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RESEACRH ON MICROWAVE TREATMENT FOR FIXATION OF POLYPHENOL OXIDASE IN PROCESSING OOLONG TEA IN VIETNAM

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Abstract

This study was aimed to optimize a microwave treatment to fix enzymes after Oolong tea fermentation based on concentrations of tannin, total polyphenols and the remaining activity of PPO (polyphenol oxidase) enzyme. Three factors including power levels (540 - 720W), radiation time (160-195 sec) and sample loading density (0.026 - 0.078 g.cm-2) were considered for the optimization. Results showed that the optimal conditions were at power of 630W, radiation duration of 190 s and the sample loading density of 0.06 g.cm-2. At these conditions, dry matter of treated tea had 23.14% tannin, and 24.10% total polyphenols, and the remaining activity of PPO was at 11.19%. The concentrations of tannin of the samples treated by microwave were higher than those of the conventionally roasted sample (21.10%). Remained total polyphenols of the former were also higher and the remaining PPO activity was lower. The color of the microwave-treated sample was better whereas the flavor and taste were less preferred as compared to the conventional-treated tea. The results showed that microwave had high potential to inactivate enzymes in fermented tea. However, flavor and taste of the microwave-treated tea needs to be improved.

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Key words: enzyme inactivation, polyphenols, tannin, Oolong tea, microwave.

1. Introduction

Vietnam has suitable weather, soil and terrain for growing tea with high quality. FAO (2014) estimated that each year Viet Nam had exported about 130,000 tons of various tea products including Oolong tea, black tea, and green tea, etc. Among these products, Oolong tea has high economic value because it has distinctive flavor, color, and taste and many health benefits. The distinctive flavor, color, and taste are the results of many steps in the meticulous manufacturing steps such as withering, fermentation, inactivation enzyme and fixation, of which inactivation of enzymes is considered as one of the most important steps. The purpose of this step is to inactivate enzymes in order to stabilize the color and retain the highest polyphenol content. The method which is mostly used for enzyme inactivation in the processing of roasted Oolong tea. Although this method inactivates browning enzymes and also contributes to flavor development of the tea, it causes significant loss of nutritional value and the changes in the appearance of the product (Tenple et al., 2001; Zobia et al., 2007; Fredman et al., 2009). The review of Queiroz et al (2008) lists other methods to inactivate enzymes in making tea like using hydrostatic pressure, gamma radiation, pulse electric field, microwave treatment or Ohmic heating. These methods could effectively inactivate enzyme while remain the nutritional value for the product. However, almost all of the methods are not applied in industry yet because of the unexpected results in damaged appearance of the tea shoot and the unsatisfactory moisture of product. Researches of Kikueet al. (1996); Wang et al. (2013); Sato et al. (2007); Zee et al (2003) and Gulatiet al (2003) have shown that microwave technology has been reported to be a faster heating treatment, have higher enzyme inactivation capacity, with lower loss of nutritional components in green tea production. However, this technology has not been investigated for Oolong tea processing, and therefore, this study was aimed to investigate the use and optimization conditions of microwave treatment for inactivating PPO in processing of such the tea.

2. Materials and methods

2.1. Materials

The tea shoots of the Kim Tuyen cultivar were used. The tea leaves were subjected to Oolong tea processing pretreatment at (according to the process of) Cau Tre Export Goods Processing Joint Stock Company (Lam Dong province, Vietnam). Briefly, the tea shoots were withered under sunlight and fermented in a cooling room.The fermented tea leaves were then put into plastic boxes with holes (15x10 cm) and transported to the laboratory and preserved in a fridge for experiments within a week. Experiments were carried out in the period of November, 2013 to May, 2014.

2.2. Chemicals

Chemicals for analysis included methanol ($\geq$ 99.7%, Chemsol Co., Ltd., Vietnam), Na_2CO_3 $\geq$ 99.8%, Guangzhou Jinhuada chemical Reagent Co., Ltd., China), Folin-ciocteu (Merk Pty. Ltd., Germany), Catehol (Merk Pty. Ltd., Germany), $KMnO_4$ 0.1N (Lobochem Vietnam Co., Ltd., Vietnam), Indigocarmin (HiMedia Laboratories Pvt. Ltd., India), and $NaH_2PO_4.{}_2H_2O$ and $Na_2HPO_4.{}_{12}H_2O$ (Xilong chemical Co., Ltd., China).

