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Gaikwad GP

Ph.D. Research Scholar,
College of Food Technology
VNMKV Parbhani,
Maharashtra, India

Kshirsagar RB

Professor and Head,
Department of Food,
Engineering College of Food
Technology VNMKV
Parbhani, Maharashtra, India

Mane RP

Assistant Professor, MIT
College of Food Technology,
Chhatrapati Sambhaji Nagar,
Maharashtra, India

Agarkar BS

Associate Professor,
Department of Food
Engineering College of Food
Technology VNMKV
Parbhani, Maharashtra, India

Patil BM

Assistant Professor,
Department of Food,
Engineering, College of Food
Technology VNMKV
Parbhani, Maharashtra, India

Corresponding Author:**Gaikwad GP**

Ph.D. Research Scholar,
College of Food Technology
VNMKV Parbhani,
Maharashtra, India

Evaluation of nutritional properties in turmeric rhizomes processed with steam boiler curing Var. Salem and Pragati

Gaikwad GP, Kshirsagar RB, Mane RP, Agarkar BS and Patil BM

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Abstract

The process of steam boiler curing (T₁) and different drying methods significantly impacts the nutritional quality of turmeric. An experiment was conducted to evaluate how these techniques influence the nutritional properties of turmeric rhizomes. After thorough washing, fresh turmeric rhizomes were cooked using a steam boiler. This step not only softens the rhizomes but also enhances their color and flavor. Following the cooking process, the rhizomes were dried using four different methods: sun drying (D₁), solar drying (D₂), cabinet drying (D₃), and shade drying (D₄). These drying methods effectively reduce the moisture content of the rhizomes, making them suitable for grinding. The observed results revealed a decreasing trend in all proximate nutrients moisture, fat, protein, carbohydrates, ash and fiber across the drying treatments D₁, D₂ and D₃ in both turmeric varieties processed through steam boiler curing.

Keywords: Proximate, steam, drying, quality, spices, fibre

Introduction

Spices are fragrant substances derived from various plant parts, including seeds, roots, fruits and bark and are widely used to enhance the flavor and seasoning of food. For thousands of years, spices have been a fundamental part of culinary traditions worldwide, enriching dishes with their distinctive flavors and complexity. They remain a source of inspiration and creativity in cooking, contributing to the cultural and historical richness of food. Whether used in small amounts or generously, spices are indispensable for crafting flavorful and unforgettable meals.

Globally, Indian spices remain the most sought after, having exquisite flavour, taste, aroma and in some cases, medicinal and nutraceutical properties. India's strength is the diversified production base in spices. India produces 75 out of the 109 spices listed out by the International Organization for Standardization (ISO), earning the name 'Spice Bowl of the World'. Indian spices export basket also is diverse and vibrant with around 225 spices and spice products which are exported to more than 180 countries. Indian spice exports contribute 9 per cent to India's total agri-export and over 40 per cent of India's horticultural exports (Mathew *et al.*, 2022) ^[9].

Turmeric (*Curcuma longa*) is a rhizomatous herbaceous perennial plant belonging to the ginger family *Zingiberaceae*, which is native to tropical South Asia. The turmeric plant needs temperatures between 20 °C and 30 °C and a considerable amount of annual rainfall to thrive. Individual plants grow to a height of 1 m, and have long, oblong leaves. The plants are gathered annually and are reseeded from some of the rhizomes in the following season. The rhizome, from which the turmeric is derived, is tuberous, with a rough and segmented skin. The rhizomes mature beneath the foliage in the ground. The rhizomes are yellowish brown with a dull orange interior. The main rhizome is pointed or tapered at the distal end and measures 2.5–7.0 cm (1–3 inches) in length and 2.5 cm (1 inch) in diameter, with smaller tubers branching off. When the turmeric rhizome is dried, it can be ground to a yellow powder with a bitter, slightly acid, yet sweet, taste (Prasad & Aggarwal, 2011) ^[12].

India is the largest producer, consumer and exporter of turmeric in the world. In the year 2022-23, an area of 3.24 lakh ha was under turmeric cultivation in India with a production of 11.61 lakh tonnes (over 75% of global turmeric production).

