International Journal of Science, Environment and Technology, Vol. 5, No 4, 2016, 2062 – 2070

ISSN 2278-3687 (O)
2277-663X (P)

EFFECT OF MICROWAVE TREATMENT ON COLOUR OF TURMERIC (*Curcuma longa L.*)

Monisha S, Niveditha A, Pavithra D, Chidanand D V, Sunil C K and Ashish Rawson
Indian Institute of Crop Processing Technology, Thanjavur, India
E-mail: sunil.ck@iicpt.edu.in

Abstract: Turmeric is one of the most extensively used spices and coloring agents in Asian cuisine, especially in the Indian subcontinent. The most valued constituent of turmeric is yellow pigment i.e., curcumin. Drying and its conditions significantly influences the level of curcuminoid pigments in the rhizomes and there by the color of the sample material. Hence, the present study investigated the color quality of turmeric following microwave heating as a pretreatment. Selected turmeric rhizomes was treated with microwave assisted boiling at different power levels i.e., 20%, 40%, 60%, 80% & 100% and for different time periods i.e., 24, 48, 72, 96 & 120s using domestic microwave oven of 900 W. It was observed that microwave heating as a pretreatment significantly affected the color of turmeric. The optimal conditions with a condition of minimal change in *L*, *a*, *b* and ΔE* values obtained by Design expert software was Microwave power level of 368.88 W and Exposure time of 45.68 s. The higher retention of color in the turmeric treated by microwave may be attributed to the uniform and quick heating of the sample compared to the conventional water immersion heating.
Keywords: Microwave, Power level, Exposure time, Curcumin, Colour.

INTRODUCTION

Turmeric is the dried rhizome of Curcuma longa L. plant of family, Zingiberaceae. It is also known as haldi, gelbwurzel, safren des Indes, cúrcuma, açafrão, yellow or golden ginger (Govindarajan, 1980). The turmeric is used widely as spice and colouring agent in South and Southeast Asian cusine, widely in the Indian subcontinent. And also it is used for the treatment of biliary disorders, anorexia, coryza, cough, diabetic wounds, hepatic disorders, rheumatism and sinusitis in India (Ammon et al., 1992).

Turmeric contains major phenolic compounds such as curcuminoids, which include curcumin (diferuloyl methane), demethoxycurcumin, and bisdemethoxycurcumin (Revathy et al., 2011). The phenolic compound responsible for the yellow colour is Curcumin (diferuloylmethane) (3–4%) and it comprises of curcumin I (94%), curcumin II (6%) and curcumin III (0.3%) (Ruby et al., 1995). Turmeric contains an average of 6% curcuminoid pigments and 5% essential oils (Bambirra *et al.*, 2002). The turmeric trade is based on the

*Received June 15, 2016 * Published Aug 2, 2016 * www.ijset.net*

appearance, weight and other quality parameters. The colour of the turmeric (yellow) is the main quality parameter to be considered (Janaki and Bose, 1967). So, to retain the turmeric colour or to improve the colour is very important for the quality. In India, the common practice followed for colour retention or improvement, is to boil the rhizomes in water/alkaline water before dehydration. After boiling the rhizomes are dried, which influences the color of rhizomes (Sampathu et al., 1988).

The microwave energy has gained popularity and is widely being applied in food industry for different processes such as for cooking, thawing, tempering, drying, freeze-drying, sterilization, baking, heating and re-heating (Cui et al., 2004)**.** The different advantages of microwave heating over conventional heating such as speed of operation, energy savings, precise process controls and faster start-up and shut-down times has resulted in wider application in all the fields of food (Kidmose and Martens, 1999)**.** The other advantages of microwave are like reduction in leaching effect on nutrients and reduction of waste water generation.

This study is conducted to study the effect of the microwave treatment on the colour quality of the turmeric.

MATERIALS AND METHODS

Material: Fresh sample of Turmeric (Salem variety) was procured from a farmer in Salem. The roots in the sample were trimmed and were washed to remove the soil adhering to it and they were in a cold room. The uniform sized and shape rhizomes were selected for the experiment based on their general appearance, size and physical form.

Microwave oven: A domestic microwave oven (Model: IFB 30SC2) was used to conduct the experiment. The microwave oven had an operation frequency of 2,450MHz and a maximum power input of 1,400 W. The rated power output from the microwave oven is 900W corresponding to 100% power level and has a facility to be used at 10 to100 % power level (at an interval of 10%).

