Available online at https://jcst.rsu.ac.th
Formerly Rangsit Journal of Arts and Sciences (RJAS)

Journal of Current Science and Technology, January-June 2020 JCST Vol. 10 No. 1, pp. 49-57

ISSN 2630-0583 (Print)/ISSN 2630-0656 (Online)

Pretreatment study of turmeric rhizomes and optimization of drying methods using microwave oven and hot air oven to obtain high quality of turmeric powder

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Received 14 December 2019; Revised 14 March 2020; Aaccepted 18 March 2020
Published online 31 March 2020

Abstract

Drying step is one of the important processes for plant preparation to use in medicinal and dietary products. There are many methods for drying; for example, using solar, hot air oven, and freeze dry. In this study, drying used hot air oven and microwave oven were compared. Quality of turmeric powder obtained from microwave oven and hot air oven was studied. Total curcuminoids, volatile oil contents, total ash, acid insoluble ash, moisture and ethanol soluble extractives were tested according to Thai Herbal Pharmacopoeia methods. There were six of turmeric powders and they were collected from the same area. Six samples were divided for boiled and unboiled in the pretreatment step and dried using microwave and hot air ovens. The results showed that drying methods either from microwave oven or hot air oven did not give any significantly differences. Total curcuminoid (7.85-8.58 %w/w) and volatile oil (5.00-7.00 %v/w) contents were met the standard criteria of WHO. However, boiling step yielded less volatile oil contents. HPLC analysis showed that there were similar profiles of curcumin, bisdesmethoxycurcumin, and desmethoxycurcumin among these samples. There was not significantly difference of curcumin content between boiled and unboiled samples, although curcumin content was slightly higher in microwave (2.84-3.77 %w/w) drying method compared with hot air oven (2.69-2.96 %w/w). Drying turmeric powder using microwave oven can reduce time and result in equivalent quality compared with drying in hot air oven.

Keywords: *Curcuma longa* L., *curcuminoids, hot air oven, microwave oven, turmeric, volatile oil*

1. Introduction

The herbal medicinal plants were widely used in Thailand and Indo-Pacific. It increased the interest to use organic herbs around the world. In order to search for high quality of plant raw materials, it needed to corporate with agricultural personnel and helped them to understand good agricultural practice (GAP). After fresh herbs were harvested, they needed to be processed before preparation of medicinal products. Pretreatment steps; for example, clean, dry and ground these herbs were performed. The pretreatment steps were mainly washing, boiling, drying, slicing and grounding herbs. Drying step is the rate-limiting step for plant preparation. Since *Curcuma longa* L. (Abbrev. *C. longa*) rhizomes which were used as plant raw material sample, washing step cleaned the dirt and other contaminants. Boiling *C. longa* rhizomes decreased the potential of microbial contamination. After slicing the rhizomes were dried by using a microwave oven which decreased the drying time compared with conventional drying in the hot air oven. It was less likely to loss of some volatile components also.

Microwave oven is a technique that is used in food processing; for example, drying, cooking, pasteurization and preservation of food (Chandrasekaran, Ramanathan, & Basak, 2013; Guo, Sun, Cheng, & Han, 2017). Microwaves are electromagnetic waves and their frequency varies from 300 MHz to 3,000 GHz. Microwave heating of food materials mainly occurs due to the ability of the materials to absorb microwave energy and convert it into heat. The presence of water or moisture in the material causes dielectric heating due to the dipolar nature of water. Microwave heating may also occur due to the oscillatory migration of ions in the materials which generate heat in the presence of a high frequency oscillating electric field. The advantages of using microwave technique are reduction in handling time and energy consumption. However, the heat distribution and penetration depth are the factors that need to be considered. In this

research focused on using microwave heating in the drying method of plant materials.

