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A novel bleaching approach: Microwave assisted sunflower oil bleaching and optimization

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SUMMARY: The factors affecting the microwave bleaching of sunflower oil and the interaction between them were investigated and optimized by response surface methodology using a three-factor five-level central composite rotatable design. Microwave power, time and the amount of bleaching clay were selected as independent variables studied in the range of 70-120 W, 2-15 min, and 0.01-0.5%. The dependent variables that measure the bleaching efficiency and oil quality were evaluated as hue angle, chroma and totox value. Optimization was carried out by minimizing totox and chroma and maximizing hue angle. Hue angle, chroma and totox were found as 96.91, 37.66 and 23.31 under optimal conditions. Optimal microwave bleaching was successfully performed by using less bleaching clay (0.4%) and a shorter time (8 min) compared to the current industrial application without any adverse effect on oil quality. Hence, microwave bleaching is thought to be an alternative method for the bleaching of edible oils.

KEYWORDS: *Bleaching; Bleaching efficiency; Microwave; Optimization; Sunflower seed oil*

RESUMEN: ***Un enfoque novedoso de blanqueamiento: optimización del proceso asistido por microondas de aceite de girasol.*** Los factores que afectan al blanqueamiento asistido por microondas del aceite de girasol y la interacción entre ellos se investigaron y optimizaron mediante la metodología de superficie de respuesta utilizando un diseño central giratorio compuesto de tres factores y cinco niveles. La potencia del microondas, el tiempo y la cantidad de arcilla blanqueadora se seleccionaron como variables independientes estudiadas en el rango de 70-120 W, 2-15 min y 0,01-0,5%. Las variables dependientes que miden la eficiencia del blanqueamiento y la calidad del aceite se han evaluado como ángulo de tono, croma y valor totox. La optimización se llevó a cabo minimizando el totox y el croma y maximizando el ángulo de tono. El ángulo de tono, el croma y el totox se encontraron en 96,91, 37,66 y 23,31 en condiciones óptimas. El blanqueamiento por microondas óptimo se ha realizado con éxito utilizando arcilla blanqueadora más baja (0,4%) y un tiempo más corto (8 min). En comparación con la aplicación industrial actual sin ningún efecto adverso sobre la calidad del aceite. Por tanto, se cree que el blanqueamiento asistido por microondas es un método alternativo para blanquear los aceites comestibles.

PALABRAS CLAVE: *Aceite de semilla de girasol; Blanqueamiento; Eficacia de blanqueo; Mejoras; Microondas*

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1. INTRODUCTION

Bleaching is the most important step in the edible oil refining process and can be described as a process which is based on removing undesirable color pigments and other undesirable impurities from the neutralized oil by using a certain amount of bleaching earth or active carbon under the determined conditions. Generally, the bleaching process is carried out at temperatures between 90-120 °C, using clay 0.5-2.0%, in times from 20-30 minutes (Zschau, 2001). The quality of the bleached oil depends on the type of earth, dosage, bleaching time, mixing, bleaching temperature and pressure. The surface area of the earth is a critical feature in the bleaching process. Clays are activated by mineral acids in order to obtain better bleaching quality with increasing specific surface area. Clay with 40-60 m^2/g dry clay surface area originally, can be increased up to 200 m^2/g dry clay (Hymore, 1996). The bleaching process in today's edible oil industry is applied batch-wise with long process times and high temperatures by using large amounts of clay. The clay absorbs approximately 0.36 kg of oil/l kg of clay (Gupta, 2017). In the existing conventional method, the desired oil color quality is achieved by increasing the amount of clay, which leads to increasing oil losses and environmental problems. Therefore, the development of new bleaching methods to overcome the problems involved in the process is necessary for the vegetable oil industry.

The use of microwave has become very popular in various industrial applications over recent years. Microwave is used especially in the food industry to reduce process time and increase food quality. In the literature, microwave heating is described as a continued promising method among the other electric heating technologies such as radio frequency, ohmic, and infrared (Torrealba-Meléndez *et al.,* 2015; Zhang *et al.,* 2006). Specific heat is a very important factor in microwave heating (Meda *et al.,* 2017). In particular, materials with low specific heat can be heated rapidly when subjected to microwave. Vegetable oils have a lower specific heat than water so they may be heated by microwave faster than water of the same weight (Schiffmann, 2014). Microwave is preferred for the heating of edible oils because of the reduction in heating time, providing inner penetration and faster heating (Gjorgjevich *et al.,* 2012). Microwave also plays an important role in the sorption capacity of clays. Li *et al.,* 2007 showed that the sorption of cetylpyridinium chloride into bentonite was greatly influenced by microwave. The velocity constant of the sorption reaction was increased 107.6 times, and the free energy of the sorption reaction system was decreased.