2.3. Experimental design

A laboratory microwave oven (National dimension 4 Microwave stove, max power 900W, frequency 2450 MHz, Panasonic, China) was used for the treatment. Each treatment was carried out with 50 g of tea leaves being spread on a 35 cm diameter plate. Three independent variables X1 (power, W); X2 (time, second); X3 (sample loading density, g.cm-2) at three levels were considered for the optimization. After preliminary tests with varying microwave powers (90 - 900W), treatment time (60-210 sec) at sample loading density of 0.052 g.cm-2, the treatment at 630W for 180s and at sample loading density of 0.052 g.cm-2 were chosen as the central point (0). A responding surface methodology using Box BehnKen model with a central composite design consisted of 17 experimental runs including 12 factorial points and 5 central points was used (Table 1). The runs were carried out in a random order. After the treatment, concentrations of tannin (response Y_1, expressed as % on dry matter basis), total polyphenol content (TPC) (response Y_2, expressed as % on dry matter basis) and PPO enzyme activity (response Y_3, expressed as % remaining activity compared to that before the treatment) were determined. The correspondence between the coded and un-coded values can be obtained using the following formula (Eq.1):

$$x_i = \frac{X_i - X_i^0}{\Delta X_i} \qquad (Eq.1)$$

where x_i is coded value;

X_i is corresponding actual value;

X_j^0 is actual value in the center of domain;

ΔX_i is increment of X_i corresponding to 1 unit of X_i

Coded value of microwave power (x_1), treatment time (x_2) and surface density (x_3) are given by Eqs. (2) - (4):

$$x_1 = \frac{microwave\ power - 630}{90} \qquad (Eq.2)$$

$$x_2 = \frac{Time - 180}{15} \qquad (Eq.3)$$

$$x_3 = \frac{Surface\ density - 0.052}{0.026} \qquad (Eq.4)$$

A second-order polynomial equation to express the concentrations of tannin (Y_1), TPC (Y_2) and PPO activity as functions of the independent variables as follows (Eq.5):

$$Y_j = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_{11}x_1^2 + a_{22}x_2^2 + a_{33}x_3^2 + a_{12}x_1x_2 + a_{13}x_1x_3 + a_{23}x_2x_3 \qquad (Eq.5)$$

Where Y_j represents the response variables, ao is constant, a_i, and a_{ij} are the linear, quadratic and interactive coefficients, respectively; x_i and x_j are the coded levels of the independent variables

Table 1. The coded and un-coded levels of three variables for the surface methodology design

Independent variables	Symbol		Factor level		
	Un-coded	coded	-1	0	1
Power (W) (X_1)	X_1	x_1	540	630	720
Time (second) (X_2)	X_2	x_2	165	180	195
Sample loading density ($g.cm^{-2}$) (X_3)	X_3	x_3	0,026	0,052	0,078

The design was aimed to find regression models and optimal conditions of treatment where total polyphenols and concentrations of tannin were at the highest and PPO remaining activity was at the lowest. After the regression models were established, validation was carried out by doing the treatment at the found optimized conditions and the real results were compared with those predicted by the models.

2.5. Analysis

Determination of polyphenol oxidase enzyme activity

In order to determine the polyphenol-oxidase activity, the modified method of Yakeln et al. (2001) and Shahriar et al. (2013) was used. Ten gram of the tea shoot was added with 60 mL sodium phosphate buffer (0.2 M, pH 7.0, 4^0C), continuously grinded (Happycook blender, VietNam) for 1 minute and then it was let stand for 6 hours at 4^0C. The homogenate was filtered through Whatman No. 42 paper under vacuum on a Buchner funnel. The mixture was centrifuged (Hethich - EBA8, French) at 6000 rpm for 20 minutes. Two replicates were performed for each analysis. The substrate was composed of 1 mL catehol (0.09M), 1.8 mL phosphate buffered solution (0.2 M, pH 7.0) and 0.2 mL enzyme PPO solution, then incubated at 35^0C. The spectral absorption

at 420 nm was determined using a spectrophotometer (Spectrometer UV - 2502, LaboMed, USA). The optical density change with time was recorded during 40 minutes for intervals of 10 minute. One catechol unit (U) is defined as the amount of enzyme that oxidizes 1μmol catechol per a minute at 25^0C and pH 7.0 under the conditions described previously. The enzymatic activities were calculated according to Beer-Lambert Law, as described in Equation (6).