Turmeric (*C. longa*) is in the Zingiberaceae family. It has been widely cultivated in Thailand especially in the southern areas. Curcumin is the major constituent in turmeric powder and exhibits anti-oxidant (Thaikert & Paisooksantivatana, 2009) and anti-inflammatory effects (Prasad, Gupta, Tyagi, & Aggarwal, 2014). Turmeric has been used as spice and medicinal products either for internal or external uses. Turmeric capsules are indicated to use as carminatives and astringents (Khamin Chan, Department of Medical Sciences, 2016, pp. 145-152). Its intense yellow color is uses as pharmaceutical coloring agents. *C. longa* rhizomes are used as adjunctive therapy for peptic ulcer, dyspepsia (Khonche et al., 2016), pain and inflammation due to rheumatoid arthritis (Fan, Li, Liu, Jiao, & Liu, 2018). Turmeric powder used in the topical formulations showed some benefits on skin health (Vaughn, Branum, & Sivamani, 2016). The extract of turmeric powder was used in cosmetics as skin whitening (Jennifer, Stephie, Abhishri, & Shalini, 2012). In the preparing process of turmeric powder, boiled turmeric rhizomes was one of the important steps. Boiled turmeric rhizomes cooked starch grains in the rhizomes which were easy for digestion when turmeric was used for relieving flatulent symptoms.

The quality of turmeric rhizomes was monitored according to a monograph in Thai Herbal Pharmacopoeia (Khamin Chan, Department of Medical Sciences, 2016, pp. 145-152). The monograph specifies universal tests; both macroscopic and microscopic characteristics, identification, physical and assay of total curcuminoids. WHO monographs on selected medicinal plants also contain a monograph of the dried rhizomes of *C. longa* (World Health Organization, 1999). In this study the physical and chemical tests for main components of *C. longa* was examined. Curcuminoids are yellow components comprising of curcumin, desmethoxycurcumin, and bisdesmethoxycurcumin (Figure 1). Its volatile oil composes of a number of monoterpenes and sesquiterpenes including zingiberene, curcumene, α- and β–tumerones. Assay of total curcuminoids was analyzed by spectrophotometric (Sharma, Agrawal, & Gupta, 2012) or high performance liquid chromatography (HPLC) methods (Osorio-Tobon et al, 2016). In this study spectrophotometric method was used for the assay of total curcuminoids contents as recommended by THP. The microwave power was studied in 2 levels of electric power because it needed to produce enough heat to dry plant materials and preserve the quality of plants.

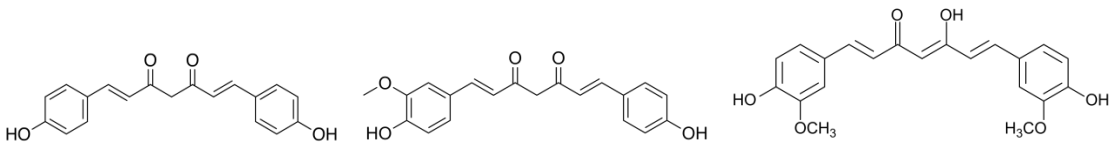

Figure 1 Chemical structures of (1) curcumin, (2) desmethoxycurcumin and (3) bisdesmethoxycurcumin

2. Objectives

The objective of the study was to determine the quality of turmeric rhizome powder processing from microwave oven compared with hot air oven. The pretreatment turmeric rhizomes were compared between boiled and unboiled step.

3. Materials and methods

3.1 Chemicals and instruments

Standard curcumin was purchased from Shaanxi Guanjie Technology Co. Ltd, China. Bisdesmethoxycurcumin and desmethoxycurcumin were purchased from Chengdu Biopurify Phytochemicals Ltd, China. Tetrahydrofuran and acetic acid was purchased from J.T. Baker, USA; methanol and toluene were obtained from Burdick&Jackson, Korea. Formic acid was purchased from Fischer Scientific, UK and hydrochloric acid was bought from Calo Erba, France. Ultra-pure water was supplied by Econoz Milli-Q water purifier system, Korea. Microwave oven was EMS3288X, Electrolux, China and hot air oven was RXH14-B, Changzhou Wangqun Pharmaceutical Machine Co. Ltd., China.

3.2 Plant materials

The rhizomes of *C. longa* were collected in February 2018 at Thap-pud district, Phang Nga

Province, Thailand. Plant sample was identified by Mr. Nirun Vipunngeun, plant taxonomist. A voucher specimen (CM-CL001-1-02-2018) was deposited at Drug and Herbal Product Research and Development Center, College of Pharmacy, Rangsit University. The rhizomes were separated for boiled and unboiled after cleaning. Then the samples were divided into 6 groups (800 g) as showed in the Table 1. After drying process *C. longa* rhizomes were ground to powder and kept in air-tight plastic bag.