There are vast numbers of studies on improving the bleaching process of oils. In all these studies, the type and amount of bleaching agent, mixing time, temperature and pressure are the parameters examined (Skevin *et al.,* 2012; Salawudeen *et al.,* 2014; Chew *et al.,* 2017; Mustafa and Abusabah, 2019; Boroujeni *et al.,* 2020.) by keeping the conventional heating method as the same. In only a few studies, new technologies such as ultrasound and high voltage electric field were used as alternative techniques to the conventional heating process (Su *et al.,* 2013; Abedi *et al.,* 2016; İçyer and Durak, 2018). Although there are a few studies (Boukerroui and Quali, 2002; Foletto *et al.,* 2013) in which the Brazilian bentonite activated by microwave treatment has been used in the bleaching of soybean oil in the literature, this current study is the first one in which the bleaching process has been applied directly with microwave treatment.

Therefore, the main purpose of this study was to evaluate the effect of microwave technology on the bleaching efficiency of sunflower seed oil and to optimize different parameters in the bleaching process, such as amount of bleaching earth, microwave power and process time, based on total oxidation value and color reduction in bleached sunflower oil.

2. MATERIAL AND METHODS

2.1. Materials and chemicals

The non-bleached sunflower oils used in this study were obtained from a local refinery. Sunflower oil samples were placed in dark bottles and stored at –18 °C until bleaching. Acid-activated (Suprefast M1FF) bleaching clay was also procured from same refinery (Gaziantep, Turkey). All chemicals and reagents used in this study were analytical grade and purchased from Sigma-Aldrich.

2.2. Experimental design

A three-level, five factorial central composite rotatable design (CCRD) was employed to analyze the effects of microwave assisted factors on the bleaching and to optimize the bleaching conditions to obtain maximum bleaching quality. The independent variables were selected as microwave power (A), amount of clay (B) and bleaching time (C). The levels of the independent variables were defined as between A, 70-120 W; B, 0.01-0.5% (w/w); C, 2-10 min. Preliminary experiments were carried out to obtain information about the independent variables and their levels prior to the experimental design. The employed CCRD was composed of 20 experiments consisting of 6 center points. At the end of optimization, verification of experiments was carried out under the optimal conditions and the average value for the experiments was compared to the predicted value.

2.3. Microwave-assisted bleaching

Microwave-assisted bleaching (MWB) treatments were performed using a microwave reactor (CEM, Discover SP). Bleaching was carried out in a 35-ml glass vessel. The vessel was not fully filled to avoid oil splash. 20 g sunflower oil were weighed into the vessels in all experiments. The bleaching earth was weighed for each vessel according to the amounts determined in the experimental design. After the addition of clay, the tube was sealed with a rubber lid (CEM) and placed in the microwave reactor. In all experiments, stirring speed mode was set on high. The mixing of clay and sunflower oil was carried out only in the reactor and during the bleaching period. The levels of microwave power and time were adjusted according to the experimental design. This microwave system consisted of an infrared sensor for temperature measurement. Therefore, temperature values varied depending on the microwave power reported during the experiment. At the end of the microwave treatment, the mixture of sunflower oil and clay was centrifuged (EBA 20, Hettich) at 6.000 rpm at 25 °C for 10 min. Sunflower oil was separated easily from the clay because of the clay sticking to the wall of the tube. The sunflower oils bleached by this way were stored in dark amber sample bottles at –18 °C until further analysis.