$$\text{Enzymatic activity } (U) = \frac{slope * 10^6 * v * df}{\epsilon * V} \qquad (Eq.6)$$

where: - Catechol molar extinction coefficient since polyphenol oxidase activity is 3450 ($M^{-1}.cm^{-1}$) at 420 nm (Waite, 1976).

v- volume of reaction mixture

V- volume of sample

Determination of total polyphenol content (TPC)

The total polyphenol content was determined according to ISO method 14502-1:2005. Tea sample (about 0.2 $\pm$ 0.001 g) was grinded, then added with 5 mL of methanol 70% and mixed well by using a Vortex mixer for 5 and 10 min . The mixture was centrifuged at 3500 rpm for 10 min and the supernatant was collected. The pellet was extracted again for the second time and the second supernatant was pooled with the first one to obtain the extraction solution. One milliliter of this solution was added with 5 mL of Folin-ciocalteu 10% and, after 5 min, with 4 mL of Na_2CO_3 7.5%. It was allowed to stand at room temperature in the dark for 60 min, and then measured the optical densities in 10 - mm path length cells against water on the spectrophotometer (Spectrometer UV - 2502, LaboMed, USA) set at 765 nm. The blank sample was prepared similarly with distilled water instead of the extraction solution.

Determination of concentration of tannin

The Lowenthal technique, which has been adopted as a tentative method by the Association of Official Agricultural Chemists (A.O.A.C, 1975), was used. A tea sample (about 2 g) was grinded, added with 100 mL of boiling water, and placed into a boiling water bath for 30 min. The mixture was filtered to collect the solution. The deposit was extracted again similarly for several times. The solutions of all the extraction steps were pooled together and added with distilled water up to 250 mL. Ten milliliters of this solution was added with 75 mL distilled water and 25mL indigo-carmine 0.1%. The obtained solution was titrated using $KMnO_4$ 0.1N until yellow color appeared. The blank sample was analyzed similarly but with distilled water instead of the extraction solution

Assessment of sensory quality of fermented tea after enzyme inactivation.

Oolong tea (3 g) was infused with 100 ml of water at 100 C for 5 min in a tea taster's cup and filtered before the evaluation. Sensory evaluation

was conducted according to standard method 10 TCN 839:2006 and TCVN 3218:2008. The panel consisted of 12 people. Attributes including taste, flavor, color, and appearance were given a score according to a 5-point scale. The levels of importance of the attributes were assigned as weight coefficients (Table 2). The general quality score of a sample was calculated by equation (Eq7):

$$D = \sum_{i=1}^{4} D_i k_i \qquad (Eq.7)$$

In which, D_i is the average score given to attribute i by the panelists and k_1 is the weight coefficient of the attribute.

Tea samples for sensorial evaluation were the fermented tea treated with microwave at the optimized conditions and the fermented tea roasted conventionally to inactivate enzymes obtained from Cau Tre Company.

Table 2. The weight coefficients representing importance of the attributes

	Weight coefficients	
Value	**percent**	**values**
1. Appearance	25	1,0
2. Tea infusion color	15	0,6
3. Flavor	30	1,2
5 Taste	30	1,2

Determination of moisture content The moisture content of the samples was gravimetrically analyzed using an AND MX-50 moisture analyzer (A&D company, Ltd., Tokyo, Japan) 2.6 Statistical analysis Both the experiment design and analysis of data were carried out using JMP software version 9.0.2 (SAS Institute Inc., 2011, USA) and Microsoft Excel 2007 (Microsoft corp., 2007, USA). The difference was considered significant when p values were $<$ 0.05.

3 Results and discussion

3.1 Optimization of microwave treatment for inactivation of PPO enzymes

The results of the three responses according to varying input variables are given in Table 3.