Methodology: The cleaned and washed samples (as a whole rhizome) were treated with microwave using a domestic microwave oven. The samples were treated at different power levels of 20 %, 40 %, 60 %, 80 % & 100 % (180, 360, 540, 720 and 900 W respectively) for five different exposure levels of 24, 48, 72, 96 and 120 seconds. The weight of the sample before and after treatment was noted using an electronic weighing balance.

Colorimeter: The Hunters Lab's colorimeter (Model: Color Flex EZ) which measures color to its highest level 45°/0° design was used for its ultimate preciseness in color measurement. The results were expressed in L*, a*, b*scale.

Methodology: The rhizome after treatment was cut into round pieces of equal thickness. The Hunter lab was standardized using black port and the white port. The samples were then equally spaced in the sample box fully covering the bottom. The L*, a* and b* values of the treated and control samples (untreated) were recorded on triplicate using a CIE L*, a*, b* uniform color space, where L* indicates lightness, a* indicates chromaticity on a green (-) to red (+) axis and b* indicates chromaticity on a blue (-) to yellow (+) axis. The control sample values are denoted as L_0*, a_0* and b_0*.

Total colour difference (ΔE*): Total color difference (ΔE*) was calculated using the following formula (Francis and Clydesdale 1975):

$$\Delta E^* = ((L_0^*-L^*)^2 + (a_0^* - a^*)^2 + (b_0^* - b^*)^2)^{1/2}$$

Where, L_0^*, a_0^*, b_0^* are the color values of the control samples. It has been reported that a casual viewer can notice a difference between two colours only when $\Delta E^* > 2\text{-}3.5$ (Krapfenbauer *et al.*, 2006). A colour difference of $\Delta E > 3.5$ would not be normally accepted as the colour change is apparent for the consumers.

Statistical analysis: All the experiments were carried out in triplicates. The significance of the different variables was analyzed using analysis of variance (ANOVA). The analysis of variance was done at 95 % confidence interval (N > 0.05). All the analysis was done using Design Expert 6.0.8 (Stat-Ease Inc., USA).

RESULTS AND DISCUSSION

Weight loss: The weight loss of the turmeric samples subjected to different microwave treatments (power level, W and exposure time, s) is shown in table 1. It was observed that with the increase in the microwave power and exposure time, the weight loss of the samples increased. At 180 W, as the exposure time was increased from 24 to 120 s, the weight loss increased from 0.03 to 0.10 g. The weight loss for different treatments ranged from 0.03g (180 W, 24 s) to 5.42 g (900 W, 120 s). The analysis of variance was conducted for the effect of the microwave power and exposure time on the weight loss indicating indicated that the model is statistically significant at 1 %. Both the microwave power and exposure time affected the weight loss significantly ($p < 0.0001$). The exposure time was more significant followed by the microwave power level. The interactions of these, variables were also significant ($p < 0.0500$). The model values are represented as response surface curve (Fig 1).

The loss in weight was modeled as a function of microwave power level and exposure time by response surface quadratic model using Design Expert. The effect is best represented by a second order polynomial equation shown below.

Weight loss = 0.64 + 1.12 * A+1.23 * B+0.31 * A^2+0.61* B^2+1.23*A*B

(R^2=0.8377)

Where A= Microwave Power Level and B=Exposure Time.

The actual values were close to the estimated values, which is evident from the close to unity slope (0.9542) and high R^2 (0.8963) of the straight line fitted between the actual and estimated values.

Colour: The L, a^* and b^* values of the control sample was 47.18, 33.52 and 64.23 respectively. The colour values (L, a^*, b^* and ΔE^*) for different treatments of microwave power and exposure time is presented in table 1. To study the effect of the microwave power and exposure time on colour of the turmeric, the analysis of variance was done using Design expert.