2.4. Determination of oxidation parameters

Peroxide value (PV) was determined according to AOCS standard method Cd 8–53 (AOCS, 1998). The p-anisidine value (AV) in sunflower oil was determined by the spectrophotometric (Optima, SP-3000nano, Japan) method as described in the AOCS Official Method Cd 18–90 (AOCS, 1998). PV and AV were converted to total oxidation value (Totox) according to Equation 1.

$$\text{Totox value} = 2\ \text{PV} + \text{AV} \qquad (1)$$

2.5. Color measurement

The color of the samples was determined by a HunterLab Colorflex colorimeter with standard illumination D_{65}, and colorimetric normal observer angle of 10°. Color values were evaluated as L*, a* and b*. Measured values L*, a* and b* were also converted to chroma and hue angle values given below in Equations 2 and 3, respectively.

$$\text{Chroma} = \sqrt{(a*)2 + (b*)2} \qquad (2)$$

$$\text{Hue angle} = \tan^{-1} (b*/a*) \qquad (3)$$

2.6. Statistical analysis

The experimental design and statistical analysis were conducted using Design Expert version 7.0 software (State-Ease Inc., Minneapolis, Minn., U.S.A.). Statistical parameters such as lack of fit, the coefficient of determination (R^2)

Table 1. Experimental and estimated values obtained for responses

Runs	FACTORS			RESPONSES					
	A (Watt)	B (%)	C (s)	Totox		Hue Angle		Chroma	
				Experimental	Predicted	Experimental	Predicted	Experimental	Predicted
1	95	0.26	360	22.02±0.61	22.36	96.24±0.05	96.73	41.21±0.03	39.80
2	110	0.11	241	20.50±0.06	19.49	93.55±0.02	93.41	48.02±0.01	49.86
3	120	0.26	360	22.73±0.08	23.82	96.99±0.01	97.30	39.70±0.01	37.37
4	95	0.26	120	19.27±0.01	19.72	92.78±0.02	92.90	50.19±0.01	49.07
5	80	0.11	241	19.28±0.01	19.76	93.56±0.01	93.52	50.05±0.01	50.41
6	110	0.40	503	29.91±0.90	28.69	99.43±0.01	99.47	30.57±0.02	30.41
7	95	0.50	360	21.73±0.24	22.43	97.48±0.01	97.40	37.47±0.01	38.67
8	95	0.26	360	23.14±0.73	22.36	96.84±0.02	96.73	38.97±0.01	39.80
9	95	0.26	360	22.85±0.73	22.36	96.73±0.01	96.73	39.40±0.01	39.80
10	110	0.40	241	21.26±0.01	21.12	96.36±0.01	96.08	40.34±0.05	41.72
11	95	0.26	360	21.69±1.14	22.36	96.63±0.02	96.73	40.44±0.04	39.80
12	80	0.40	503	23.31±0.14	23.59	97.31±0.01	97.44	37.18±0.04	35.60
13	110	0.11	503	26.17±0.01	26.12	96.06±0.01	95.86	42.75±0.01	44.12
14	95	0.01	360	20.55±0.02	20.90	93.67±0.01	93.76	55.48±0.01	53.92
15	95	0.26	360	22.98±0.03	22.36	97.10±0.01	96.73	38.67±0.01	39.80
16	95	0.26	600	28.58±0.02	29.16	97.76±0.01	97.65	34.80±0.01	35.55
17	70	0.26	360	19.84±0.01	19.80	96.00±0.01	95.70	40.15±0.01	42.12
18	95	0.26	360	21.65±0.74	22.36	96.86±0.01	96.73	40.05±0.04	39.80
19	80	0.40	241	19.70±0.07	19.01	94.05±0.02	94.24	47.06±0.02	45.94
20	80	0.11	503	24.01±1.21	23.41	95.56±0.01	95.78	46.34±0.01	45.60

A: Microwave power (W), B: Earth amount (%), C: Time (Sec). ±: Standard Deviation. Data are means of triplicates and the F-test value obtained from the analysis of variance (ANOVA) were used to evaluate the best fitting polynomial model. Regression analysis and three-dimensional surface plots were generated to understand the effect of microwave-assisted conditions on response variables. All experiments were performed in three replicates and the results were given as mean ± standard deviation.

3. RESULTS AND DISCUSSION

3.1. Fitting the model

The experimental design and the experimental results for the microwave bleaching of sunflower oil are presented in Table 1. The bleaching efficiency and the oil quality have been analyzed in terms hue angle, chroma and totox value for MWB sunflower oil. The totox value the MWB sunflower oil obtained in this study ranged from 19.27 to 29.91; while the hue angle and chroma ranged from 92.78 to 99.43 and 30.57 to 55.48, respectively.