It can be seen from Table 4 that the co-efficient of determination (R2) for three models were all above 0.95. This means that the models explained well the experimental data. For each model (response), p values of each regression coefficient can indicate if that coefficient was relevant for the model. A p value

Table 3. Experimental design and the results of the responses

Exp. run[a]	Coded and non-coded Variable Level			Response		
	X_1 (W)	X_2 (s)	X_3 (g/cm^2)	Y_1 (% on dry matter basis)	Y_2 (% on dry matter basis)	Y_3 (% remaining activity)
1	(- 1) 540	(-1) 165	(0) 0.052	19.27	21.24	17.32
2	(-1) 540	(+1) 195	(0) 0.052	21.40	22.29	15.17
3	(+1)720	(-1) 165	(0) 0.052	21.93	23.42	13.54
4	(+1) 720	(+1) 195	(0) 0.052	21.47	22.65	7.03
5	(0) 630	(-1) 165	(-1) 0.026	19.11	21.31	10.56
6	(0) 630	(-1) 165	(+1) 0.078	19.27	19.74	20.59
7	(0)630	(+1) 195	(-1) 0.026	18.17	18.51	8.87
8	(0) 630	(+1) 195	(+1) 0.078	22.46	23.51	14.33
9	(-1) 540	(0) 180	(-1) 0.026	21.14	21.98	15.75
10	(+1) 720	(0) 180	(-1) 0.026	16.78	18.01	44.77
11	(-1) 540	(0) 180	(+1) 0.078	18.64	17.42	20.28
12	(+1) 720	(0) 180	(+1) 0.078	22.70	23.79	14.79
13	(0) 630	(0) 180	(0) 0.052	22.31	23.26	11.30
14	(0) 630	(0) 180	(0) 0.052	22.43	22.81	10.60
15	(0) 630	(0) 180	(0) 0.052	22.88	23.38	99.97
16	(0) 630	(0) 180	(0) 0.052	22.63	23.42	10.12
17	(0) 630	(0) 180	(0) 0.052	22.47	23.50	10.10

of higher than 0.05 indicates that coefficient was not relevant and can be omitted in the model equation. From the p values of model coefficients, it could be concluded that all the independent variables (X_1, X_2, X_3) and three quadratic terms (X_1^2, X_2^2, X_3^2) significantly affected the concentrations of tannin, TPC and PPO enzyme remaining activity ($p < 0.05$). However, the tannin concentrations were not influenced by the linear coefficient of power (p of $a_1 = 0.11$). The TPC was not by both linear (p of $a_2 = 0.28$) and quadratic (p of $a_{22} = 0.30$) coefficients of treatment time. The analysis showed there were significant interactions between power and time, power and sample loading density, and time and sample loading density for all three responses (Table 4). The results of the study also showed that the power and time were the most significant parameters influencing tannin concentrations. In contract, for TPC, power and simple loading density were the most important parameters ($p < 0.0001$).

Based on the data in Table 4, the models for the three responses were selected as followings:

$Y_1 = 22.54 + 0.49.x_2 + 0.98.x_3 - 0.66.x_1.x_2 + 2.10.x_1.x_3 + 1.03.x_2.x_3 - 0.73.x_1^2 - 0.80.x_2^2 - 2.00.x_3^2$

$Y_2 = 23.28 + 0.61.x_1 + 0.58.x_3 - 0.46.x_1.x_2 + 2.59.x_1.x_3 + 1.64.x_2.x_3 - 0.67.x_2^2 - 2.31.x_3^2$

$Y_3 = 10.42 - 3.55.x_1 - 2.07.x_2 + 3.75.x_3 - 1.09.x_1.x_2 + 1.37.x_1.x_3 - 1.14.x_2.x_3 + 1.58.x_1^2 + 1.27.x_2^2 + 1.90.x_3^2$ In which: Y_1, Y_2, and Y_3 were concentrations of tannin (% on dry matter basis), TPC (% on dry matter basis), and PPO enzyme

Table 4. Regression coefficients of the fitted quadratic equations and standard errors for tannin concentrations, and total polyphenol content and PPO enzyme activity

Regression cofficients	Response					
	Tannin (Y_1)		Total polyphenol content (Y_2)		PPO activity (Y_3)	
	Regression cofficients	P value	Regression cofficients	P value	Regression cofficients	P value
a^o	22.54	< 0.001*	23.28	< 0.001*	10.42	< 0.001*
Linear						
a_1	0.30	0.11	0.61	0.0024*	-3.55	< 0.001*
a_2	0.49	0.0209*	0.15	0.28	-2.07	< 0.001*
a_3	0.98	0.0005*	0.58	0.0032*	3.76	0.0001*
Interaction						
a_{12}.	-0.65	0.0272*	-0.46	0.0457*	-1.09	< 0.001*
a_{13}	2.10	< 0.001*	2.59	< 0.001*	1.37	0.0082*
a_{23}	1.03	0.0030*	1.64	< 0.001*	-1.14	0.0189*
Quadratic						
a_{11}	-0.73	0.0144*	-0.67	0.0079*	1.58	0.0035*
a_{22}	-0.80	0.0098*	-0.20	0.30	1.27	0.0105*
a_{33}	-2.00	< 0.001*	-2.31	< 0.001*	1.90	0.0013*
Coefficient						
R^2	0.97		0.99		0.99	
R^2_{Adj}	0,94		0,97		0,97	

(Notes: "" Significant at $p < 0,05$)*

activity (% remaining activity). x_i are the coded independent variables.

