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Effect of drying temperature on the curcumin content of turmeric rhizomes (*Curcuma longa* L.)

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Abstract
Turmeric is processed in a series of operational steps which includes boiling, drying and polishing. Each process has its own importance to get a quality end product. The moisture content of fresh, boiled and dried turmeric was 342% d.b, 485% d.b. and 9% d.b. respectively. The main objective of this research was to study the effect of drying temperature on drying time and curcumin content of the turmeric rhizomes. The study was conducted in a flat-bed dryer at different temperatures of 50, 60 and 70°C. The results revealed that the curcumin content of the turmeric rhizomes decrease as the drying temperature increased. The curcumin content of the fresh rhizomes was observed as 1.783%. After boiling, the curcumin percentage was increased due to its uniform distribution. The drying temperature had inverse relationship with the curcumin percentage of the turmeric. It was also revealed that the drying temperature had impact on the drying time. As the drying temperature increases, the drying time to reach the safe moisture level was found to decrease. Thus, the most appropriate drying condition would be the one which has lesser drying time along with good retention of the curcumin percentage.

Keywords: Turmeric drying, flat bed dryer, curcumin content, drying temperature, turmeric processing, drying rate, drying time

1. Introduction
India is the largest producer of turmeric in the world and accounts for 80% of the world's total production and 60% world exports. The global production of turmeric is around 11 lakh tonnes per annum. The quantity of turmeric produced in India during 2019 was 938,955 tonnes valued at 141,616.00 lakhs. The major turmeric producing states in India are Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Orissa, West Bengal and Maharashtra. The importing countries of Indian turmeric are UAE, Bangladesh, Malaysia, Iran, Japan, Sri Lanka, UK and South Africa [1].
Turmeric is an important spice, grown in India since ancient times for its culinary and medicinal properties. It has greater importance especially in Ayurveda due to its anti-oxidant and anti-carcinogenic properties [2]. The recent pandemic COVID-19 had also added more to its value being an immunity booster [3]. The major bioactive components responsible for these properties are curcuminoids, phenolic acid and flavonoids [4]. Turmeric is found to have around 235 bioactive compounds primarily phenolic compounds and terpenoids, including diarylheptanoids diarylpentanoids, sesquiterpenes, sterols, triterpenoids, curcuminoids, monoterpenes, diterpenes, alkaloid, etc [5].
The main preservative technique for turmeric is drying. Drying helps in the retardation of microbial and fungal growth [6]. Dried rhizomes are the major form of turmeric which possess market demand in international trade [7]. The turmeric is boiled before drying as boiling promotes uniform distribution of curcuminoids [8]. The traditional drying method used by farmers is sun drying. But it has high disadvantages like contamination, prolonged drying time, improper drying rate and quality deterioration [9]. Thus, hot-air drying can be used to avert these problems. This research aims to find the effect of drying temperature on the drying rate and curcumin content of the turmeric rhizomes in a flat-bed dryer.

2. Materials and Methods
2.1. Experimental procedure
The Erode local variety turmeric rhizomes were procured from local farmer. The turmeric rhizomes were washed using turmeric washer to remove the soil and dirt. The clean rhizomes were boiled using pressure boiler at 0.5 kg/cm^2 for 7 minutes [10]. The boiled rhizomes were subjected to flat-bed drying.

The flat-bed drying was carried out at temperatures 50, 60 and 70 ℃. The weight of the samples was checked every 30 minutes.

2.1.1 Moisture content
The moisture content of the turmeric samples was determined using Dean and stark apparatus [11].

2.2 Quality analysis
2.2.1 Sample Preparation
The turmeric rhizomes dried at different trials were collected. It was made to powder form using a pulveriser. The powdered samples were packed in LDPE (50 µm) zip lock covers. It was covered further using aluminium wraps to prevent volatile loss until the analysis.

2.2.2 Curcumin content
The curcumin content of turmeric estimated by BIS – 10925: 1984 method. In this method, the standard curcumin solution has to be prepared. 25 mg of standard curcumin was taken in a 100 ml volumetric flask and it was diluted to mark with alcohol. From this standard solution 1 ml was transferred to 100 ml volumetric flask and it was diluted to mark with alcohol. This contains 2.5 mg (0.0025 g/L) of curcumin.
Fifty mg of ground sample was taken in a round bottom flask with 50 ml alcohol were taken in it. The mixture was refluxed in an air condenser for a period of 2.5 h. The extract was cooled, filtered and taken in a 50 ml volumetric flask. From this extract, 1ml was diluted to 9 ml with alcohol in a cuvette. The absorbance of the standard solution and the extract were measured at 425 nm in a UV- Visible spectrophotometer with alcohol as blank.
A_{425}: Absorbance of standard curcumin solution – The standard solution containing 0.0025 g/l of curcumin gives absorbance value of 0.42 at 425 nm.
The curcumin content was estimated by Equation 1

$$\text{Curcumin (\%)} = \frac{0.0025 \times A \times Vm \times Df \times 100}{0.42 \times W \times 1000} \quad (1)$$

Where
A is the Absorbance at 425 nm
V_m is the Volume made up, ml
D_f is the Dilution factor
W is the Weight of the sample, g

2.3 Data analysis
Analysis of variance (ANOVA) was used to determine the significance of drying temperature on the curcumin content using SPSS software (Version 16.0).