The multiple regressions and backward elimination were employed to get the best fitting statistical model for each response. Table 2 summarizes the results from the ANOVA and regression analyses for the hue angle, chroma and totox values. Non-significant lack of fit and high R^2 value indicate that the statistical model fits well with data (Içyer and Durak, 2018; Islam *et al.,* 2018). The quadratic model was deter-

Table 2. ANOVA results for responses

Source	Sum of squares	Df	Mean Square	F value	p- value
Model (Totox)	146.07	6	24.35	31.60	< 0.0001
A-MW power	19.73	1	19.73	25.61	0.0002
B-Clay content	2.82	1	2.82	3.65	0.0782
C-Time	107.44	1	107.44	139.45	< 0.0001
AB	2.84	1	2.84	3.69	0.0770
AC	4.45	1	4.45	5.77	0.0319
C^2	8.79	1	8.79	11.41	0.0049
Residual	10.02	13	0.77		
Lack of fit	7.72	8	0.96	2.10	0.2154
Pure error	2.30	5	0.46	31.60	< 0.0001
Core total	156.09	19	-	25.61	0.0002
R^2=0.94, Adj. R^2= 0.91, Pred. R^2=0.83, Adeq Precision =18.37					
Model (Hue Angle)	54.30	7	7.76	95.13	< 0.0001
A-MW power	3.11	1	3.11	38.17	< 0.0001
B-Clay amount	15.99	1	15.99	196.12	< 0.0001
C-Time	27.24	1	27.24	334.08	< 0.0001
AB	1.90	1	1.90	23.32	0.0004
BC	0.44	1	0.44	5.45	0.0378
B^2	2.33	1	2.33	28.57	0.0002
C^2	3.77	1	3.77	46.19	< 0.0001
Residual	0.98	12	0.08		
Lack of fit	0.56	7	0.08	0.97	0.5329
Pure error	0.42	5	0.08	95.13	< 0.0001
Core total	55.27	19	-	38.17	< 0.0001
R^2=0.98, Adj. R^2=0.97, Pred. R^2=0.95. Adeq Precision=36.56					
Model (Chroma)	627.77	6	104.63	36.32	< 0.0001
A-MW power	27.47	1	27.47	9.54	0.0086
B-Clay amount	280.68	1	280.68	97.44	< 0.0001
C-Time	220.64	1	220.64	76.59	< 0.0001
BC	15.25	1	15.25	5.29	0.0386
B^2	76.89	1	76.89	26.69	0.0002
C^2	11.54	1	11.54	4.01	0.0667
Residual	37.45	13	2.88		
Lack of fit	32.85	8	4.11	4.47	0.0580
Pure error	4.59	5	0.92	36.32	< 0.0001
Core total	665.22	19		9.54	0.0086
R^2=0.94, Adj.R^2=0.92, Pred. R^2=0.83, Adeq Precision =22.02					

mined as the best fitting model according to non-significant lack of fit and R^2 values for all responses (Table 2). Adequate precisions for totox, hue angle and chroma were found as 18.37, 36.56 and 22.02. These values were higher than 4. Therefore, it can be said that there is a good correlation between the estimated values and experimental data (Gasemloo *et al.,* 2019). Similarly, Chew *et al.* (2017) and Garcia-Moreno *et al.* (2013) reported that the quadratic model was found suitable for the bleaching studies based on totox and color parameters. The reduced model created with the terms that are only statistically significant are expressed in Equations (4), (5), (6) for totox (Y1), hue angle (Y2) and chroma values (Y3), respectively:

$$Y1 = 22.03 + 1.20xA + 0.45xB + 2.80xC + 0.59xAxB + 0.74xAxC + 0.77xC2 \quad (4)$$

$$Y2 = 99.67 + 0.47xA + 1.08xB + 1.41xC + 0.48xAxB + 0.24xBxC - 0.4xB2 - 0.51xC2 \quad (5)$$

$$Y3 = 39.78 - 1.41xA - 4.43xB - 4.02xC - 1.38xBxC + 2.30xB2 + 0.89xC2 \quad (6)$$

The magnitude of coefficients for bleaching time and amount of clay are higher than the coefficients for current microwave power and other interactions. On the other hand, the magnitude of coefficients for microwave power and amount of clay are higher than the coefficients for current hue angle, chroma and other interactions, indicating that these parameters have a more significant effect on hue angle, chroma and totox values. The other parameters seem to have a quadratic effect on the hue angle, chroma and totox values.

