.50±0.71[d]	22.00±0.01[d]	6.80±0.00[a]	0.87±0.00[c]
COD	248.00±2.83[b]	29.00±0.00[b]	6.10±0.01[d]	0.31±0.00[d]

Values are expressed as mean ± standard deviation of duplicate determination. Means with the same letters along the same column are not significantly different (p>0.05); KEY: OD – oven dried; BOD – Blanched + Oven Dried turmeric powder; SUN – Sun Dried turmeric powder; COD – Cooked + Oven Dried turmeric powder

Curcumin content of the turmeric powders ranged from 22.00% in sun dried sample to 33.00% in blanched/oven dried sample. Processing was observed to have a significant ($p<0.05$) effect on the curcumin content of the powders. Curcumin is the main ingredient responsible for the bright-yellow colour of turmeric powder. Its heat and light sensitive [34]. This could be the reason why cooking/oven drying and sun drying resulted to a significant reduction in the curcumin content of the processed turmeric powders. This study agrees well with that of Raza et al. [34] who reported that boiling and sunlight affects the curcumin concentration significantly. Suresh et al. [11] also reported curcumin loss of 27-53% during heat processing with maximum loss in pressure cooking for 10 min.

pH of the turmeric powders were found to range from 6.10-6.80 with sun dried powder as highest and cooked/oven dried sample as lowest. Result also showed that processing methods employed had a significant ($p<0.05$) effect on the pH of the turmeric powders. The pH is associated with the development of a pleasant taste [35]. It is a critical factor in developing flavour and aroma characteristics of foods and also determines the stability of the food product [36]. The high pH in sun dried turmeric powder is undesirable as it might predispose the product to bacterial spoilage.

Total acidity (TTA) found in the turmeric powders ranged from 0.31-1.61%. The highest TTA was found in turmeric powder processed by oven drying method followed by blanched/oven dried sample while the least was found with powder processed by cooking/oven drying method. Result indicated that there was a significant ($p<0.05$) difference in the TTA of the turmeric powders with cooking/oven drying resulting to a significant reduction in the TTA. This could be attributed to the loss of volatile acidity and organic compounds during cooking. Similar finding was also reported by Akoja and Coker [37].

4. CONCLUSION

The present study shows that the functional and physicochemical properties of turmeric powder are significantly affected by processing methods. Turmeric powder processed by cooking/oven drying had significantly ($p<0.05$) higher bulk density, oil and water absorption capacities and swelling power while those sun dried were higher in dispersibility. Cooking and sun drying caused a significant reduction in the mineral contents (sodium, calcium, magnesium, iron, and manganese) of the turmeric powders. The mineral content of the turmeric powders were also found to vary with processing methods with significantly higher concentrations in the blanched/oven dried turmeric powder. Sun drying also resulted to a significant ($p<0.05$) reduction in the colour value and curcumin content while these were significantly ($p<0.05$) retained on blanching/oven drying. Cooking and oven drying also led to a significant ($p<0.05$) reduction in the TTA and pH of the turmeric powders while these values were improved for blanched/oven dried and sun dried samples. It is therefore recommended from the study that blanching/oven drying be used in the processing of turmeric powder for better nutrient retention. For better functionality of the turmeric powder, cooking/oven drying method should be employed.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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