More than 30 varieties of Turmeric are grown in India and it is grown in over 20 states in the country. The largest producing states of Turmeric are Maharashtra, Telangana, Karnataka and Tamil Nadu. India has more than 62% share of world trade in turmeric. During 2022-23, 1.534 lakh tonnes of turmeric and turmeric products valued at 207.45 million USD was exported by more than 380 exporters. The leading export markets for Indian Turmeric are Bangladesh, UAE, USA and Malaysia. With the focused activities of the Board, it is expected that turmeric exports will reach USD 1 Billion by 2030 (PIB, 2023).

Freshly harvested turmeric rhizomes undergo several postharvest operations, including curing, drying, polishing and milling, before entering the market as a stable commodity. It has been demonstrated that curing and drying methods have a serious effect on physicochemical quality attributes of turmeric powder. Curing after harvesting is an important postharvest processing operation that involves cooking fresh turmeric rhizomes in boiling water. It is an essential operation before drying to avoid the raw odor, destroy the vitality of fresh rhizomes, yield uniformly colored product and reduce the drying time. The method of curing turmeric varies from place to place. There are conventional and improved methods of curing turmeric; however, during the conventional method of boiling turmeric, contents might be leached along with water, which in turn lowers curcumin, oleoresin and essential oil contents (Lokhande *et al.*, 2013; Jayashree *et al.*, 2018) [6, 8].

In North India, turmeric is commonly called “haldi,” a word derived from the Sanskrit word haridra, and in the south it is called “manjal,” a word that is frequently used in ancient Tamil literature. It has a long history of usage in traditional medicine in India and China. The bio-active polyphenol component of turmeric is curcumin, also known as diferuloylmethane, with an ability to prevent and cure diseases. Turmeric contains about 2-5% curcumin alone (Ammon & Wahl, 1991) [3].

Value addition means the maximum realization of the process of the product through processing, packaging and marketing. Value addition is essential for the modern competitive world. The original product will be transformed into a more valuable form by value addition. Consumers pay higher prices willingly for value-added products when they fulfil their satisfaction. It can be done by farmers, suppliers, processors or distributors. Value added products prepared from spices are ground spices, oil, oleoresins, powder, pickle, candy, flavour, essence, paste, colour. After extracting the oils and oleoresins, the spent spices also can be used for other productions by value addition as they contain a very high amount of nutrients in them especially including dietary fiber, vitamins and minerals as protein supplements, starch, bio films for packaging, bio ethanol (Arachchige *et al.*, 2021) [4].

Materials and Methods

Raw materials

The raw materials used during the experiment such as fresh turmeric rhizomes of variety ‘Salem’ and ‘IISR-Pragati’ procured immediately after harvest from the local villages as Italapur, Sayala, Pedgaon of Parbhani District and Hatta of Vasmat Taluka. Rhizomes kept in the room at ambient room temperature prior to conducting different drying experiments. The raw materials, turmeric rhizomes, were selected, cleaned and washed thoroughly in tap water to

remove the adhering soil, hairs and extraneous matter. The undesirable portions were removed manually and then the rhizomes were again washed and cleaned properly.

Chemicals and glassware

Chemicals used in this investigation were of analytical grade and required glassware were used from the laboratory of Department of Food Engineering and Department of Food Chemistry and Nutrition, College of Food Technology, Vasantnaik Marathwada Krishi Vidyapeeth, Parbhani.

Equipments and machineries

The equipments and machineries used in the present investigation include weighing balance, vernier calliper, soxhlet extraction apparatus, muffle furnace, hot air oven, micro kjeldhal apparatus, steam distillation unit, spectrophotometer, water bath, solar dryer, cabinet dryer, etc. The equipments utilized were made available from different department viz., Department of Food Engineering, Department of Food Chemistry and Nutrition and Niche Area Laboratory of College of Food Technology, VNMKV, Parbhani.

Proximate composition

The fresh turmeric rhizomes and turmeric powder were characterized for their proximate composition including moisture content, ash, fat, fibre, protein and carbohydrate content (by difference) by following the (AOAC, 2005) [2] methods.

Determination moisture content

Moisture was estimated by weighing the 5 g turmeric powder and subjected to oven drying at 105 °C for 4 hr. It was again weighed after cooling in desiccators until constant weight. The resultant loss in weight was calculated as moisture content (AOAC, 1990) [1].

