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RESEARCH ARTICLE

Effect of different drying treatments on the concentration of nutrient content and functional properties of black turmeric (*Curcuma caesia*)

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ABSTRACT

Curcuma caesia is the blackish-blue variant of yellow turmeric. Plant rhizome is popularly used by tribal communities due to its medicinal properties, still it remains unknown and underutilized by majority of population. The study aims to analyse the effect of different drying treatments (sun drying, hot-air-oven drying, and microwave drying) on nutrient composition and phytochemical content of black turmeric. Results showed that the Hot-air-oven Dried sample had significantly ($p<0.05$) higher retention of protein, total phenolic and flavonoid content. The high phenolic and flavonoid content of the Hot-air-oven dried sample contributed to higher antioxidant capacity compared to other dried samples.

Keywords: Black turmeric, phytochemical components, medicinal benefits, hot-air-oven drying.

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INTRODUCTION

Turmeric stands as one of the oldest plants known to humanity, boasting numerous health benefits and finding versatile applications in various cuisines and beverages worldwide. Often referred to as "Indian saffron," turmeric has deep roots in ancient Indian medicinal practices, particularly in the revered system of Ayurveda (Arya et al., 2018). The yellow variant of turmeric is the most commonly recognized type, extensively utilized in Indian cuisine.

However, Black Turmeric remains relatively unknown to many despite its profound potential. Also known as black zedoary, it belongs to the perennial flowering plant family Zingiberaceae, with the scientific name *Curcuma caesia*. This distinctive variety, characterized by its blackish-blue hue, emanates a potent aroma owing to its rich essential oil content. Black Turmeric finds its habitat in South and Southeast Asia, particularly indigenous to regions in central and northeastern India (Sahu et al., 2018). Traditionally, many tribal communities have embraced its usage.

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Despite its native origins and traditional usage, Black Turmeric remains largely underutilized, with awareness about its medicinal properties scarce among the populace. Nonetheless, it stands as a reservoir of various phytochemicals, including phenolic compounds, flavonoids, and terpenoids. These bioactive compounds, produced in small quantities by plants, offer protective health benefits, including antioxidant, anti-inflammatory, anticarcinogenic, and anti-asthmatic properties.

The present study aims to explore the bioactive components present in Black Turmeric samples prepared using three distinct dehydration techniques. Drying, being one of the oldest preservation methods, serves to reduce moisture content, thereby enhancing quality and extending shelf life. Furthermore, it curbs chemical alterations and microbial proliferation during storage. Each drying method yields a distinct final product, with nutritional quality varying accordingly. Through this investigation, a comparative analysis is conducted to discern the nutritional quality and phytonutrient content of sundried, hot-air oven-dried, and microwave-dried black turmeric powder samples, thereby identifying the most nutrient-retentive method.

MATERIALS AND METHODS

Procurement

Black Turmeric was chosen keeping in mind its high phytochemical content and numerousmedicinal properties and related health benefits. For the study, the sample was collected from BCH Organic, a wholesale supplier located near T. Dsarahalli, Bangalore. For this experiments 1kg grade A medicinal quality Black turmericwas procured for this experimental purpose.

Pre-processing

After the procured Black turmeric was received, it was washed with water to clean the dart andsoil present on the surface. Then the Black turmeric was peeled and sliced into thin to mediumslices. Later this sliced turmeric was subjected to different drying conditions (Fir. 1).

Drying methods

Dehydration is one of the oldest techniques of food preservation. Drying follows the principleof ‘Heat-mass transfer’. With the application of heat the moisture present in food sample gets evaporated and helps to reduce the water activity. This helps to arrest the growth of the pathogenic micro-organisms and render food safe to consume by the consumer for long time by increasing the shelf life. The black turmeric was subjected to 3 different drying technique as follows:

Sun drying: Sundry is the oldest and cheapest method of dehydration. Almost all the spices around the worldused to be dried using sun drying methos. It requires less technical skill and can be done anyoneat home-scale level. The sliced Black turmeric was spread on a flat surface covered with thin cloth and kept in the sun for 3 days at a temperature between 25 to 28 ˚ Celsius (Humidity <60 %). The sun drying process is presented in (Fig. 2).

Hot-air-oven dry: Hot-air Oven drying is currently used dehydration technique in various food industries which dehydrates the food in controlled condition and less chance of environmental contamination and provide quality product. The sliced Black turmeric was spread on petri dish and kept insidethe Hot-air Oven at 60 to 80 ˚ Celsius for 3 to 4 hours. The Hot-air oven drying process is presented in (Fig. 3).

