INDIAN INSTITUTE OF CHEMICAL ENGINEERS
CHENNAI REGIONAL CENTRE

CHEMCON
2016

CHEMICAL ENGINEERING TOWARDS SUSTAINABLE DEVELOPMENT
DECEMBER 27 – 30th, 2016 @ Chennai

ISOLATION AND CHEMICAL ANALYSIS OF TURMERIC OIL FROM RHIZOMES

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Abstract

The modified steam distillation process was used to obtain the essential oil from turmeric rhizomes. The modified steam distillation process is the combination of continuous water circulation, steam distillation and a packed bed for turmeric rhizomes. Fresh rhizomes were collected from local market of Patiala and Chandigarh. The process was optimized for the operation time of 210 minutes with ~2.5% (v/w) yield of essential oil. The present process is lead to redused wastage of water soluble components and the continious operation provides the short exposure of the heat sensitive components. The obtained turmeric oil was analyzed using Gas Chromatography-Mass Spectroscopy (GC-MS). It has been observed that Ar-turmerone, Curlone, Turmerone, Zingiberene and ar-curcumene are presnt as major component of the turmeric oil. Approximately ~35% components of turmeric oil were remained unidentify. The components of turmeric oil are having antifungal, antibacterial and antioxidant properties and uses in various medical treatments.

Keywords: Turmeric oil; Essential oil; Curcuma Longa L.; Curcumin; steam distillation

1. Introduction

India is considered as the "Land of species" and approximately 65 species/medicinal plants/ herbs are being grown in the country at present. It is cultivated extensively in India, Sri-Lanka, China, Pakistan, Halti, Jamaica, Peru, Bangladesh, El Salvador, Thailand, Taiwan and Indo-China [1]. Turmeric is considered and used as spice/herbs/medicinal plant. India is the largest producer of turmeric in the world and contributes almost 80% of total world production [1]. In India, Andhra Pradesh is the largest producer of turmeric and having more than 60% share of total production in the country [1]. According to one of the international report [1], other than India, China contributes about 8% of world's turmeric production, Myanmar with 4%, Nigeria and Bangladesh with 3% share of the total turmeric production of the world [2].

The Indian turmeric is considered as one of the best turmeric in the world because of its high curcumin [3]. Its botanical name is *Curcuma longa L.* and it is also known as Haridra in Sanskrit and Haldi in Hindi. It has great religious importance in the Indian subcontinent science ancient era [3]. In Hinduism and Buddhism, turmeric is linked to fertility, luck and sun [3]. Turmeric has several health beneficial properties as exceptional medicine used for chronic anterior uveitis, conjunctivitis, skin cancer, chicken pox, small pox, urinary tract infections and liver ailments etc. Turmeric has anti-inflammatory, choleretic, antimicrobial, antioxidant and antifungal properties which makes compatible for a variety of biotechnical applications [4]. Besides these, the turmeric are commonly used as natural dye, spices and curry powder in the form of powder, oleoresin and essential oil. Steam distillation, super critical fluid extraction[5], solvent extraction, hydro-distillation are common methods for obtaining essential oil from turmeric rhizomes[6]. The essential oil of turmeric is a mixture of ~75 compounds, some of them are identified and some not. The chemical composition of turmeric oil has been carried out various researchers [7, 8, 9].