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Weight of sample}} \times 100$$

Determination of fat

The 5 g ground turmeric powder sample was weighed accurately in thimble and defatted with petroleum ether in Soxhlet apparatus for 6-8 hrs at 60°C. The resultant ether extract was evaporated and lipid content was calculated (AOAC, 1990) [1].

$$\text{Crude fat (\%)} = \frac{\text{Final weight of flask} - \text{Empty weight of flask}}{\text{Weight of sample}} \times 100$$

Determination of protein

Protein content was determined by Micro-Kjeldhal method as per the method given by (AOAC, 2005) [2].

Digestion

Accurately weighed 200 mg (0.2 g) of defatted ground sample and add a 1g of catalyst mixture contained K₂SO₄:CuSO₄:HgO (red) (91:8.2:0.8 g) then transferred into the digestion flask, digestion was carried out with 5 ml concentrated H₂SO₄ for 25-30 minutes at 420 °C using infrared kjeldhal digestion system till the content becomes colourless clear liquid.

Neutralization and distillation

Digested sample was diluted to the 25 ml in volumetric flask and made final volume to 25ml with double glassed distilled water. Then the 5ml of aliquot was neutralized with 40% NaOH containing 5g of sodium thiosulphate. Distillation was carried and liberated ammonia was absorbed in 2% boric acid solution containing methyl red as indicator.

Titration

The collected ammonia was titrated against 0.01N H₂SO₄. Titre reading was noted, % Nitrogen was calculated by using following formula and % protein was calculated by multiplying with factor 6.25. Simultaneously a blank sample was also run.

$$\% N = \frac{\text{CBR} \times \text{Normality of H}_2\text{SO}_4 \times \text{Moles of Nitrogen} \times \text{D.F}}{\text{Wt. of sample (g)}} \times 100$$

Where

CBR= Sample burette reading (SBR) - Blank burette reading (BBR)

Normality of acid (H₂SO₄) = 0.01N

Moles of Nitrogen = 14/1000

% Protein = % Nitrogen X 6.25

Determination of crude fibre

About 2 to 5 g of moisture and fat free samples were weighed into 500 ml beaker and 200 ml boiling 0.255 N H₂SO₄ was added. The mixture was boiled for 30 minutes keeping the volume constant by addition of water at frequent intervals. At the end of this period, the mixture was filtered through a filter paper and the residue washed with hot water till free from acid. The material then transferred to the same beaker and 200 ml of boiling 0.313 N NaOH solution added. After boiling for 30 minutes the mixture was filtered through filter paper. The residue was washed with hot water till free from alkali followed with some alcohol. It was then transferred to crucible. The crucible was heated in a muffle furnace at 550-600 °C for 4 hours cooled and weighed again. The difference in the weights represented the weight of the crude fibre.

$$\text{Crude fibre (\%)} = \frac{\text{weight of residue} - \text{weight of ash}}{\text{Weight of sample}} \times 100$$

Total carbohydrate

The total carbohydrate content of the prepared food products was determined by using the Phenol Sulphuric acid method as described and determined by (AOAC, 2005) [2]. Weigh accurately 100 to 500 mg of dried defatted food sample in test tube kept in ice chilled condition, add 2ml of 70% HCl and make its paste with glass rod in chilled condition. Transfer slowly the same in 500 ml conical flask by using 23 ml distilled water and reflux in to boiling water bath for 3h to facilitate hydrolysis Cool the hydrolysate and centrifuge or filter through Whatman No. 42 filter paper and make final volume 100ml with distilled water. Take a known volume of aliquot (0.2-0.5ml) for analysis. Prepare a calibration curve (std curve) by taking 0,0.2,0.4,0.6,0.8 and 1.0ml of std glucose (working solution) in series of taste tube correspond to 0,20,40,60,80 and 100 µg respectively. Make up the volume of each taste tube with distilled water. Add 0.2 ml of phenol 80% in each taste tube followed by 5ml of conc. H₂SO₄ (96%). Shake the content of taste tube

vigorously on vortex mixer After 10 min read the OD at 480 nm on a spectrophotometer and prepare a std graph follow the same procedure for sample aliquot. Calculate the amount of total carbohydrate in the sample using the standard graph.