3.2 Effect of microwave-assisted bleaching parameters on the oxidation of oil

The oxidation of fats and oils during bleaching is one of the important deteriorative reactions. Totox value is one of the important ways to express the total oxidation degree of fats and oils. Hence the totox value was taken as oxidation indicator in this study. Among the independent variables, microwave power, time and their interaction (AC) were found to significantly affect ($p < 0.05$) the Totox value. The second-order term of time (C2) also had significant ($p < 0.05$) effects on the totox value. On the other hand, neither the first-order term of amount of bleaching clay nor its interactions with other responses (AB, BC) had a significant ($p > 0.05$) effect on the totox value of bleached sunflower oil. The 3D response surface plots for the totox value of bleached sunflower oil samples as a function of independent variables are shown in Figure 1a. The totox value for sunflower oil increased with the rise in microwave power and longer irradiation time. The exposure of material to high microwave power increased the temperature of the material. Therefore, the increase in temperature due to high microwave power negatively affected the oxidation stability of the oil. Marrakchi *et al.* (2015) stated that the bleaching temperature significantly affects oxidation stability. In another study in which the optimization of industrial bleaching conditions was studied, it was emphasized that temperature and bleaching earth had significant effects on totox values (Chew *et al.,* 2017). Contrary to the findings of Chew *et al.* (2017) the amount of clay in MWB was not found to be more effective on the totox value than the commercial bleaching process. It may be due to using a small amount of clay and less bleaching time in MWB conditions. İçyer and Durak (2018) emphasized that especially p-anisidine and totox value increased as bleaching time increased in both conventional and ultrasonic bleaching methods. The maximum totox value (29.91) obtained from MWB was found to be comparable to the totox value (31.07) re-

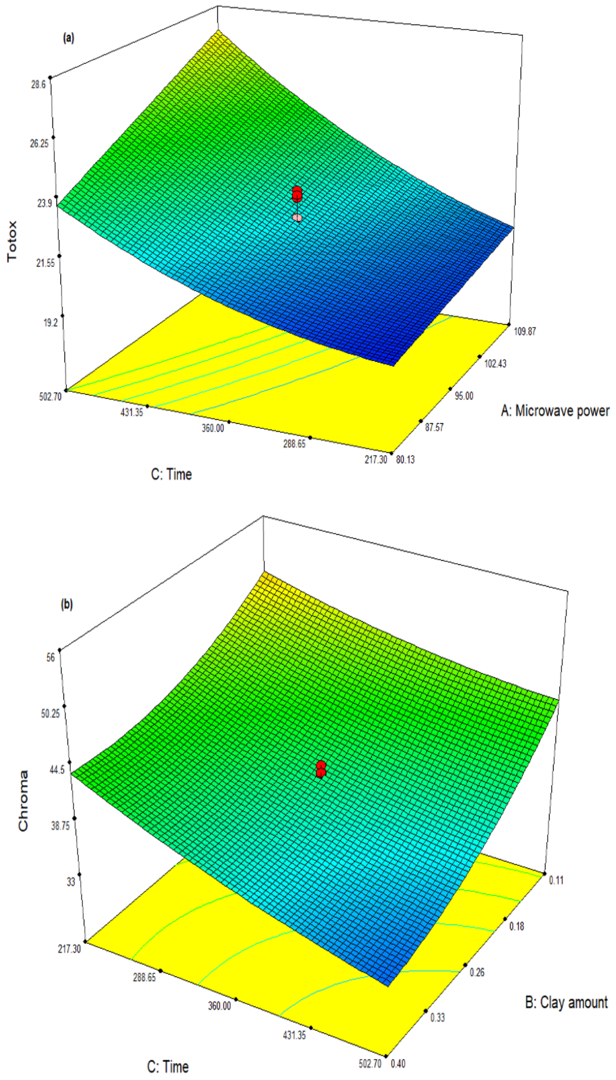

FIGURE 1. 3D response plots of significant interactions between totox value and chroma.

ported by İçyer and Durak (2018) for 30 min conventional bleaching. In general, increasing the amount of clay can facilitate the removal of unwanted compounds in the oil during bleaching. On the other hand, the catalytic properties of acid-activated bleaching earth convert hydroperoxides into secondary oxidation products. Consequently, this situation affects the totox value (Zschau, 2000; Bonveh *et al.,* 2001). It is quite clear from our findings that the low microwave power (80 W) and short processing time (8 min) has no effect on oil quality and only a small effect on peroxide and p-anisidine values of the oil processed by microwave. Even if the totox value increased slightly with increasing peroxide and p-anisidine values, they are similar to the findings obtained by the conventional bleaching process (Chew *et al.,* 2017; Zschau, 2000; Bonveh *et al.,* 2001). In addition, it should be kept in mind that the following deodorization process removes the formed oxidation products which are commonly produced in conventional technology, which has been emphasized in the literature in many sources (Shahidi *et al.,* 1997; Zschau, 2001; Skevin *et al.,* 2012).