According to the available literature, the curcumin is the major compound present in turmeric oil [1, 2, 3, 4, 5, 6]. The essential oil can also be extracted from the leaves of turmeric. Priya et al. [10] was extracted the turmeric oil from leaves of the Curcuma Longa L. and they show that sequiphellandrene (22.8%) and terpinolene (9.5%) are the major components present in the leaf oil of the turmeric. They also proposed that the turmeric oil is capable of retarding oxidation reaction and is free radical mediated damage. The important properties of turmeric is the antimicrobial activity [9].The antimicrobial activity of turmeric oil were investigates by Singh et al. [11] The average yield of volatile oil is 8.20± 1.66 %v/w from powder turmeric using hydro-distillation method. The total curcuminoids was obtained as 7.57±0.04%w/w. For antibacterial activity they were evaluated against medically important bacteria by Agar diffusion method and it showed better results as compared to volatile extracted from turmeric. In another study, solvent extraction method is used by Jain et al. [12] for isolating herbal medicament from rhizomes of curcuma longa. GC-MS and HPLC analysis were done for identification and standardization of herbal medicaments. The approximate 50-90% curcuminoids were found in herbal medicament [13]. Further, hydro-distillation was used to obtain the essential oil of the rhizomes, which were harvested from 27 different accession of curcuma longa grown in Lucknow by Garg et al. [5, 6]. They found the curcumin contents vary from 0.61% to 1.45% (on dry basis) [14]. The chemical composition of tissues of curcuma longa L. was studied by Li and Yuan et al. [15]. The approximate 235 compounds were discovered by using chromatographic and NMR techniques[16]. It was found that the product quality of turmeric oil is controlled by curcumin. Some other researchers were also obtained the turmeric oil by various extraction methods [9, 17-23] . They also analyze the composition of the turmeric oil.

Hence, only one researcher suggest the modified hydro-distillation of turmeric powder [1].

Following the same scheme, we modified the steam distillation and develop present method of essential oil extraction [24]. The present work is concentrating on the extraction of essential oil using proposed modified steam distillation process and establishing its feasibility for obtaining the essential oil from plant origin.

2. Materials and Methods

2.1 Plant raw material

Fresh rhizomes of turmeric were collected from local markets of Patiala, Chandigarh and Haryana region. The collected turmeric rhizomes was made sure from the vendor that it was fresh and it was cultivated in period of May-January. The length of the turmeric rhizomes used were of 5-8 cm in length and 1-3 cm in diameter. The fresh rhizomes were chopped in sizes of length varying from 0.2 cm to 1cm .The chopped turmeric rhizomes were fed to the cylindrical container of the apparatus. A packed bed of turmeric rhizomes was obtained.

Figure 1 Fresh turmeric rhizomes

2.2 Description of experimental setup and method

The modified steam distillation process was used to obtain the essential oil from turmeric rhizomes. Modified steam distillation is a modification of the Clevenger apparatus which is used to obtain essential oil from herbs and plant origins. The sliced turmeric rhizomes pieces are fed into the packed bed with a wire gauge at the bottom to provide bottom support to feed. Condensed water is fed back to the flask A in which distilled water is boiled continuously with the help of the heating mantle.