$$\text{Total Carbohydrate in sample (mg)} = \frac{\text{Sugar value from graph (mg)} \times \text{total vol. of extract (ml)}}{\text{Aliquot sample used} \times \text{weight of sample}} \times 100$$

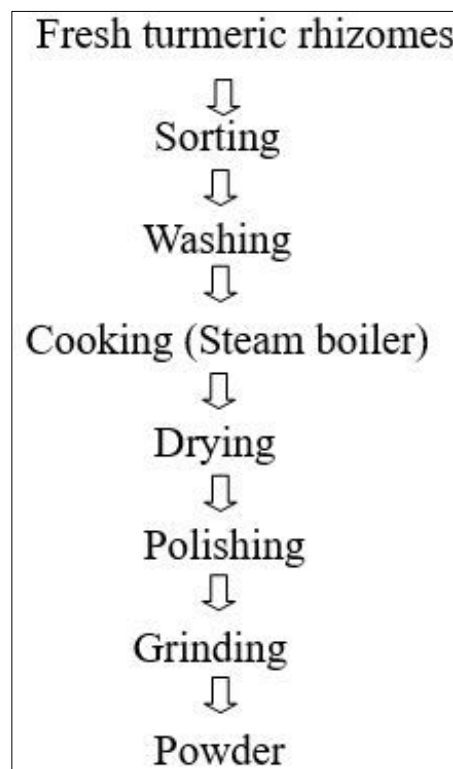
Determination of ash

5 g sample was weighed into silica crucible and ignited on low flame till all the material was completely charred and cooled. Then it was kept in muffle furnace for about 4 hr at 550 °C. It was again cooled in desiccator and weighed and repeated until two consecutive weights were constant. The per cent ash was calculated by knowing the difference between the initial and final weight (AOAC, 1990) [1].

$$\text{Ash (\%)} = \frac{\text{Weight of crucible with ash} - \text{Weight of empty crucible}}{\text{Total weight of sample}} \times 100$$

Steam boiler curing (T₁) and drying

First, the rhizomes are sorted to remove any damaged or unsuitable pieces. They are then thoroughly washed to eliminate dirt and impurities. After washing, the rhizomes are cooked using a steam boiler, which helps to soften them and enhance the colour and flavor. Once cooked, the rhizomes are dried by sun (D₁), solar (D₂), cabinet (D₃) and shade dryer (D₄) to reduce their moisture content, making them easier to grind. The dried rhizomes are then polished by rotary drum polisher to remove any remaining outer skin and impurities. Finally, the polished rhizomes are ground into a fine powder in impact pulverizer, which is then ready for further analysis.



Flow 1: Processing of turmeric rhizome into powder

Sun drying (D₁)

Farmers mostly prefer sun drying as it is economical to dry the rhizomes in the drying yard. Place the prepared

rhizomes/slices in direct sunlight. Choose a location that receives full sunlight throughout the day. Ideally, use a drying rack or a tray with a mesh bottom to promote airflow from all sides. Turmeric rhizomes after boiling were spreaded uniformly (5 cm thick) and exposed to sunlight until the moisture content reached 7%. The time taken for drying depends on the sun intensity and were dried at 30 to 40 °C (Pradeep *et al.*, 2016) [12].

Solar drying (D₂)

The drying was carried out in the developed indirect natural convection solar dryer. The drying was done from 9 AM to 5 PM. Solar drying was done in a solar tunnel dryer and the drier is a concave structure made up of UV stabilized semi-transparent polyethylene sheet (200 micron), with area of 18 m x 3.75 m x 2 m. Rhizomes and slices were spread in trays and the loss in weight was recorded at specific intervals until 7-10% moisture content in about 2-3 days at 30-45 °C. The sample was dried until the moisture level in the sample reduced to a safe storage level of 8% (w.b.) (Singh *et al.*, 2010) [14]. The dried sample was ground to powder.

Cabinet tray drying (D₃)

After completion of curing in T₁, T₂ and T₃ treatment turmeric rhizomes and slices were placed in tray drier for drying. Once the dryer is preheated; the rhizomes were loaded in trays. The optimum drying temperature was 60 °C, temperatures higher than this result in a darker coloured product. The drying process regularly monitored to ensure even drying. The dried sample was ground to powder.