L value: The L value indicates darkness and lightness. The average L value for different microwave power level increased in all the power levels except in 360 W power level irrespective of the exposure time. The maximum average increase in the L value when compared to control value of L was observed in 180 W, followed by 720, 940 and 540 w power levels. The microwave power level had significant effect on the L values (@ $p < 0.0500$).

a^* value: The a value decreased in all the microwave power levels at different exposure times. The recorded a^* values were lesser than the control sample a value. The average value of a^*decreased in all the power levels irrespective of the exposure time. The lowest reduction in a^* value was observed in 720 W power level treatment. The highest average change (reduction) in a value was observed in 360 W treatments. The microwave level had significant effect and exposure time did not have any significant effect on a^* value (@ $p < 0.0500$).

b^* value: The b^* value decreased with different microwave power level treatments and exposure times. The maximum reduction in average value of b^* was in 360 W treatments. The lowest reduction in b^* value was observed in 180 W treatments. The b^* value indicates the yellowness, if reduction in b^* value, disappearance of yellow colour. The microwave power levels and exposure times did not have any significant effect on the b^* value, which is desirable (@ $p < 0.0500$).

Total Colour difference (ΔE*): The total colour difference was ranging from 5.1329 to 15.8027. The highest change in colour was recorded for 360 w and 120s treatment. The lowest value of 5.1329 was observed in 720 W and 72 s treatment. The total colour difference increased with increase in the exposure time in all the power levels. The total colour difference was easily identifiable, as the values are greater than 3.5, which is apparent for the consumer. The highest average value of ΔE* was observed in 360 W treatments, followed by 540, 900, 180 and 720 W treatments.

The change in colour or total colour difference ΔE* was plotted as a function of microwave power and exposure time (Fig 2d). The analysis of variance was conducted for the effect of the microwave power and exposure time on total colour difference. The analysis of the variance of the model indicated that the model is statistically significant. The microwave power had significant effect on the total colour difference (@ $p < 0.0500$). Exposure time was non significant on the total colour difference of turmeric.

The total colour difference was modeled as a function of microwave power level and exposure time by response surface cubic model using Design Expert. The effect is represented by a third order polynomial shown below;

$$\text{Colour Difference} = 8.96-6.72*A+1.53*B-1.82*A^2+1.02*B^2-0.38*A*B+7.94*A^3+0.24*B^3+0.12*A^2*B-0.96*A*B^2$$

(R^2=0.1783), Where A= Microwave Power Level and B=Exposure Time.

The actual values were close to the estimated values, which is evident from the close to unity slope (0.8707) and R^2 (0.6955) of the straight line fitted between the actual and estimated values.

Model optimization

The General Factorial Design optimization demonstrated that the optimum treatment for minimizing the microwave power level & treatment time and to minimize the weight loss and colour change following microwave treatment of rhizome were conducted. The optimal conditions with a condition of minimal change in L, a, b and ΔE* values were Microwave power level of 368.88 W and Exposure time of 45.68 s. Moreover the predicted values at optimal condition were in close agreement with experimental values. In addition, variations with predicted and experimental values were within acceptable error range as depicted by average mean deviation E %; therefore, the predicted performance of the established model may be acceptable.

CONCLUSION

The different microwave power level applied at different exposure time had effect on the colour of turmeric. The L value was increased, a^* value decreased and the b^* value also decreased. The desirable value for turmeric is b^* value which indicates the yellowness. The effect of microwave power level and exposure time on the yellowness (b^*) was non-significant, which is a desirable observation. The L value increased resulting in increase in the lightness, whereas a^* value decreased which was also non-significant. The overall colour difference compared to control, was increasing with increase in the exposure level and the maximum colour change was observed in 360 W treatments. The conditions were optimized using the design expert software. The optimal conditions with a condition of minimal change in L, a, b and ΔE^* values were Microwave power level of 368.88 W and Exposure time of 45.68 s. So, it can be concluded that microwave treatment is an effective treatment in maintaining the colour during processing of turmeric. And Factorial design is a useful tool for predicting the optimized conditions with very low error.

REFERENCES

[1] Ammon, H.P.T., Anazodo, M.I., Safayhi, H., Dhawan, B.N. and Srimal, R.C. 1992. Curcumin: a potent inhibitor of leukotriene B4 formation in rat peritoneal polymorphonuclear neutrophils (PMNL). *Planta Med.*, 58:26.

[2] Bambirra, M.L.A., Junqueira, R.G., and Gloria, M.B.A. 2002. Influence of post harvest processing conditions on yield and quality of ground Turmeric (*Curcuma longa* L.). Brazilian Archives of Biology and Technology, 45 (4): 423 – 429.

[3] Cui Z.W., Xu S.Y., and Sun D.W. 2004. Microwave–vacuum drying kinetics of carrot slices, Journal of Food Engineering, 65: 157–164.