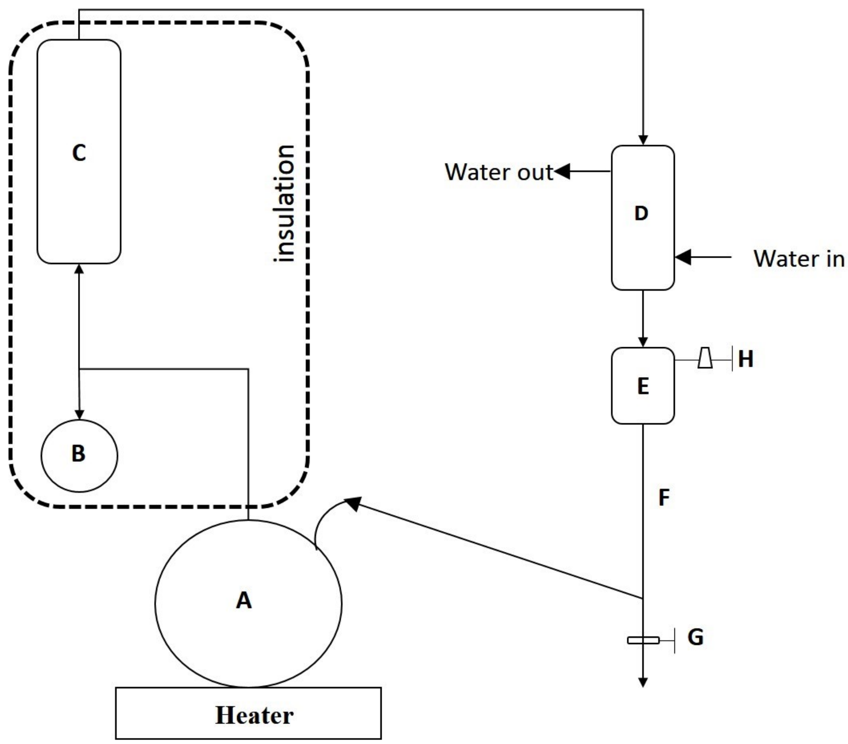

Figure 2 Process flow diagram for production of Turmeric oil

The experimental setup consisted of equipment made up of glass. Component of the experimental setup are: flask A (Round bottom flask) , flask B (Round bottom flask) , condenser D, oil collector E and feed F. The below figure 2 shows the experimental setup. Distilled water is taken in round bottom flask A and is continuously heated at 100 °C using heating mantle. The column of the flask is joined with bottom line of packed bed which is further connected with a round bottom flask B for collection of condensate mixture. Packed bed contains random packing of sliced turmeric rhizomes. The proper insulation was provided to the entire setup to prevent heat losses. The steam generated in the flask A pass through the turmeric bed. The slices of turmeric rhizomes absorbs the heat from the steam and steam got condencd. The condencate along with yellow color of turmeric collected in vessel B. The cells of the turmeric rhizomes busted and the volatile components of essential oil evaporated. The evaporated volatile components sweep off by the trailling steam and pass through the top mounted condensr D. All oil and vapour mixture is got condensed and collected in collector E. the essential oil is lighterthen the water, hence turmeric oil collect as top layer in collector E. Some of the water soluble component mixed with water and the condenced water recycled back into flask A through column F to prevent the wastage of water and water soluble component. Tthe concentration of the water soluble components increase through the process. After 5-6 hours operation, the turmeric oil is collected from the collecter E as top layer. The vent H was provided for maintain the atmospheric pressure inside the equipment and regular release of uncondensed gases.

2.3 Calculation of oil yield and moisture content

The biological material contains approximate 80% moisutre. The moisture content of turmeric was estimated by drying a known amount of sliced turmeric rhizomes. The sliced turmeric (100 gram) was kept in a oven at around 105 ^{o}C for about 4 hours. The loss of weight determines as the % moisture content using the following equation:

$$\%\ \text{Moisture}\ = \frac{(Initial\ weight - final\ weight)}{initial\ weight\ of\ rhizomes\ sample} \times 100 \qquad (1)$$

The essential oil yield was calculated using the following expression:

$$\%\text{Oil yield} = \frac{Essential\ oil\ obtained}{Fresh\ feed\ weight \times (1 - \%moisture\ content)} \times 100 \qquad (2)$$

3. Results and Discussions

The essential oil from turmeric is obtained from proposed modified distillation process. All the experiments were performed at room temperature and atmospheric pressure. The room temperature was observed in between 20-30 ^{O}C during the experiments.

3.1 Moisture content

The moisture content of the raw turmeric was estimated for seven different samples. The chopped turmeric rhizome samples of 50 gm. weight was taken. Each sample was kept in oven at constant temperature of 105^{o}C for 4 hrs. Then the residue weight was estimated and the difference in initial and final weight was termed as moisture content. The % moisture content was obtained between 75.2-77.2 % with an average value as ~76%.

3.2 Turmeric oil yield

The essential oil was obtained and the total yield was calculated using the equation (2). To check the reproducibility and optimizing the operation (process) time of the system the nine turmeric rhizome samples of 500 gram weight were taken (sample no. X8 to X16). The operation time was varied and the % turmeric oil yield has been calculated to optimize the operation time (Table 1 and Figure 3).

Table 1 Variation of % oil yield with time

Sample No.	Time (hr.)	% Oil Yield
X8	30	0.31
X9	60	0.54
X10	90	1.10
X11	120	1.64
X12	150	2.07
X13	180	2.50
X14	210	2.50
X15	240	2.50
X16	270	2.50

Initially, we select the operation time as 30 minutes and we obtain the oil yield as 0.31(v/w). Further the operation time was increased as interval of 30 minutes, (i.e., 30, 60, 90, 120, 150, 180, 210, 240 and 270 minutes) and % turmeric oil yield was calculated (Table 1) and shown in Figure 3.