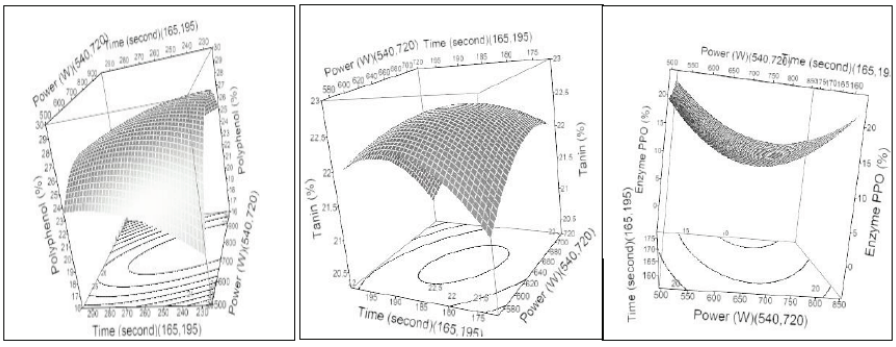
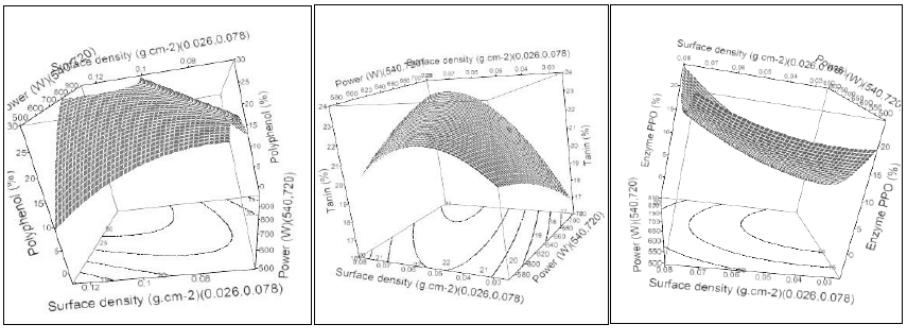


Figure 1. The impact of time and powers at sample loading density of 0.052 (g.cm^{-2}) on (a) concentrations of tannin (% on dry matter basis), (b) the total polyphenol content (% on dry matter basis), and (c) PPO enzyme activity (% remaining activity).

Response surfaces showed in Figure 1, 2 and 3 could predict the influence of 3 microwave parameters on the concentrations of tannin, the total polyphenol content and enzyme activity. Figure 1 describes the effects of treatment time and powers at the density 0,052 g.cm^{-2} to tanin concentrations, TPC and PPO activity. Figure 1a shows that when time increased up to 195s and power at 700W the TPC and tanin concentrations increased while PPO activity de-

creased. PPO activity also decreased when the time continued increasing over 195s and the power over 700W but tanin concentration and total polyphenols remained the same. This result can be explained as the destruction of tannin and polyphenols caused by the time that the tea was exposured to microwave for too long at the high power which produced high intensity of waves which increased temperatures inside the tea to a very high value. These results were consistent with the studies of Ashu et al (2003) when applying microwave to dry green tea, where power levels of 270 W, 540 W, 810 W, 1080 W and 1350 W affected activity of PPO enzyme and total polyphenols. They reported that at 1080 W, the enzyme was no longer active and TPC and catechins was 12.76% and 12.18%, respectively. At power of 1350 W, total polyphenols was 12.76% and catechins 12.19% (were not significantly different from the values at 1080 W) (Ashu et al., 2003) . Similar results could be also found in the study of Gulati et al (2003).