Table 1 Sample preparation

Sample No.	Preparation	Drying Process
1	Clean the rhizomes, unboiled them	Microwave oven 850 Watt, 5 minute
2	Clean the rhizomes, unboiled them	Microwave oven 450 Watt, 5 minute
3	Clean the rhizomes, unboiled them	Hot air oven 60 °C, 5 hours
4	Clean the rhizomes, and boiled for 30 minutes	Microwave oven 850 Watt, 5 minute
5	Clean the rhizomes, and boiled for 30 minutes	Microwave oven 450 Watt, 5 minute
6	Clean the rhizomes, and boiled for 30 minutes	Hot air oven 60 °C, 5 hours

3.3 Determination of total curcuminoids content

Total curcuminoids content was determined using spectrophotometric technique according to Thai Herbal Pharmacopoeia 2016 (Khamin Chan Monograph) (Khamin Chan, Department of Medical Sciences, 2016, pp. 145-152). The samples were accurately weighed 300 mg (n=2) and were stirred in 10 mL of tetrahydrofuran for 24 hours using a shaker (WiseShake® SHO-2D, Witeg Germany). The samples were filtered, pipetted 1 mL of the solution and diluted in 25 mL of methanol. The sample solution (1 mL) was further transferred to 50 mL of methanol. Then they were measured the absorbance at the wavelength of 420 nm in triplicate using a UV-visible spectrophotometer (Spectronic Genesys 5, Milton Roy, USA). The standard curcumin was prepared in methanol at the concentration of 400 μg/mL and diluted to 10 μg/mL in methanol. Then it was further diluted to 0.8, 1.6, 2.0, 2.4 and 3.2 μg/mL. The standard solutions were measured the absorbance relative to blank at 420 nm. The content of curcuminoids in the sample was calculated relative to the standard curve of curcumin.

3.4 Determination of volatile oil content

Volatile oil content was determined according to THP (Appendix 7.3H) (Department of Medical Sciences, 2016, pp. 575-576). *C. longa* rhizome powder was accurately weighed 10 g (n=2) in a 500 mL round bottom flask and added 100 mL of water. The samples were distilled for 5 hours and the volatile oil was collected and measured. The volatile oil content was calculated as %volume by weight of dried plant material as showed in the equation.

$$\%Volatile\ oil\ content\ (\%v/w) = \frac{Volume\ of\ volatile\ oil\ (mL)}{Dried\ weight\ of\ plant\ powder\ (g)} \times 100$$

3.5 Total ash and acid insoluble ash

Total ash was determined according to Thai Herbal Pharmacopoeia (Appendix 7.7) (Department of Medical Sciences, 2016, pp. 577). The crucible was heat at 120 °C until the constant weight was obtained. *C. longa* rhizome powder was accurately weighed 1 g (n=3) in a tare crucible. The samples were dried at 100-105 °C for 1 hour and were ignite in the furnace at 500° ± 5 °C for 5 hours. The crucible was allowed to cool in a desiccator after each ignition and accurately weighed. The total ash was calculated by % weight by weight of plant powder as showed in the equation.

$$\%Total\ ash\ (\%w/w) = \frac{Weight\ of\ plant\ ash\ after\ ignition\ (g)}{Dried\ weight\ of\ plant\ powder\ (g)} \times 100$$

Acid insoluble ash was determined according to Thai Herbal Pharmacopoeia (Appendix 7.6) (Department of Medical Sciences, 2016, pp. 577). The total ash was boiled with 25 mL of 10% hydrochloric acid for 5 minutes in the water bath. The insoluble matter was collected on an ashless filter paper (Whatman No.41) and washed with hot water until the neutral pH of the filtrate was

obtained. The residue was ignited in the furnace at 500° ± 5 °C for 5 hours. The acid insoluble ash was calculated by % weight of the residue by weight of plant powder as showed in the equation.

$$\%Acid\ insoluble\ ash\ (\%w/w) = \frac{Weight\ of\ plant\ residue\ after\ ignition\ (g)}{Dried\ weight\ of\ plant\ powder\ (g)} \times 100$$

3.6 Water determination

Moisture content was determined using azeotropic method (Thai Herbal Pharmacopoeia, 2016 Appendix 4.12) (Department of Medical Sciences, 2016, pp. 569-570). Toluene 200 mL and water 2 mL were distilled for 2 hours and cooled down. Then *C. longa* rhizome powder was accurately weighed 15 g and added. The distillation was continued for 2 hours. Water content was calculated as % volume by weight as showed in the equation.