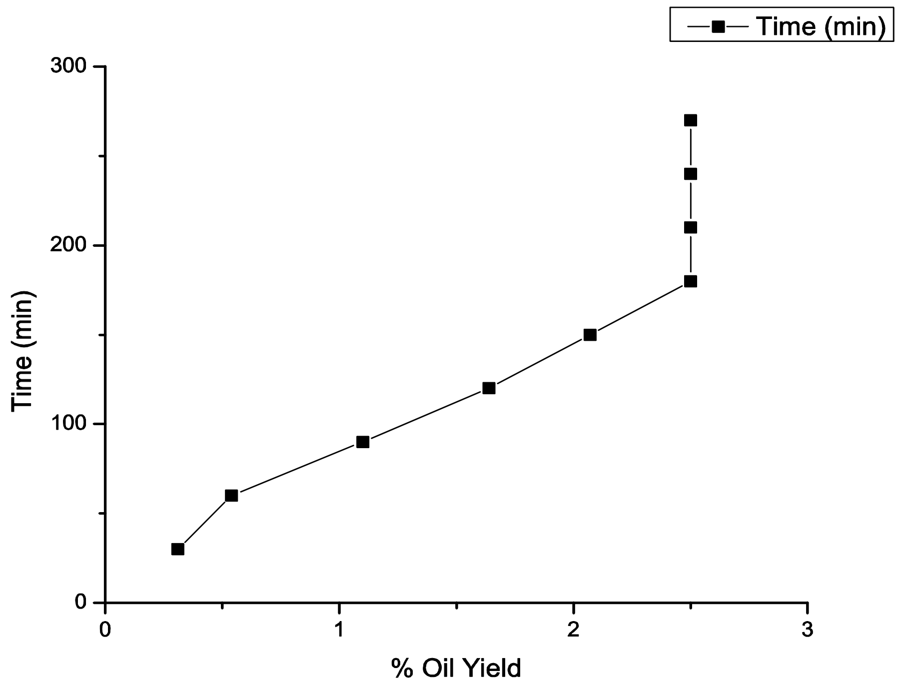

Figure 3 plot of % oil yield with respect to time

The observation of Table 1 and Figure 3 show that the variation in the % yield of turmeric oil yield for the first, second and third hour was 0.54%, 1.64%, and 2.50% respectively. It is also observed that the oil yield become constant as 2.50% (v/w) after three hour (180 minutes) of operation (Figure 3), which indicates that the further operation will not improve the oil yield and the operation can be terminated after three hours. Hence, three hour is considered as optimize operation time.

Furthermore, to see the effect of sample weight on the oil yield, the other samples from X17 to X21 was taken. The rhizomes weight was increased from X17 to X21 in between 50 gram to 1000 gram. The obtained oil and % yield is tabulated in Table 2 and plotted in Figure 4.

Table 2 Turmeric oil (ml.) with increasing weight of samples

Sample No.	Sample Weight	Oil obtained	% yield (v/wt.)
X17	50	0.30	2.50
X18	400	2.11	2.20
X19	500	3.37	2.98
X20	800	4.43	2.48
X21	1000	5.01	2.09

The observation of Table 2 and Figure 4 shows the obtained oil yield as 2.5% (v/w) for X17 (50 gram). For the next sample (X18), we obtained 2.11 ml. turmeric oil with 2.2% yield from 400 gram of turmeric rhizomes as shown in table 2 and Figure 4. Further, for the next sample (X19) the sample weight was increased as 500 gram. In this case the turmeric oil increased as 3.37 ml. with 2.98% yield (Table 2, Figure 4). Similarly, the sample weight was increased upto 1000 gram (X20, X21). For sample X20 and X21 the % oil yield obtained is 2.48 and 2.09 respectively.