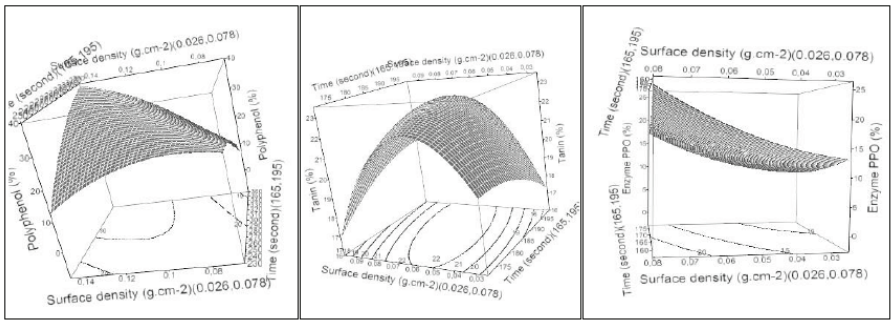
(a) (b) (c)

Figure 2. *The effects of sample loading density and powers at treatment time of 3 min on (a) concentrations of tannin (% on dry matter basis), (b) the total polyphenol content (% on dry matter basis), and (c) PPO activity (% remaining activity).*

Similarly, Figure 2 showed the effects of powers and sample loading density when the treatment time was at 180s. TPC and concentrations of tannin increased with increasing powers when they were lower than 700 W with the loading density lower than 0.078 g.cm^{-2}. Whereas PPO activity decreased to 5%. The reverse results were observed when powers were applied at over 700 W and the density higher than 0.078 g.cm^{-2}; the TPC and concentrations of tannin decreased but PPO remaining activity increased.

In Figure 3, it was observed that TPC and concentrations of tannin significantly increased with increasing treatment time up to 195s and sample loading density 0.078 g.cm^{-2} were increased at power with 630 W. When the treatment time and sample loading density were above a certain value, TPC, concentrations of tannin and PPO remaining activity were reduced.

In this study, the aim of optimization was to find the conditions which gave



(a) (b) (c)

Figure 3. *Effects of sample loading density and treatment time at power of 630W on (a) concentrations of tannin (% on dry matter basis), (b) the total polyphenol content (% on dry matter basis), and (c) PPO enzyme activity (% remaining activity).*

the maximum of tannin, polyphenol content and the minimum of PPO remaining activity. By solving the regression equations and analyzing the response surface plots, the optimum conditions were at power of 700W, time of 188.7s and sample loading density of 0.06 g.cm-2. At these conditions, the predicted values of the three responses were referred (Table 5).

Table 5. *The optimally predicted and validated values of the concentrations of tannin, total polyphenol content, and enzyme PPO activity.*

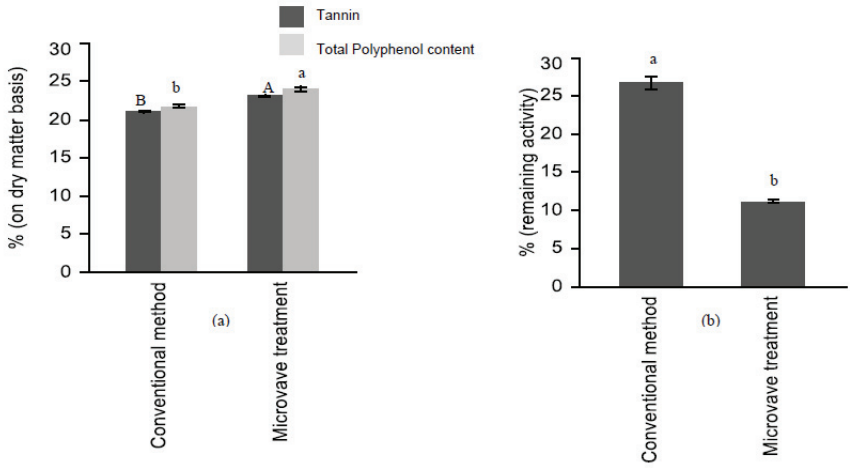
	Response		
	Tannin (% on dry matter basis)	**TPC (% on dry matter basis)**	**PPO activity (% remaining activity)**
Measured value	23.16 ± 0.62 [a]	24.32 ± 0.50 [a]	9.86 ± 1.01[a]
Practical value	23.14 ± 0.12[a]	24.10 ± 0.31[a]	11.19 ± 0.22[a]

Notes: "a" in the same columns express that it was not significant different (p>0.05).

