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EFFECTS of ULTRAVIOLET IRRADIATION of BATTER and DIFFERENT BAKING METHODS on CAKE QUALITY

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ABSTRACT

In this study, cake batters were subjected to ultraviolet (UV) irradiation for different durations (0, 1, 2 and 4 hours) and baked applying conventional, microwave and combinations of both methods and cake quality characteristics were investigated. Quality parameters evaluated were proximal chemical composition, specific volume, water activity, crust and crumb color, textural parameters (hardness, springiness, cohesiveness and resilience) and sensory attributes. Application of UV irradiation along with different baking methods had a significant effect ($p<0.05$) on quality parameters. Application of combined baking methods resulted in improved cake quality, comparatively to microwave method. Browning reactions on cake surfaces were enhanced with increasing UV irradiation and duration of conventional baking in combined methods. Increase in specific volume was observed with 1 and 2 hours of UV irradiation treatment, however further increasing the duration resulted in lower values. Cake texture varied depending on the duration of the UV irradiation treatment and baking method. Sensory evaluation results showed that unappealing taste and aroma developed in cakes with increased duration of UV irradiation treatment and this had a negative effect on consumer appreciation. However, cakes prepared with UV irradiation also received higher scores for the appearance owing to browning reactions, especially those subjected to the conventional baking procedure.

Keywords: Microwave, combined baking, UV irradiation, cake

INTRODUCTION

There is a wide range of microwave applications and one of the important fields is microwave-baked products. Microwave baking offers some advantages, due to penetration of microwaves, such as brief startup times and internal heating that save energy efficiency and reduce process times. These advantages make it an attractive source of thermal energy **(Ayappa *et al.*, 1991)**. However, there are quality problems associated with microwave baked products that include unacceptable texture, rapid staling and lack of browning, crust formation and flavor development **(Bell and Steinke, 1991; Pan and Castell-Perez, 1997)**. These problems were overcome by the use of some applications in order to improve the product quality and to obtain the same quality of product as in conventional oven. One of these applications is to use combination methods with microwaves such as baking in conventional, hybrid and impingement oven **(Bernussi *et al.*, 1998; Bilgen *et al.*, 2004; Li and Walker, 1996)** and using **infrared (Demirekler *et al.*, 2004; Sakiyan *et al.*, 2007; Sumnu *et al.*, 2005)** in production of breads, cakes and cookies. Sufficient browning in baked products has been achieved by these applications.
Non-thermal technologies such as UV light treatment which occupies a wide range of wavelengths in the non-ionising region of the electromagnetic spectrum have been applied in food industry for preservation. UV-C treatment which refers to the wavelength of 254 nm is used for sterilization or disinfection of surfaces, water and various liquid food products. It is considered to have germicidal effect against microorganisms at the nucleic acid level by causing crosslinking between thymine and cytosine in the same DNA stand **(Bintsis *et al.*, 2000; Guerrero-Beltran and Barbosa-Canovas, 2004)**. Besides the preservative effect, UV irradiation has also been used for other purposes related to product improvement. Protein-protein crosslinks plays an important role in determining the functional properties of food proteins. One of the applications of UV light is to manufacture protein films and coatings. UV irradiation has been reported to crosslink collagen, gelatin and soy protein films **(Gennadios *et al.*, 1998; Tohimata *et al.*, 1992; Weadock *et al.*, 1984)**. Other application of the UV light is to perform the starch modification. Applying UV irradiation is results in the formation of crosslinking between starch molecules. Biscuit expansion has been achieved in the studies performed with UV irradiated starch **(Bertolini *et al.*, 2000; Fiedorowicz *et al.*, 1999; Vatanasuchart *et al.*, 2003; Vatanasuchart *et al.*, 2005)**. Crosslinking may occur between different chemical components in food. Methods that have been employed to form crosslink in food are reported in the literature **(Gerrard, 2002; Singh, 1991)**.
The aim of this study was to investigate the application of combined baking methods in order to reduce the baking time and enhance the surface color of cakes. A second objective of the study was monitoring of the effect of UV irradiation of the batter prior to baking on cake quality attributes by physical, chemical, textural and sensory analyses.

MATERIAL AND METHODS

Materials

All ingredients used for cake baking were obtained from the local commercial market (Antalya, Turkey) and all chemicals used in analyses were purchased from Merck (Darmstadt, Germany) and Sigma-Aldrich (St. Louis, MO, USA).