$$\%Water\ content\ (\%v/w) = \frac{Volume\ of\ water\ (mL)}{Dried\ weight\ of\ plant\ powder\ (g)} \times 100$$

3.7 Ethanol-soluble extractives

C. longa rhizome powder was accurately weighed 5 g (n=2) and added 100 mL of 95% ethanol in a closed erlenmeyer flask, Thai Herbal Pharmacopoeia, 2016 Appendix 7.12 (Department of Medical Sciences, 2016, pp. 578). The samples solutions were shake frequently for the first 6 hours using a shaker (WiseShake® SHO-2D, Witeg Germany) and allowed to stand for 18 hours. The sample solution was filtered and 20 mL of the solution was transferred to an evaporating dish. The solution was evaporated to dryness and dried at 105°C until constant weight. Ethanol-soluble extractive was calculated as % weight by weight of plant powder.

$$\%Ethanol - soluble\ extractives\ (\%w/w) = \frac{Dried\ weight\ of\ extractives\ (g)}{Dried\ weight\ of\ plant\ powder\ (g)} \times 100$$

3.8 HPLC analysis of curcuminoid profile

Curcuminoids were determined using HPLC (Agilent 1260, USA) coupling with a Zorbax Extend C_{18} column (4.6 x 250 mm, 5 μ, Agilent PN: 770450-902) and EZChrom software. The mobile phase was 2% acetic acid in water and acetonitrile in the ratio 40 : 60 at the flow rate of 0.8 mL/minute. Samples were prepared the same procedure as determination of total curcuminoids in the spectrophotometric method. Standard curcumin, bisdesmethoxycurcumin, and desmethoxycurcumin were prepared in the concentration 10-100 μg/mL. Sample and standard solution were filtered through 0.45 μm syringe filter and injected 10 μL into HPLC autosampler. The peak area was observed at the wavelength of 420 nm. The contents of curcumin, bisdesmethoxycurcumin, and desmethoxycurcumin were calculated from their peak areas relative to each standard curve.

3.9 Statistical calculation

The data were analyzed by ANOVA and independent *t*-test using IBM SPSS version 21.

4. Results

Turmeric rhizomes in this study were obtained from the same source and harvested at 8 months old. The color of turmeric powder was bright orange to orange bricks. The turmeric powder showed good flow ability and was not lumpy. So, the appearance and color of dried sample were good characteristics. This study used optimized boiling time for 30 minutes because it still maintained the content of major curcuminoids. Although the volatile oil yields were lower and less than THP standard criteria, these can be improved if the rhizomes were harvested at longer than 8 months old. In this report presented the effect of drying method and process of preparing turmeric powder. The quality control of turmeric powder was showed in Table 2.

Table 2 Quality control of *C. longa* raw materials

Samples	Total curcuminoids (%w/w)	Volatile oil content (%v/w)	Ethanol soluble extractive (%w/w)	Total ash (%w/w)	Acid insoluble ash (%w/w)	Moisture content (%v/w)
1	8.21±0.07	6.75±0.35	15.04±1.53	7.08±0.04	0.05±0.04	6.33±0.47
2	8.01±0.36	7.00±0.00	14.46±0.59	7.51±0.87	0.12±0.04	7.33±0.95
3	7.85±0.06	7.00±0.00	15.51±0.57	8.07±1.08	0.08±0.00	8.66±0.00
4	7.96±0.19	6.00±0.00	15.70±0.30	6.82±0.04	0.06±0.02	8.99±0.48
5	8.58±0.16	5.25±0.35	16.86±0.31	6.76±0.11	0.08±0.02	7.99±0.00
6	7.98±0.08	5.00±0.00	16.76±0.19	6.88±0.09	0.16±0.14	9.33±0.01
THP criteria	NLT 5.0%	NLT 6.0%	NLT 10.0%	NMT 8.0%	NMT 1.0%	NMT10.0%
WHO criteria	NLT 3.0%	NLT 4.0%	NLT 10.0%	NMT 8.0%	NMT 1.0%	NMT10.0%

The values (in row 1-6) are mean ± SD

4.1 Total curcuminoids contents

All turmeric samples were met the THP and WHO criteria for total curcuminoid contents. The sample which was boiled and dried with microwave (450 Watt) showed the highest total curcuminoid content. In opposite, the sample which was dried with hot air oven and unboiled showed the lowest total curcuminoid content.