[4] Francis, F.J., and Clydesdale, F.H. 1975. Food colorimetry theory and applications. Avi Publishing, Westport, pp 131–224

[5] Govindarajan, V.S. 1980. Turmeric-chemistry, technology and quality. *CRC Critical Reviews Food Science and Nutrition*, 12(3):199-301.

[6] Janaki, N., and Bose, J.L. 1967. An improved method for isolation of curcumin from turmeric, *Curcuma longa* L. J. Indian Chem. Soc., 44:985

[7] Kidmose, U. and Martens, H.J. 1999. `Changes in texture, microstructure and nutritional quality of carrot slices during blanching and freezing. J. Sci. Food Agric., 79:1747-1753.

[8] Krapfenbauer, G., Kinner, M., Gossinger, M., Schonlechner, R., and Berghofer, E. 2006. Effect of thermal treatment on the quality of cloudy apple juice. J. Agric. Food Chem., 54:5453–5460

[9] Revathy, S., Elunmalai, S., Benny, M., and Antony, B. 2011. Isolation, Purification and Identification of Curcuminoids from turmeric (*Curcuma longa* L.) by Column Chromatography. Journal of Experimental Sciences 2(7): 21-25.

[10] Ruby, A.J., Kuttan, G., Dinesh Babu, K., Rajasekharan, K. N. and Kuttan, R.1995. Anti-tumor and antioxidant activity of natural curcuminoids. *Cancer Lett*., 94:79–83.

[11] Sampathu, S.R., Krishnamurthy, N., Sowbagya, H.B. and Shankarana-Rayanan, M.L. 1988. Studies on quality of (*Curcuma longa*) in relation to curing methods. Journal of Food Science and Technology, 25 (3):152-155.

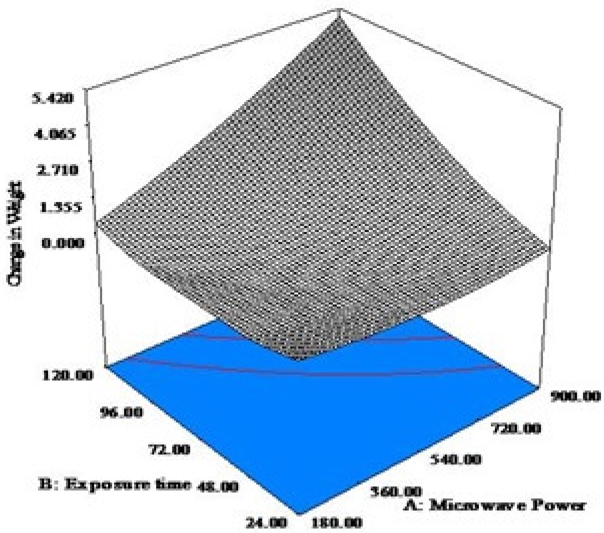
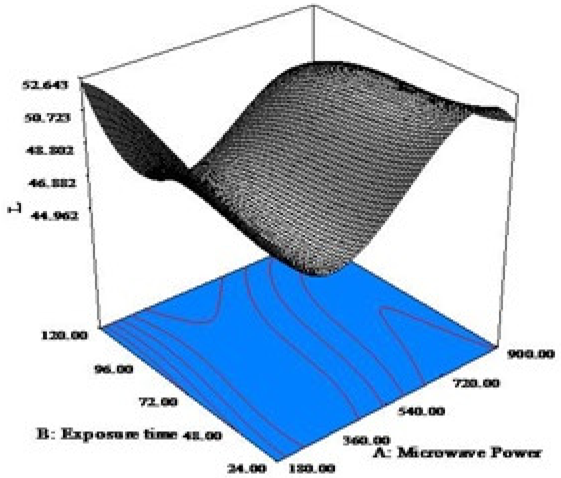
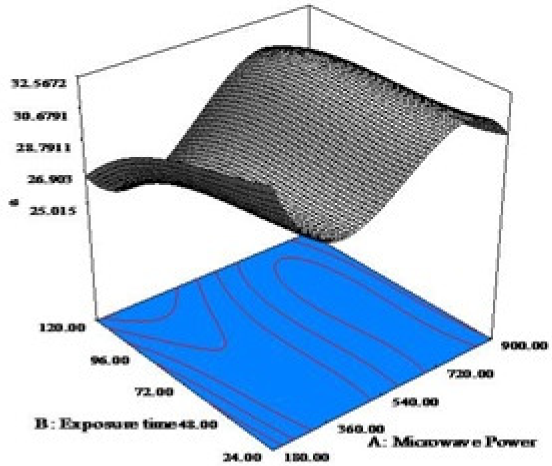