3.3. Effect of microwave-assisted bleaching parameters on color properties

Although the Lovibond tintometer is widely accepted as a standard method for measuring the color of oils, Hunterlab has been used in many studies to measure the color of oils (Abedi *et al.,* 2015; Abedi *et al.,* 2016; Chew *et al.,* 2017). In addition, Abedi *et al.* (2015) reported a correlation between b* and a* values and carotenoid and chlorophyll concentrations, respectively. Hue angle and chroma were monitored for the prediction of color change during the MWB of sunflower oil. While hue angle represents color appearance (0°: red, 90°: yellow and 180°: blue), chroma is defined as a measurement of whiteness and vividness of color (Mínguez-Mosquera *et al.,* 1991). All independent variables (A, B and C) were found to be significantly effective on the hue angle and chroma value. In addition, some interactions such as microwave power/amount of clay (AB), amount of clay/time (BC) and second-order term of time (C^2) were found to be significantly effective ($p < 0.05$) on the hue angle. García-Moreno *et al.* (2013) found a similar correlation between hue angle and chroma. Response surface plots for chroma and hue angle values for bleached sunflower oil samples as a function of independent variables are shown in Figures 1b, 2a and 2b, respectively. Based on Figure 2a, microwave power and amount of clay had significantly positive effects on hue angle. Moreover, interactions between microwave power and amount of clay had a synergistic effect on hue angle. The interaction of microwave power and amount of clay caused an increase in hue angle. This means that the redness was removed from the sunflower oil. Bleaching time was found as another important parameter for hue angle. In particular, interaction of time and amount of clay

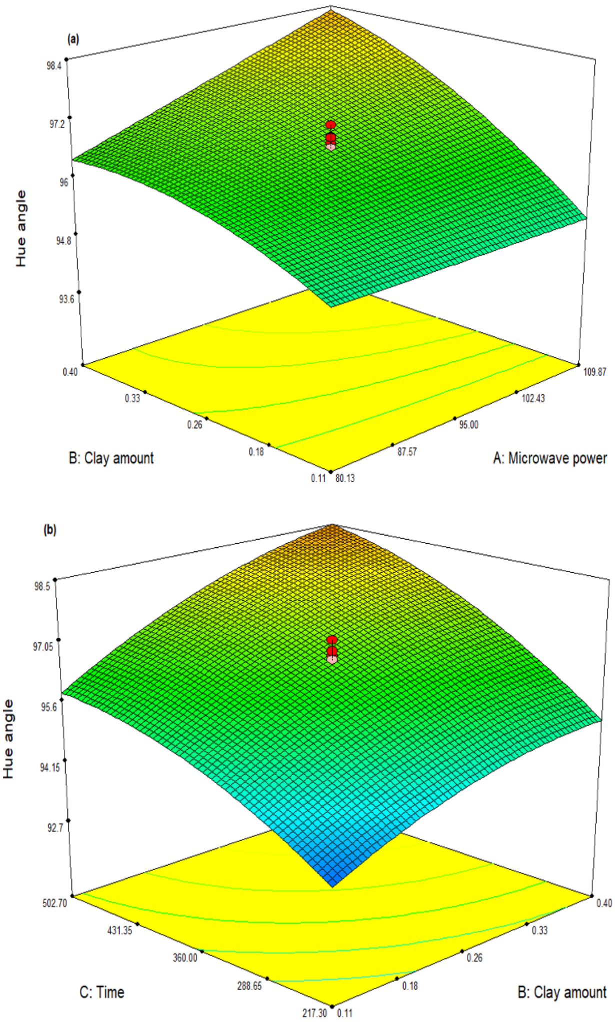

FIGURE 2. 3D response plots of significant interactions for hue angle.

caused a positive effect on the hue angle (Figure 2b). Furthermore, the second order effects of these two variables on the hue angle had a negative coefficient which means that these variables had reached an optimum value in the studied range. In other words, the increase in time and amount of clay did not cause further rising in hue angle after a certain point. Interactions of BC and second-order term of amount of clay (B^2) were found significant on the chroma. Chroma value decreased with increasing amount of clay and time and vice versa (Figure 1b). A negative correlation was determined between the hue angle and chroma value. Although the hue angle increased, the chroma values decreased. Marrakchi *et al.* (2015) reported a similar trend in their study.