In addition, HPLC analysis showed that bisdesmethoxycurcumin was the highest content, secondly curcumin and desmethoxycurcumin, respectively (Table 3). The curcuminoid profile was in the same direction for six samples. Either boiled or unboiled sample and dried with high electric power (850 Watt) of microwave oven showed the highest curcumin content. It could be heat from microwave dry out moisture in the sample but it did not affect the major chemical components in the sample. The sample which was boiled and dried in hot air oven showed the least curcumin content. HPLC chromatograms showed that bisdesmethoxycurcumin (BDMC), desmethoxy-curcumin (DMC), and curcumin were eluted, respectively (Figure 2).

Table 3 HPLC analysis of curcuminoids profile of the turmeric samples

Samples	Curcuminoid contents (%w/w)		
	Bisdesmethoxycurcumin (BDMC)	Desmethoxycurcumin (DMC)	Curcumin (C)
1	4.99 ± 0.55	2.14 ± 0.27	3.68 ± 0.32
2	4.68 ± 0.40	1.85 ± 0.21	2.84 ± 0.31
3	4.81 ± 0.21	1.92 ± 0.12	2.96 ± 0.19
4	5.70 ± 1.15	2.52 ± 0.70	3.77 ± 1.09
5	5.76 ± 0.27	2.49 ± 0.18	3.65 ± 0.29
6	4.57 ± 0.06	1.84 ± 0.05	2.69 ± 0.14

The values are mean ± SD

4.2 Volatile oil contents

All samples showed that the volatile oil contents were higher than WHO criteria. Turmeric rhizomes that were unboiled showed the volatile oil contents were above 6.0%v/w, while boiled samples were slightly less than THP criteria except for the sample that was boiled and dried with microwave oven 850 Watt.

4.3 Ethanol-soluble extractive

Samples that were unboiled were slightly lower in ethanol-soluble extractives than those of boiled samples. Samples dried with microwave oven contained slightly less ethanol-soluble extractives than those from hot air oven.

4.4 Total ash and acid insoluble ash

Total ash of all samples was less than 8.0%w/w except for the one that was unboiled and dried in the hot air oven. In comparison, acid insoluble ash was less than 1.0% w/w. It means low inorganic substance contamination.

4.5 Moisture content

All samples showed that moisture contents were less than 10.0% v/w. However, drying in hot air oven for both boiled and unboiled samples showed slightly higher moisture content than drying in microwave oven. The temperature used in hot air oven was general 60 °C because lower temperature took longer time to dry these rhizomes and may cause mold contamination during this step and high

temperature can cause loss of volatile oil contents. Therefore, the temperature for hot air oven was selected at 60 °C and did not use other conditions. The sample which was the lowest moisture content was unboiled and dried with higher electric power of microwave oven.