Overall, the oil yield increases with increase in sample weight. Although, the % oil yield is not increasing continuously with increase in sample weight. For sample, X18, X20 and X21 the % oil yield is decreased with increase in weight of rhizomes. This decrease in % oil yield may be due to multiple reasons such as, the premature cultivation of turmeric rhizomes, different cultivation conditions, non-uniform chopping of rhizomes for samples.

4.3 Identification of major compounds using GC and GC- MS

In the present method of operation, we obtained one product and two residue. In the product stream (section G of Figure 2), we obtain essential oil from turmeric rhizomes. In vessel B

(Figure 2), the condensate of initial heating of the rhizomes was collected. In vessel A (Figure 2), initially distilled water was taken but during the operation the process water was continuously re-circulated. So, in vessel A, some of the water soluble components of essential oil may present. In vessel B, we obtain dark orange color mixture. The samples from vessel G (essential oil), vessel A and vessel B were analyzed using GC-MS.

Table 3 Identified compounds present in turmeric oil, water and mixture

Turmeric oil	Water	Residue mixture
1,8-cineole	Beta turmerone	Zingiberene
Beta-cedrene	Ar.- Turmerone	L-Phellandrene
Terpan	Alpha curcumene	Turmerone
l-phellandrene	Cinnamyl Tiglate	Farnesol
ar-curcumene	Cedrene	Paracymene
Gama.-Terpinene	Caryophyllene	ar curcumene
Alpha.-terpinilene	A-Phellandrene	2-Methyl-Nonane
Para-cymene	L-Phellandrene	Para-cymene
Turmerone	Alpha-thujene	Nonane, 2-Methyl
Beta Sesquiphellandrene	Cycloheptane	Cyclohexane, Methyl
Alpha.- Terpinolene	Zingiberene	Methyl cyclohexane
Curlone	Beta sesquiphellandrene	Sextone B
zingiberene	(+)-2-Caren	

The GC-MS of the samples was carried out at Sophisticated Analytical Instrument Laboratory, Thapar University, Patiala. The specific components of the essential oil and residue was identified by comparing mass spectra fragmentation pattern and retention time with the library values. The identified components of the samples are presented in Table 3. Identification of compounds has been done by comparing mass spectra fragmentation pattern and retention time. The identified compounds as given in Table 3 are ar-curcumene, zingiberene, dehydro-curcumene, ar-turmerone, turmerone, curlone and many of them are still unidentified. The chemical composition of obtained essential oil is given in Table 4. It can be state here that the present method for turmeric oil extraction is suitable. In addition of turmeric oil we are obtaining two more fractions, one in residue water and other is dark orange condensate.

Table 4 Turmeric oil composition

S. No.	Identified compound	Composition
1	ar-turmerone	45.27%
2	Curlone	5.6%
3	Turmerone	4.4%
4	Zingiberene	4.01%
5	ar-curcumene	4.01%
6	Dehydro curcumene	2.0%
7	Unidentified	34.71%

The observation of Table 3 shows that there are trace amount of turmeric oil components present. Usually, in conventional methods these trace components are not recoverable and drains in the waste water steam. Conversely, in present method, it is separated into two fractions, one of them is highly concentrated dark orange mixture. This dark orange mixture can further separated into their components or group of components. Similarly, the residue water can be used for recovery of water soluble turmeric oil components. Hence, in this method we are obtaining three different streams. This is an Eco-friendly process for separation of essential oil from plant materials. In this method the essential oil loss is minimum.

4. Conclusion

In present investigation the emphasis was laid on the feasibility of the modified distillation process to obtain essential oil from plant origins. A new design has been used for the entire experimental work. The modified design can be used efficiently for obtaining essential oil from plant materials/spices. The oil yield obtained from rhizomes ranges between 2.09-2.50% (v/w). The GC-MS analysis of turmeric oil was used to obtain the chemical composition of turmeric oil. Overall, the present method (modified steam distillation method) is feasible technique for the essential oil extraction from plant origins with minimum losses. It can be considered as eco-friendly technique.

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