Preparation of Cake Batters

Preparation of the cake mix was performed according to ***Gomez et al.* (2007)** with some modifications. Composition of the cake mix was 320 g flour, 260 g sugar, 160 g oil, 180 g milk, 100 g whole egg and 10 g baking powder. In order to prepare the cake batter sugar and whole egg were mixed with a mixer (Philips HR1492, Holland) at medium speed for 2 minutes, then, oil and milk were added and mixed at the same speed for 1 minute, and finally, flour and baking powder were also added and mixed at the same speed for 2 minutes. Aluminum baking pans (8 cm in diameter) were lined with wax paper and 70 g of cake batter was weighted into each pan. The UV irradiated samples were treated with UVC at 254 nm by placing in a UV crosslinker (CL-1000 UVP Inc. CA, USA) for 1, 2 and 4 h. The capacity of the UV chamber allowed for surface irradiation of 10 pans at a time, placed in random order. Sample processing was performed as quickly as possible, with no intermittent waiting periods. The UV intensity (lamp intensity) of UV crosslinker was 3.636mJ/m^{2}s.

Baking Parameters

Cakes were baked in a microwave oven (Ariston MW211W, Italy) at 450 W (as indicated in the specifications sheet provided by the oven supplier) or in a conventional stone based double deck oven (Fimak EKF60, Turkey) at 175°C. The microwave baking was applied for 3 min, conventional baking for 25 min and combination methods were 1.5 min microwave baking followed by 13 min conventional baking and 2.5 min microwave baking followed by 5 min conventional baking. The conventional oven was preheated to the desired temperature before placing the dough samples.

Cake Analyses

Analyses were performed on cake samples following their cooling down to room temperature at ambient conditions.

Proximate analysis

To determine the moisture content, 2 g of cake was weighed in glass dishes and dried to a constant weight in a drying oven at 70 °C **(Ji *et al.*, 2007)**. The ash, crude fibre and protein contents of cakes were determined by the standard methods of **ICC (1960)**, **ICC (1972)** and **ICC (1980)**, respectively. Lipid contents were determined using the Soxhelet extraction **(AOAC, 1945)**.

Specific volume

Cake volumes were determined by the rape seed displacement method **(AACC, 2001)**. Specific volume of cakes was calculated by dividing the cake volume to the cake weight.

Color

Crust and crumb color (*L*, *a*, *b* values) of cakes were measured according to the Hunter system with a Minolta colorimeter (CR-400, Japan) that was standardized with a white color tile (*L*= 96.98, *a*= 0.09 and *b*= 1.81). Crust color was measured at five different positions on the cake surface. Then, each cake was cut in two halves to measure the crumb color at three different positions on the surface of each half.

Water activity

Water activity was determined with a water activity analyzer (Testo 650, Argentinia) according to the manufacturer's directions. Specific cup that belongs to the analyzer was filled up to 2/3 with each sample and closed with its cover prior to measurement. After allowing enough time for the sample to equilibrate to temperature of the probe, the value was recorded automatically.

Texture

The textural analyses were performed according to ***Megahey et al.* (2005)** with some modifications. The instrument used was a TA-XT Plus texture analyser (Stable Microsystems, Godalming, Surrey, UK) with a 5 kg load cell. A cylinder probe (25 mm diameter) was used and test conditions were: test speed 1.0 mm/s; strain 25%; time 5 s; trigger type: auto; force. The following parameters were obtained with cake slices of 2 cm thickness; hardness (the peak force during the first compression cycle), springiness (the ability to gain the initial shape after deforming in the first compression), cohesiveness (the withstanding of the product to a second deformation relative to its behavior under first deformation) and resilience (the resistance that the food shows to be able to return the initial shape) **(SMS, 2011)**.

Sensory evaluation

Sensory evaluation was carried out on the representative samples of cake by 3 male and 3 female trained panelists selected among graduate students at the Department of Food Engineering at Akdeniz University, aged 25-35. Cakes were coded by three-digit random numbers. Each parameter was graded with points ranging from 1 to 9 for appearance, texture, taste and odor (1 reflected a very low and 9 a very high score) **(Ji *et al.*, 2007)**.

Statistical Analysis

Analysis of variance (ANOVA) was used to determine significant differences between duration of the UV irradiation and different baking methods with a factorial design by using SAS System Software (SAS Institue Inc., Cary, NC, USA). If a significant difference was observed in mean values, the treatments were compared by Duncan's Multiple Range test ($p<0.05$). Duplicate samples were used in each experiment and the experiments were replicated twice. For the results, mean value and standard deviation were calculated.