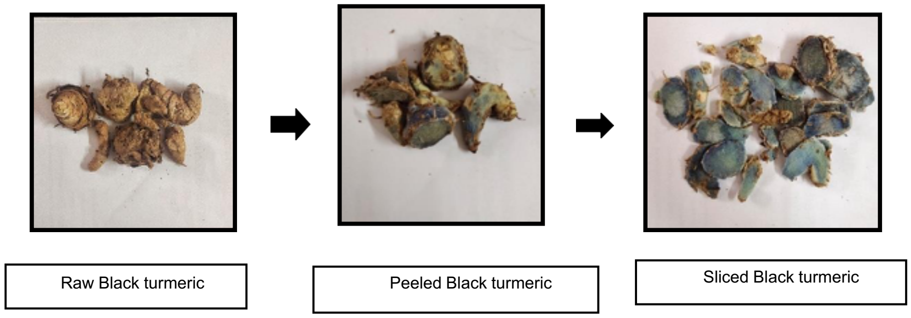

Fig. 1: Pre-processing of black turmeric

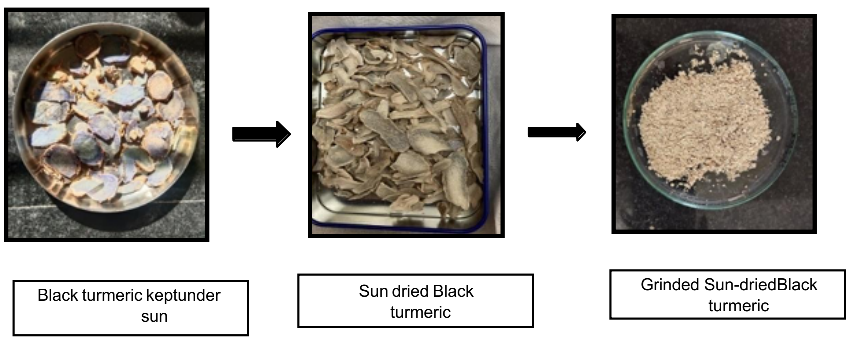

Fig: 2 : Sun drying of black turmeric

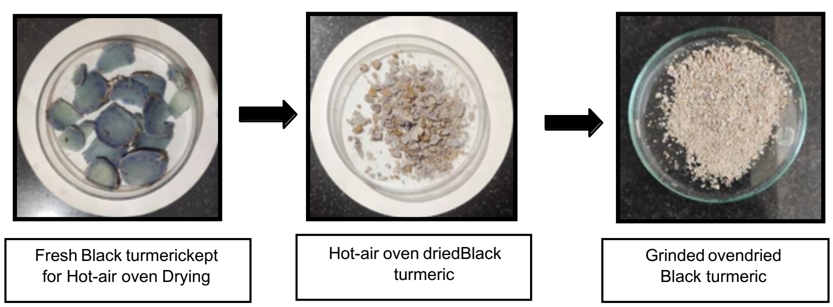

Fig. 3: Hot air oven drying of black turmeric

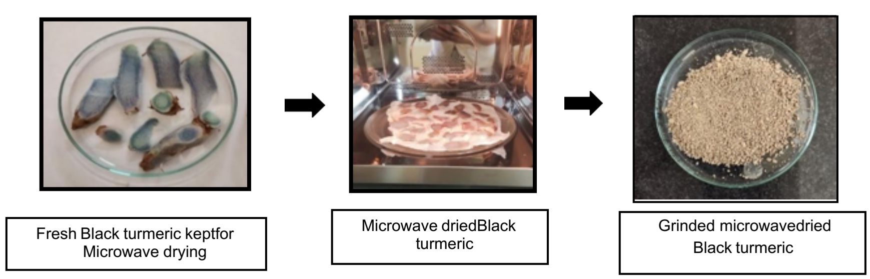

Fig. 4: Microwave drying of black turmeric

Microwave drying: Microwave drying is another home-scale dehydration techniques, where electromagneticwaves are used to evaporate the moisture from the food. The sliced Black turmeric was spreadon a paper inside the microwave at 900 W for 2minutes and 30 seconds. The Microwave dryingprocess is presented in (Fig. 4).

Proximate Analysis

Proximate analysis is a system of analysis of nutrients also termed "conventional analysis" in which the components (carbohydrate, protein, fat, moisture, and ash content) of the food material are determined rather than individual nutrients (monosaccharides, amino acid, fatty acids). All the three different dried black turmeric sample were utilized for estimation of ash content using muffle furnace (AOAC 2016), moisture content using desiccator (AOAC 2016),protein by Kjeldahl method (AOAC 2016), fat by Soxhlet extraction method (AOAC 2016), carbohydrate by Anthrone reaction (AOAC 2016).