Shade drying (D₄)

The turmeric rhizomes and slices are spread out in a single layer on drying trays or mats. These trays are then placed in a well-ventilated area with ample shade. The turmeric is left to dry naturally over a period of several days to weeks, depending on the weather conditions. Shade drying helps preserve the natural color and flavor of turmeric while allowing it to dry slowly and evenly without being exposed to direct sunlight, which can degrade its quality.

Results and Discussion

The research study initially focused on analyzing the nutritional properties of fresh turmeric rhizomes from two prominent varieties, Salem and Pragati, which are widely cultivated in Maharashtra, particularly in the Marathwada region. The study examined the impact of various processing techniques such as whole rhizome boiling, and drying methods including sun drying (D₁), solar drying (D₂), cabinet drying (D₃) and shade drying (D₄) along with polishing, on the nutritional qualities of fresh turmeric rhizomes to assess their overall quality.

Proximate analysis of fresh turmeric rhizomes

The proximate composition of fresh turmeric without any processing refers to its fundamental nutritional components such as carbohydrates, proteins, fats, fiber and minerals. Understanding the proximate composition of fresh turmeric is important for various reasons, including assessing its nutritional value, exploring its health benefits, optimizing its culinary use, assessing its quality. The proximate composition of the Salem and Pragati turmeric varieties is given in table 1

Table 1: Proximate analysis of fresh turmeric rhizomes

Characteristics (%)	Turmeric variety	
	Salem	Pragati
Moisture	79.60±0.49	78.05±0.08
Fat	0.79±0.01	0.78±0.02
Protein	2.31±0.20	2.20±0.12
Carbohydrate	12.73±0.45	12.39±0.37
Ash	1.98±0.05	1.96±0.04
Dietary fibre	1.91±0.07	2.30±0.06

* Each value is average of three determinations as means± SD

The initial moisture content of the fresh turmeric rhizomes was determined by oven drying method and the average moisture content of Salem and Pragati turmeric varieties was 79.60% and 78.05% respectively. The disparity of moisture content could be due to many factors as harvest season and turmeric varieties. The present results of moisture content were in good agreement with the results reported by (Thul *et al.*, 2022) [15] indicating the average moisture content was 81.26% in Salem turmeric variety. Moisture content of the produce determines the shelf life and the keeping quality of the turmeric. (Singh *et al.*, 2010) [14] have suggested that the drying of fresh turmeric to a safe limit of moisture content about 10% for milling and 6% for storage.

The protein content in the Salem turmeric variety was 2.31% which was higher than Pragati turmeric variety having 2.20% protein content. Dietary fibre content was more in Pragati turmeric variety 2.30% as compared to Salem turmeric variety 1.91% while carbohydrates, ash and fat content were higher in Salem turmeric variety 12.73, 1.98 and 0.79% than Pragati turmeric variety (12.39, 1.96 and 0.78% respectively). The proximate composition of fresh turmeric tends to be lower compared to dried turmeric due to the presence of high-water content. Fresh turmeric contains a significant amount of water, which dilutes the concentration of other components such as carbohydrates proteins and fats.

Previous studies by (Leonel *et al.*, 2003) [7] have reported that carbohydrate 10.84%, protein 2.03%, dietary fibre 1.77%, moisture 81.23%, ash 2.01%, fat 0.91% in analysis of *Curcuma longa* and (Yewle *et al.*, 2019) reported that carbohydrate 60.23%, protein 1.30%, dietary fibre 0.79%, moisture 60.23%, ash 2.86%, fat 0.78% in fresh Salem turmeric rhizomes. The variation in the chemical composition is may be due to the genetic makeup of the cultivars, climatic variations, irrigation practices, milling, soil fertility and agricultural practices.

Effect of steam boiler curing (T₁) on proximate composition of turmeric powder

In table 2 the effect of steam boiler curing (T₁) on proximate composition of turmeric powder with different drying method viz. D₁, D₂, D₃ and D₄ has been given.

The highest moisture content was found to be highest in both the variety which dried with D₄ (shade drying) i.e. 9.12% in Pragati and 8.99% in Salem variety. Across all drying methods, Salem generally exhibits slightly higher moisture content compared to Pragati. D₄ appears to result in the highest moisture content for both varieties.