Table 5 showed that the predicted and the validated values were not significantly different ($p > 0.05$). The optimal conditions were at power of 630W, time of 190s and sample loading density of 0.06 g.cm^{-2}. Moisture content of tea leaves after microwave treatment at the optimized conditions was 31.25%. This was in the range of moisture of fermented tea treated by conventional method (30 to 40%). The optimal treatment was only exactly when the moisture content of the tea shoots from 60 to 70%.

The concentrations of tannin and TPC of samples treated by microwave were higher than those of sample treated by conventional roasting method (Figure 3a). Whereas, the PPO remaining activity of the microwaved sample was lower than that of the sample treated by the conventional method (Figure 3b).

The TPC was 24.10% (on dry matter basis) for the microwaved sample and



Notes: "A, B, a, b": the different at significant level ($p<0.05$)

***Figure 4**. Difference in total polyphenol content, concentrations of tannin, and PPO remaining activity between fermented tea treated by microwave and that treated by conventional roasting method.*

21.79% for the conventionally roasted sample. In the same trend, the tannin concentrations of the microwaved sample was significantly higher than that of the conventional sample (23.14%, on dry matter basis, vs. 21.79%). Lin et al. (2010) and Wang et al. (2013) observed that green tea dried by microwave had higher total polyphenols compared to green tea dried by hot-air. Similarly, Baruah et al. (2012) reported that the antioxidant activity of microwave-dried green tea was higher than that of hot-air-dried green tea ($90.07 > 85.62$).

Our results also showed a huge difference in PPO enzyme activity between the two ways of treatments (Figure 4b). When the fermented tea was roasted, 27.6% PPO activity remained whereas when the tea was microwaved at the optimized conditions, only 11.19% of PPO activity remained ($p < 0.05$). The sensorial quality scores of the two kinds of samples are showed in Table 6.

Table 6. The quality score of the sample by microwave and conventional method (n = 12)

Attributes / Methods	appearance	flavor	Taste	Tea infusion color	Quality score
Microwaved sample	4.63±0.31[a]	3.15±0.43[b]	3.4±0.36[b]	2.00±0.39[b]	13.18±0.88[b]
Conventionally roasted sample	2.83±0.83[b]	5.2±0.39[a]	4.75±0.54[a]	2.35±0.42a	15.13±0.79[a]

Note: the data are the average of 12 panelists, which had been already multiplied with weight coefficients. Values in the same row do not have a common superscript differ significantly ($p <0.05$)

According to TCVN 3218:2008, tea sample was treated by microwave obtained a score of 13.83 and conventional a score of 15.13. The difference was

significant. According to the evaluation method criteria, these tea samples were classified as average in quality. Microwaved tea had significant lower scores of taste and flavor compared to those of roasted tea processed at Cau Tre Company. For appearance, the tea treated with microwave method had higher score than that treated using conventional roasting method. This result was consistent with result of Lin et al. (2010) and Wang et al. (2013). When they dried green tea by vacuum of microwave , the appearance was lighter than that dried with hot-air drying. Kikue et al (1996) compared hot- air drying and microwave in combination with hot- air drying to reduce the moisture content from 3 to 5% . The microwave treatment suppressed remarkably the formation of pyrazines, pyrroles and furan compounds which were well known as the typical thermally generated compounds and were responsible for roasted flavor. Similarly, Schiffmann (1994) reviewed different factors of microwave treatment to affect to flavor. He showed that, the time to do microwave treatment was too short, therefore it was not enough for Mallard reaction. Besides that, the enzymes were inactivated immediately, so polyphenols, glucid and proteins were kept the best. Because there was not enough time for them to react together. Yeo and Shibamoto. (1991) found that volatile substances were formed by microwave treatment and conventional method was heated at the same level. All most of volatile compounds were appeared in conventional samples. Therefore, the oolong tea leaves by microwave had refreshing flavor and low astringency

4. Conclusions

The result showed that the optimal conditions for inactivation enzyme by microwave were at power of 630W, treatment time of 190s at sample loading density of 0.06 g.cm^{-2}. The concentrations of tannin and total polyphenol content of tea samples treated by microwave were higher than those of tea treated by conventional roasting method (23.14%, 24.10%; 21.10, 21.79%). The former method also inactivated better PPO activity. However, sensorial quality in term of taste and flavor of tea sample treated by microwave was lower than that of tea samples treated by conventional roasting.

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