3. Results and Discussion
3.1 Drying characteristics of turmeric rhizomes
3.1.1 Drying time
The safe moisture for turmeric rhizomes for processing and storage is less than 9% d.b. After boiling the turmeric rhizomes were subjected to flat-bed drying. The trials were conducted at three temperatures-50, 60 and 70 ℃. Boiling has significant impact on both drying time and the curcumin percentage [12]. The time taken for the turmeric rhizomes to reach the safe moisture content is presented in Figure 1. The results revealed that the moisture removal rate increased as the temperature increased. The maximum drying time of 61 h was found at the drying trial of 50 ℃ to reach the moisture content to 9% d.b. As the drying temperature increases, the drying time generally decreases. The shortest drying period was observed at 70 ℃. Thus, the drying temperature, significantly ($P \leq 0.01$) influence the drying time (Table 1).

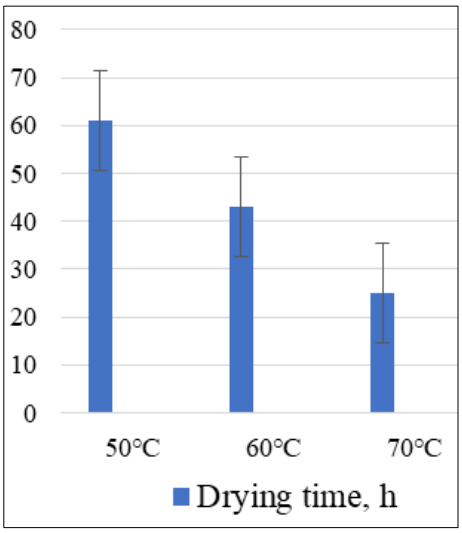

Fig 1: Effect of drying temperature on drying time

3.2 Quality analysis of the turmeric
3.2.1 Curcumin content
The curcumin content of the turmeric rhizomes dried at temperatures 50, 60 and 70℃ was determined. The results are presented in Fig 1. The boiling process increases the curcumin percentage due to the starch gelatinization [13, 14]. From the result, it was found that the highest curcumin retention was found in the drying temperature of 50 ℃. This might be due to the congenial drying environment for the rhizomes at this temperature.

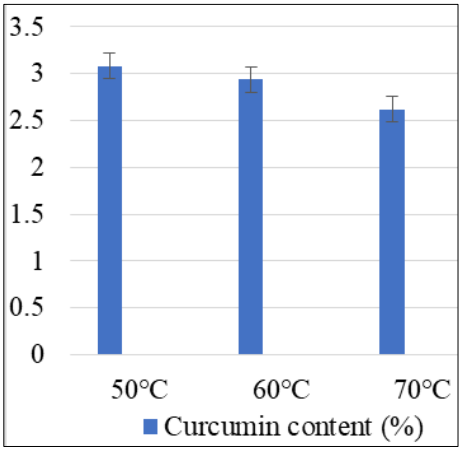

Fig 2: Effect of drying temperature on the curcumin percentage

But this temperature for drying has negative impact on the drying time showing a longer time to attain the safe moisture level of 9% d.b. (Fig 1). At 60 ℃ and 70 ℃, the curcumin percentage was determined as 2.94% and 2.62%. Thus, from the results, it is evidently revealed that there exist significant ($P \leq 0.01$) interaction effects between the drying temperature and the curcumin percentage of the processed turmeric (Table 1). The scientific literatures also reported that curcumin retention was directly correlated with the drying temperature and time [15, 16]. Though the curcumin percentage wasn't the highest, experiment trial at 60℃ showed highly satisfying results both in terms of drying time and quality of the end product.

Table 1: ANOVA summary for the effect of drying temperature on curcumin content and drying time of turmeric rhizomes

	df	F value
Curcumin percentage	1	97.87394*
Drying Time	1	7.708647*
CV (%)	1.1	

*P value is significant at 1% level ($P \leq 0.01$) and NS- Non-significant; CV-coefficient of variation; T- temperature.

4. Conclusion

Curcumin is the most important constituent for the quality determination of the turmeric. It is responsible for the medicinal properties of turmeric which is highly heat sensitive. Thus, the research was conducted to find the response of curcumin percentage of the turmeric on drying temperature. The results showed that optimum drying condition for flat-bed drying is 60 ℃ both in terms of curcumin retention and drying time. The data analysis results showed that the drying temperature had significant interaction effects ($P \leq 0.01$) on curcumin content.

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