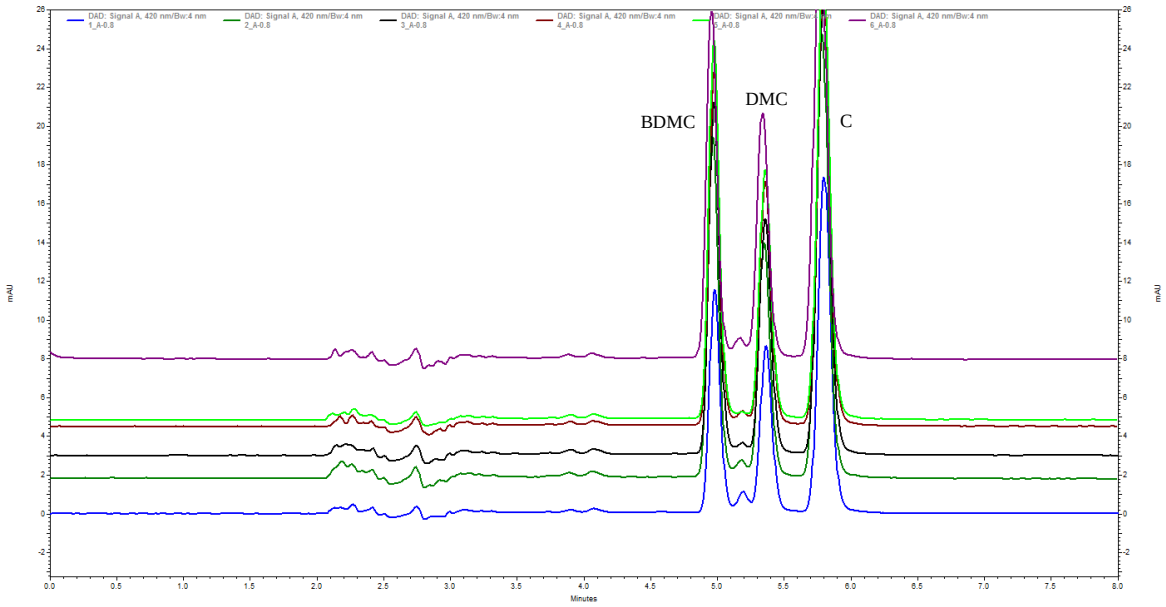

Figure 2 Overlay HPLC chromatogram of sample 1-6

5. Discussion

This research reported that the quality of turmeric powder dried with microwave and hot air oven and pretreated by boiled and unboiled the rhizomes. Total curcuminoid content, volatile oil content and ethanol-soluble extractives showed that the quality of these turmeric samples was complied with the standard criteria. Curcuminoid content was not significantly different between these two drying methods and pretreatment steps. There was a report of curcuminods of *C. longa* from different locations in Thailand but they were tested by TLC densitometry (Pothitirat & Gritsanapan, 2005). In comparisons, curcuminoids contents of those samples were in the range of 2.74-4.72 %w/w of dried plant powder. The other study reported similar results to our study that the highest total curcuminoid content (8.99±0.83%w/w) was from the southern area of Thailand (Pothitirat & Gritsanapan, 2006). Another study reported that the highest total curcuminoid content was 10.23±4.99%w/w from the central part of Thailand after planting for 6 months (Thaikert & Paisooksantivatana, 2009). There was a study of soil nutrients and fertilizers affecting quality of turmeric rhizomes which reported that organic fertilizer yielded high turmeric production with their qualities of main constituents met standard criteria (Kulpapangkorn & Mai-leang, 2012).

In addition, volatile oil contents in these turmeric powders were statistically differences (p-value < 0.05) between boiled and unboiled samples. Boiled water (80 °C) was used in the boiling step although it was 30 minutes, it may cause loss of volatile oil. Therefore, volatile oil contents in unboiled turmeric rhizomes significantly higher than those of boiled samples. As mentioned previously the boiling step was necessary for pretreatment of *C. longa* rhizomes because it was the important step to cook the starch grain in the rhizomes. Cooked starch in turmeric powder would not cause stomachache when turmeric powder is prepared for use as medicinal herb. However there were not significantly different volatile oil contents between microwave oven and hot air oven. Therefore, the drying conditions did not affect volatile oil yield.

Ethanol-soluble extractives were statistically significant between boiled and unboiled samples, but they were slightly different between two drying methods. In the boiling step, the rhizome tissues were swell with water, it can be possibly saturate in ethanol and chemical compositions were easy to soluble in ethanol. Therefore, the boiled

samples showed higher ethanol-soluble extractives. Low microwave power should maintain plant integrity, while high microwave power can reduce drying time, but it may cause some hot spots and burn samples (Guo, Sun, Cheng, & Han, 2017). In this study there were no statistically significant between turmeric samples dried with different microwave power at 450 watt and 850 watt. It implied that the microwave power may not affect the quality of turmeric powder but it was still need to consider for prevention loss of major components. Additionally, the electric power of microwave oven may affect the distribution of heat uniformly. The statistical results were showed in the Tables 4-7.

For contamination test of turmeric powders, total ash was significantly differences between groups and significantly higher in unboiled samples than those of boiled samples. In the boiling step the samples were removed other contaminants again after washing and cleaning at the beginning while unboiled samples were only cleaning and washing. In addition, it was found that microwave oven yielded slightly lower total ash compared with those from hot air oven. Acid insoluble ash was not significantly differences between groups. Boiled and unboiled turmeric rhizomes were not statistically difference also. Microwave oven and hot air oven did not give any significant differences of the moisture content in turmeric powder but it was significantly lower in unboiled sample compared with boiled turmeric rhizomes. The samples which were boiled the rhizome tissues were saturate with water, so they were still higher of moisture contents after drying. Two microwave powers did not give any significant differences of total ash, acid insoluble ash and water content also. The limitation of microwave oven was that drying needed to be divided into several batches due to small size of the instrument compared with drying at the same scale of plant materials with hot air oven.