3.4. Optimization and model verification

The optimization of MWB was carried out by minimizing totox and chroma, maximizing hue angle in sunflow-

Table 3. Comparison of experimental and estimated values for each response under optimum conditions

Response	Experimental	Predicted	p value
Totox value	23.31 ± 0.28	22.48	0.13
Hue angle	96.91 ± 0.02	97.28	0.19
Chroma	37.66 ± 0.02	35.67	0.08

± Standard Deviation. Data are means of triplicates.

er oil samples. Under optimal conditions, the temperature started at ambient temperature and reached 100 °C at the end of bleaching. In other words, the temperature increased during the treatment period but remained below 100 °C without applying vacuum. Optimal conditions for MWB were found as 80 W, 8.0 min and 0.4% for microwave power, time and amount of clay, respectively. Compared to studies in the literature on reducing clay and bleaching time, it was shown that optimized MWB conditions provided more effective decreases. For example, Abedi *et al.* (2015) reported that two optimized bleached oils were produced by using 1.22 and 1.35% clay amount in 28 minutes. In a different study on the bleaching of sunflower and soybean oil by using a high voltage electric field, the same researchers (2016) found optimal conditions at 1% clay amount and 20 minutes; 0.5% clay amount and 20 minutes for soybean and sunflower oil, respectively. In another study Asgari *et al.* (2017) studied the bleaching of olive oil and they obtained 13 minutes and 1.21% for bleaching time and amount of clay. The bleaching time could not be decreased below 10 minutes in any of these studies. It ranged from 15 min to 30 min. In these studies, the amount of clay used was at its minimum at 0.8% as determined by İçyer and Durak (2018). Temperature is one of the important parameters for effective bleaching. The temperature values used in the ultrasonic bleaching process can be a limiting factor because with the rapid increase in the liquid temperature, a dense bubble formation begins in the liquid and continues increasingly. But the tendency of the bubbles to collapse becomes harder due to the high pressure inside of them acting as a bed (Thompson and Doraiswamy, 1999). Therefore, in the ultrasound-assisted bleaching process, the bleaching effect at high temperatures needed for obtaining the desired oil quality cannot be due to sonication (Abedi *et al.,* 2015). In addition, in cases where high temperatures are inevitable, unwanted taste and odors have been observed in the ultrasonic method (Jahouach-Rabai *et al.,* 2008). But due to having lower specific heat, vegetable oils can be heated to high bleaching temperatures easily in a short time by microwave, which is an important advantage compared to the ultrasound method. Abedi *et al.* (2016) used 1.5% bleaching earth and 30 minutes bleaching time to imitate the industrial process as a control system. The microwave bleaching results showed that MWB was more advantageous in terms of clay usage (0.4%) and bleaching time (8 min) than those used in industrial processes.

For verification of the response values estimated as a result of the optimization, three independent MWB bleaching studies were carried out under optimal conditions and experimental response values were determined. Experimental and estimated values for each response under optimal conditions are given in Table 3. The adequate precision values obtained from Design Expert for totox, hue angle and chroma were found to be 23.31, 96.91 and 37.66, respectively. One-way t-test showed that there was no statistically significant difference between the experimental data and the predicted values for all three responses ($p > 0.05$).

4. CONCLUSIONS

Microwave was used for bleaching for the first time in this study. The optimization of MWB conditions (microwave power, time and amount of clay) was successfully achieved by using RSM. Optimum values for MWB were found as 80 W, 8 min and 0.4% for microwave power, bleaching time and amount of bleaching, respectively. Under optimum conditions the adequate precision values obtained for hue angle, chroma and totox value were found to be 96.91, 37.66 and 23.31. The microwave power, time and amount of clay used were found as significantly effective parameters on the MWB for color parameters. The amount of clay was not significantly effective on the totox value. However, totox value was also significantly affected by microwave power and time. Bleaching time and the amount of clay used for the MWB of sunflower seed oil were found to be the lowest values compared to new bleaching technologies such as ultrasound and high voltage electric field bleaching methods. Therefore, it can be concluded that MWB seems to be a promising technology for the bleaching of oils.

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