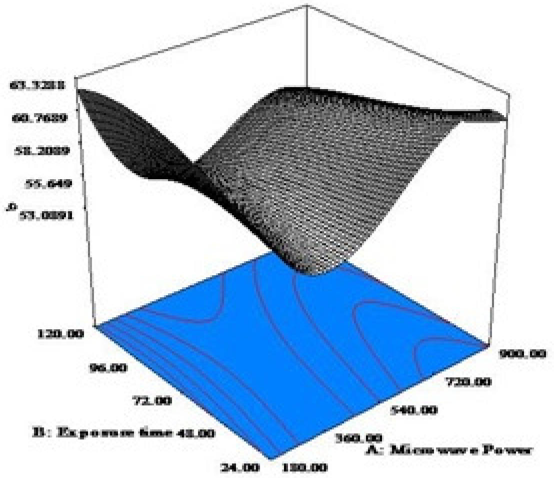
Fig 1. Response surface plot for weight loss (g) of turmeric with different microwave power (w) and exposure times (s)



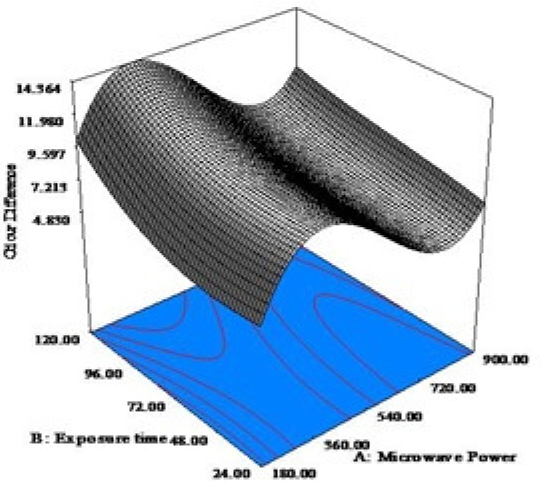
a. L values



b. a values



c. b values



d. Total Colour difference

Fig 2. Response surface plot for L, a, b and ΔE* values of turmeric with different microwave power (w) and exposure times (s)

Table 1. Weight changes and colour values of turmeric treated with microwave

MICROWAVE POWER (W)	TIME (s)	CHANGE IN WEIGHT (g)	L	a*	b*	ΔE*
Control	**-**	-	47.180	33.520	64.230	-
180 W (20 %)	**24**	0.03	50.215	32.885	59.445	5.7018
	48	0.03	47.500	31.800	58.850	5.6573
	72	0.10	52.310	31.895	64.260	5.3813
	96	0.05	52.720	26.385	62.070	9.2879
	120	0.10	53.620	27.850	64.82	8.6006
360 W (40 %)	**24**	0.12	45.615	26.385	54.140	12.4565
	48	0.18	52.045	28.205	62.900	7.3271
	72	0.29	46.880	29.485	56.540	8.6895
	96	0.54	43.925	27.680	52.430	13.5625
	120	1.20	44.060	24.845	51.395	15.8028
540 W (60 %)	**24**	0.11	51.240	31.185	61.670	5.3375
	48	0.59	46.615	28.310	54.910	10.6923
	72	0.57	47.085	27.205	54.215	11.8401
	96	2.00	48.040	29.485	56.760	8.5336
	120	3.34	45.360	28.940	53.995	11.3598
720 W (80 %)	**24**	0.15	50.205	32.155	59.410	5.8520
	48	0.40	49.685	30.635	58.275	7.0753
	72	0.71	51.795	33.695	61.990	5.1329
	96	0.69	51.370	33.060	60.620	5.5498
	120	3.38	50.205	28.860	58.260	8.1552
900 W (100 %)	**24**	0.10	52.745	29.965	63.745	6.6214
	48	1.18	49.370	29.865	57.955	7.5849
	72	2.19	51.805	28.950	59.900	7.8118
	96	3.91	49.005	28.680	56.065	9.6656
	120	5.42	47.945	28.935	54.980	10.3523