In this study pretreatment of turmeric rhizomes and drying method were optimized to prove that drying in the microwave oven can be the alternative method to drying with hot air oven. The preliminary steps of preparing herbal raw materials can be applied to process in a mobile unit (ThaiPBS program, 2018). This mobile unit is beneficial for local communities in Thailand, so they do not need to collect big volumes of herbs and transport far away factory. It reduces shipping, storage and labour costs. It can solve the problems for people in the rural areas. They can process plant materials right after harvesting.

Table 4 Independent *t*-test of drying methods

Parameters	Drying methods (Mean ± SEM)		*p*-value
	Microwave oven	Hot air oven	
Curcuminoids contents	8.19 ± 0.11	7.92 ± 0.05	.13
Volatile oil contents	6.25 ± 0.27	5.99 ± 0.58	.25
Ethanol-soluble extractives	15.52 ± 0.41	16.13 ± 0.40	.61
Total ash	6.92 ± 0.05	7.56 ± 0.38	.06
Acid insoluble ash	0.16 ± 0.06	0.15 ± 0.04	.93
Moisture content	7.66 ± 0.40	8.99 ± 0.19	.05

SEM = standard error of means

Table 5 Independent *t*-test of treatment of turmeric rhizomes

Parameters	Treatment of turmeric rhizomes (Mean ± SEM)		*p*-value
	Unboiled	Boiled	
Curcuminoids contents	8.01 ± 0.09	8.18 ± 0.14	.36
Volatile oil contents	6.92 ± 0.08	5.42 ± 0.20	.00*
Ethanol-soluble extractives	15.00 ± 0.37	16.44 ± 0.25	.01*
Total ash	7.55 ± 0.28	6.82 ± 0.03	.02*
Acid insoluble ash	0.13 ± 0.04	0.18 ± 0.06	.48
Moisture content	7.44 ± 0.47	8.77 ± 0.27	.03*

SEM = standard error of means
*The mean difference is significant at *p*-value < .05

Table 6 Independent *t*-test of microwave oven watt

Parameters	Microwave oven power (Mean ± SEM)		*p*-value
	450 W	850 W	
Curcuminoids contents	8.29 ± 0.20	8.08 ± 0.09	.38
Volatile oil contents	6.13 ± 0.52	6.38 ± 0.24	.68
Ethanol-soluble extractives	15.66 ± 0.72	15.37 ± 0.49	.75
Total ash	6.93 ± 0.12	6.94 ± 0.06	.90
Acid insoluble ash	0.23 ± 0.11	0.09 ± 0.04	.22
Moisture content	7.66 ± 0.79	7.66 ± 0.34	.99

SEM = standard error of means

Table 7 Independent *t*-test of curcuminoid profile

Parameters	Curcuminoid profile (Mean ± SEM)		
	BDMC	DMC	C
Boiled	5.34 ± 0.33	2.28 ± 0.19	3.37 ± 0.30
Unboiled	4.83 ± 0.14	1.97 ± 0.09	3.16 ± 0.19
p-value	.18	.17	.56
Microwave oven	5.28 ± 0.25	2.25 ± 0.15	3.48 ± 0.21
Hot air oven	4.69 ± 0.09	1.88 ± 0.05	2.82 ± 0.10
p-value	.14	.12	.07

SEM = standard error of means

6. Conclusion

This study examined pretreatment procedure of turmeric powder using a microwave oven compared with hot air oven especially drying process. Drying methods between microwave oven and hot air oven did not give any significant differences of total curcuminoids and volatile oil contents. Plant breeding and harvesting time are in consideration to get high volatile oil contents. Microwave oven showed lower moisture content, total ash and reduced drying time. Boiled turmeric rhizomes showed less total ash but higher moisture content compared with unboiled samples. In this study showed that the quality of turmeric powder dried using a microwave oven met the standard criteria of WHO in comparison with drying in hot air oven. In addition, microwave oven had proved that it did not change turmeric quality compared with drying by hot air oven. It can be benefit for use in the mobile unit. Therefore, primary processing of plant raw materials would expedite herbal manufacturing in regional areas of Thailand.

7. Acknowledgements

This study was supported by College of Pharmacy, Rangsit University for laboratory facility. The authors sincerely appreciated Krisana Kraisintu Foundation for providing the modified microwave oven used in this research.

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