Phytochemical analysis

Phytochemicals are the secondary plant metabolites with various medicinal properties and health benefits. Black turmeric is high in bioactive compounds including phenolic compounds,flavonoids. These compounds have essential antioxidant properties capable of producing beneficial effects in the body (Sahu et al., 2018). All the three different dried black turmericsample were utilized for estimation of total phenolic content using Folin-ciocalteu method (Sánchez-Rangel et al., 2013), total flavonoid content using Aluminium Chloride colorimetrictechnique (Sahu and Saxena, 2013) and alkaloid content using acid-base titration method(Debnath et al., 2015), and antioxidant activity using DPPH method (Kalita et al., 2013).

RESULTS AND DISCUSSION

Proximate analysis of dried black turmeric samples

Table 1 depicts the moisture, ash, protein, fat, and carbohydrate content of three different black turmeric powder (BTP) samples dried using sun drying, hot air oven drying, and microwave drying. The results showed that there was no significant difference in the ash content of all three samples ($p > 0.05$), although the mean values slightly differed from each other: 7.57% for sundried BTP, 7.91% for hot air oven-dried BTP, and 7.89% for microwave-dried BTP samples. A similar study conducted by Charoenchai et al. (2020) showed that the ash content of hot-air oven-dried Curcuma longa powder was similar to the results observed in the present study.

Table 1: Proximate analysis of Dried Black Turmeric samples

Parameters	Sun dry	Hot-air ovendry	Microwave dry	pValue
Moisture (%)	6.8 ± 1.11	5.27± 1.55	4.07± 0.8	0.2 NS
Ash (%)	7.57 ± 0.51	7.91±0.19	7.89±0.19	0.7 NS
Protein (g/100gm)	3.5 ± 0.46	7.46 ± 0.36	6.76 ± 0.66	< 0.001*
Fat (g/100gm)	0.67 ± 0.29	1 ± 0.00	1.33 ± 0.29	0.03*
Carbohydrate (g/100gm)	14.93 ± 1.6	15.88 ±0.83	13.01 ± 2.1	0.1 NS

expressed as Mean ±Standard deviation of triplicates

*: indicates p-value is <0.05 by ANOVANS - Non-significant

The three different dried samples showed a slight difference in the mean moisture content with no significant difference ($p > 0.05$). The highest moisture content was observed in sundried BTP sample (6.8%), whereas the lowest moisture content was observed in the microwave-dried BTP sample (4.07%). This difference might be attributed to the fact that in sun drying, the black turmeric's moisture content is influenced by environmental moisture, as the food sample is exposed to the open environment for several days. The lowest moisture content during microwave drying processes could be due to quick dehydration caused by high heat generated by the electromagnetic wave in a short time.

The fat content was retained at the maximum by the microwave-dried BTP sample (1.33 gm), and the minimum retention was observed in the sundried BTP sample, showing significant differences ($p < 0.05$). Protein content retention was at its maximum in the hot-air oven-dried BTP sample (7.46 gm) and at its minimum in the sundried BTP sample (3.5 gm), which was significantly different ($p < 0.05$). The decreased nutrient retention in the sundried BTP sample might be attributed to prolonged exposure to UV radiation from the sun for several days, leading to the degradation of macronutrients (Hassan et al., 2007). Microwave treatment can degrade the structure of starch (due to molecular vibration) and degrade protein quality by inactivating amino acids, but it does not significantly affect the lipid content of food (Jiang et al., 2017).

Phytochemical analysis of dried black turmeric samples

Parameters such as total phenolic content and total flavonoid content showed significantly higher retention in the hot-air oven-dried BTP sample ($p < 0.05$), which were 51.32 mg/100g and 2.34 mg/100g, respectively (Table 2). The lowest retention was observed in the microwave-dried BTP sample, which were 16.42 mg/100g and 1.21 mg/100g, respectively. Heat treatment causes thermal degradation and structural changes in phytochemical content, rendering it less available for absorption by the human body. The electromagnetic waves of microwaves generate high heat in a very short time through molecular friction. An in vitro study conducted by Suna (2019) stated that hot-air oven-dried sample of medlar fruit leather (pestil) dried at 175°C exhibited a better total phenolic content compared to microwave-dried samples dried at 180 W. Similar results were observed in the current study.