The D₄ dried powder retained the highest fat content in Salem and Pragati variety with a value of 7.44 and 7.28% respectively. The fat content in D₁, D₂ and D₃ dried powder

values were 6.9, 7.0, 7.2 and 7.0, 7.18, 7.22% in both varieties respectively.

Proteins can denature under heat and prolonged exposure to high temperatures might lead to some degree of protein degradation. However, the impact on protein content can differ among the drying methods. In D₂ and D₃ drying, where temperature and airflow can be controlled more precisely, there might be less degradation in Salem and Pragati variety 8.88, 8.89 and 8.68, 8.76% compared to D₄ with a value of 8.92, 8.75% respectively. The change in protein content could be attributed to mild heating effect associated with all the drying conditions which could result

in the unzipping of hydrophobic forces leading to a partial distribution of the primary, secondary, tertiary and quaternary structure of the protein molecule (Ihekoronye & Ngoddy, 1985) [5].

The carbohydrate content of dried turmeric powder was found in the range of 66.2 to 67.2% in Salem and 65.6 to 66.4% in Pragati. Carbohydrates are generally stable during drying processes. D₂ and D₃ drying which offer better temperature control, might preserve carbohydrate content better than D₁. D₁ and D₄ are natural methods that may result in more variable outcomes.

Table 2: Effect of steam boiler curing (T₁) and drying methods on proximate composition of turmeric powder

Variety	Drying Method	Characteristics					
		Moisture (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Ash (%)	Dietary fibre (%)
Salem	D ₁	8.69	6.9	8.30	66.2	6.2	4.29
	D ₂	8.53	7.0	8.88	66.5	6.1	4.25
	D ₃	8.50	7.2	8.89	67.0	5.8	4.22
	D ₄	9.12	7.4	8.92	67.2	6.0	4.27
	SE±	0.007	0.03	0.004	0.05	0.04	0.004
	CD@5%	0.022	0.11	0.012	0.16	0.14	0.014
Pragati	D ₁	8.59	7.00	8.20	65.6	5.92	4.06
	D ₂	8.41	7.18	8.68	65.9	5.88	4.01
	D ₃	8.52	7.22	8.76	66.2	5.81	4.0
	D ₄	8.99	7.28	8.75	66.4	5.90	4.03
	SE±	0.004	0.002	0.005	0.005	0.05	0.002
	CD@5%	0.014	0.007	0.016	0.015	0.16	0.008

The ash content in both the variety powder i. e. Salem and Pragati ranged from 5.8-6.2% and 5.81-5.92% respectively. The ash content across all drying method was found more in D₁ and D₄ as compare to D₂ and D₃. The crude fibre of dried powder was found in the range of 4.22 to 4.29% and 4.0 to 4.06% in Salem and Pragati variety respectively. Dietary fibre, being predominantly composed of carbohydrates, may experience similar changes as carbohydrates during drying. However, since fibre is less prone to degradation under heat compared to other nutrients, its content might remain relatively stable across different drying methods.

The changes in moisture, fat, protein, carbohydrate, ash and dietary fibre content after different drying methods can vary depending on factors like the initial composition of the material being dried, the drying conditions and the duration of drying. (Jayashree *et al.*, 2018) [6] observed that steam cured turmeric samples in TNAU boiler with values corresponding to 64.2, 7.8, 7.3 and 4.9%, respectively showing significant reduction in carbohydrate, protein, fat content and ash content.

(Sanishya *et al.*, 2021) [13] illustrates the proximate composition of the commercial turmeric powder samples and the control sample. The highest moisture content is observed in sample 11 (12.00±0.00%) and the lowest moisture content is recorded in sample 3 (6.72±0.03%). The proximate composition of turmeric powder depends on the soil, climatic condition, temperature, humidity, geography, seasonal changes and the growing condition of the turmeric rhizomes which were used as the raw materials.

Conclusion

The observed results showed a declining trend in all proximate nutrients, including moisture, fat, protein, carbohydrates, ash and fiber content, across the drying

treatments D₁, D₂, and D₃ in both steam boiler-cured turmeric varieties.

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