Table 2: phytochemical analysis of dried Black turmeric samples

Parameters	Sun dry	Hot-air oven dry	Microwave dry	p Value
Total Phenolic content (mg/100g)	19.97 ± 0.3^{a}	51.32 ± 0.5^{b}	16.42 ± 0.4^{c}	0.006*
Total Flavonoid content (mg/100g)	1.58 ± 0.1^{a}	2.34 ± 0.03^{b}	1.21 ± 0.13^{c}	<0.001*
Alkaloids (mg/100g)	3.5 ± 0.09^{a}	2.2 ± 0.09^{b}	1.9 ± 0.06^{c}	<0.001*

Data expressed as Mean ±Standard deviation of triplicates
*: indicates p-value is <0.05 by ANOVANS - Non-significant
a, b, c, Indicates the superscripts in the row indicates the same to each other and different superscripts inrow indicates different to each other are significantly different (p<0.05) by DMRT

On the other hand, alkaloid content was highest in the sundried sample and lowest in the microwave-dried sample. Higher alkaloid content acts as an antinutrient, and elevated levels of alkaloids exert toxicity and adverse effects on humans, especially in physiological and neurological activities (Egbuna and Ifemeje, 2015). Thus, the reduction in alkaloid content decreases the toxicity level of food. High-temperature treatment reduces the alkaloid content of food due to thermal degradation, and as microwave drying produces high temperatures instantly, it leads to a greater reduction of alkaloid content in the microwaved sample.

Antioxidant property

Antioxidant activity refers to the ability to reduce oxidative stress by scavenging and neutralizing free radicals. Table 3 represents the radical scavenging activity of the different dried samples with ascorbic acid as the standard. The antioxidant property of a food sample depends on the phytochemical content of the food. Thus, the higher total phenolic and flavonoid content of the hot-air oven-dried black turmeric sample contributed to significantly higher antioxidant activity or percent inhibition capacity among the three dried samples, followed by sundried and then microwave-dried samples. At the lowest concentration (200 mcg), the percentage inhibition of the hot-air oven-dried sample was significantly higher ($p < 0.05$), which was 82.90%, followed by sundried BTP sample with 68.09%, and then microwave-dried BTP sample with 58.55%. This might be because when the food is exposed to sunlight for several days, UV radiation decreases the antioxidant activity by destroying the phytochemical content. Similarly, the electromagnetic waves created by the microwave machine destroy the phytonutrients of the BTP sample through thermal decomposition and structural changes.

Table 3: DPPH radical scavenging activity for different Dried BTP samples

Concentration (µg/ml)	Percentage of inhibition			
	Ascorbic acid	Sun dry	Hot-air ovendry	Microwavedry
200	97.02	68.09	82.90	58.55
400	97.48	70.53	84.81	71.30
600	97.79	74.27	85.73	72.90
800	98.40	78.40	88.24	77.40
1000	98.85	79.54	89.24	79.62

CONCLUSION

In this study, fresh Black turmeric rhizome was subjected to three different dehydration methods: sun drying, hot air oven drying, and microwave oven drying. Proximate analysis of the different dried BTP samples was estimated in terms of moisture, ash, carbohydrate, protein, and fat. The results showed that the sundried BTP had the highest moisture content compared to the other samples, with no significant difference observed. Ash and carbohydrate content were highest in the hot-air oven dried sample, with no significant difference. However, significant protein retention was found in the hot air oven sample. This decrease in the protein, fat, and carbohydrate content of the sundried BTP sample might be due to prolonged exposure to UV radiation from the sun for several days, leading to the degradation of macronutrients. Microwave drying degrades the protein quality by inactivating amino acids, but it does not significantly affect the lipid content of food. Thus, fat retention was highest in the Microwave dried BTP sample. The bioactive compounds such as total phenolics, flavonoids, and alkaloids were estimated for the different dried BTP samples. The results showed that the total phenolic content and total flavonoid content were significantly higher in the hot-air oven dried sample. This might be because in sun drying, black turmeric is exposed to UV radiation that decreases the phytochemical content. Similarly, the electromagnetic waves created by the microwave machine destroy the phytonutrients of the BTP sample through thermal decomposition. Alkaloid content was found to be significantly low in the microwave-dried BTP sample. Hot-air oven-dried BTP sample also showed significantly higher percentage inhibition capacity compared to other dried BTP samples. A lower percentage inhibition was found in sundried BTP sample and microwave-dried BTP sample due to exposure to UV radiation and thermal destruction of antioxidant content, respectively.

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