RESULTS AND DISCUSSION

Proximate analysis

Mean values and Duncan's multiple range test results of chemical composition of cakes are given in table 1. An apparent change in the water and crude fiber contents of the cakes were observed depending on the duration of the UV irradiation applied and the baking method. Application of prolonged periods of UV irradiation resulted in decreased water content of the cakes. Increasing the duration of the UV irradiation can be expected to cause an increase in the surface temperatures of cake batters (to ca 30 ºC following the 4 h application measured using an IR thermometer), which would affect the water evaporation and encourage crust formation. This relatively small rise in temperature could be attributed to the indirect warming effect of the UV lamp on the chamber. Also, the water contents of microwave oven baked cakes were found to be lowest. Moisture loss from the microwave oven baked cakes was, in general, reported to be greater than that of cakes baked in convection ovens **(*Lambert et al.*, 1992; Pan and Castell-Perez, 1997; Sumnu, 1997)**. These reports indicate that moisture loss in microwaved products occurs owing to the absence of a crust that develops in the conventionally baked products and acts as a barrier against moisture transfer. However, with the combined baking method, it was observed that the moisture loss decreased probably due to the crust formation. A decrease was observed in the crude fiber content of the cakes along with increased duration of the UV irradiation applied. This finding indicates that UV irradiation could stimulate the degradation of cellulose. It has previously been reported that UV irradiation can result in deterioration of food components when applied at high doses **(Kolakowska, 2003; Tomasik, 2004)**. However, in this study, no significant difference among UV irradiation duration with regard to protein, lipid and ash content were observed.

Table 1 Proximal chemical analysis of cakes

	Moisture	Protein	Lipid	Crude fiber	Ash
Baking method					
C(25)	$17.99^{a} \pm 0.34$	7.63 ± 0.03	$21.62^{b} \pm 0.09$	$0.50^{a} \pm 0.03$	$1.14^{b} \pm 0.01$
M(1.5)+C(13)	$17.32^{ab} \pm 0.60$	7.60 ± 0.02	$22.17^{a} \pm 0.13$	$0.35^{b} \pm 0.02$	$1.13^{c} \pm 0.01$
M(2.5)+C(5)	$16.90^{b} \pm 0.47$	7.78 ± 0.02	$22.43^{a} \pm 0.03$	$0.49^{a} \pm 0.05$	$1.14^{b} \pm 0.01$
M(3)	$15.76^{c} \pm 0.37$	7.72 ± 0.03	$22.31^{a} \pm 0.09$	$0.31^{c} \pm 0.04$	$1.17^{a} \pm 0.01$
UV irradiation					
0 h	$18.29^{a} \pm 0.45$	7.67 ± 0.04	22.10 ± 0.16	$0.51^{a} \pm 0.04$	1.15 ± 0.01
1 h	$17.39^{b} \pm 0.37$	7.65 ± 0.02	22.10 ± 0.19	$0.47^{b} \pm 0.04$	1.14 ± 0.01
2 h	$16.61^{b} \pm 0.39$	7.71 ± 0.05	22.24 ± 0.09	$0.37^{c} \pm 0.03$	1.15 ± 0.01
4 h	$15.69^{c} \pm 0.43$	7.70 ± 0.03	22.08 ± 0.13	$0.30^{d} \pm 0.03$	1.14 ± 0.01

Results are presented as the mean ± standard deviation result of ANOVA performed on data obtained by analysis of duplicate samples taken from two replications.
Means not sharing a common letter within the same column and baking method/UV irradiation are significantly different at $p<0.05$.
C-conventional baking, M-microwave baking, numbers in parentheses indicate number of minutes applied.

Specific volume

The specific volumes of the cakes are given in figure 1. The statistical evaluation of raw data revealed that the application of UV irradiation had a significant effect ($p<0.05$) on specific volume of cakes. An increase in specific volume was observed with 1 hour (2.18±0.06 cm^3/g) and 2 hours (2.18±0.11 cm^3/g) of UV irradiation treatment, however further increasing the treatment to 4 hours (2.06±0.15 cm^3/g) caused decreased specific volume values. The non-treated sample had a specific volume of 2.07±0.08 cm^3/g. **Vatanasuchart *et al.* (2003)** have reported increased biscuit specific volumes prepared from UV-A, UV-B and UV-C irradiated cassava starch. They also observed decreases in specific volumes with extended periods of UV treatments, especially apparent with UV-C. In the current study, the volume increase observed with 1 and 2 h of UV-C treatment could be explained with the cross-linking effects, forming a firmer surface, enabling better crust formation. A firmer crust would account for entrapped gas bubbles to remain and expand throughout the baking procedure. Further increasing the duration of UV-C treatment to 4 h could have resulted in depolymerization of starch molecules as suggested by **Vatanasuchart *et al.* (2003)** in their study, resulting in poor expansion and gelatinization of starch molecules. In comparing the different baking procedures applied, it was observed that the combination baking with 2.5 min in microwave oven resulted in the cakes with greatest specific volume average (2.21±0.08 cm^3/g). However, there was no significant difference between the specific volume of cakes baked by the combined procedures and conventionally baked cakes (2.15±0.08 cm^3/g). Cakes baked only in the microwave oven had significantly lower specific volume (2.03±0.12 cm^3/g). Similarly, **Bilgen *et al.* (2004)**; **Li and Walker (1996)**; **Megahey *et al.* (2005)** demonstrated that cakes baked with microwaves had the lowest volume. Results of the present study show increased volumes achieved using combined baking methods, the volumes of these cakes being comparable to those baked with the conventional oven alone.

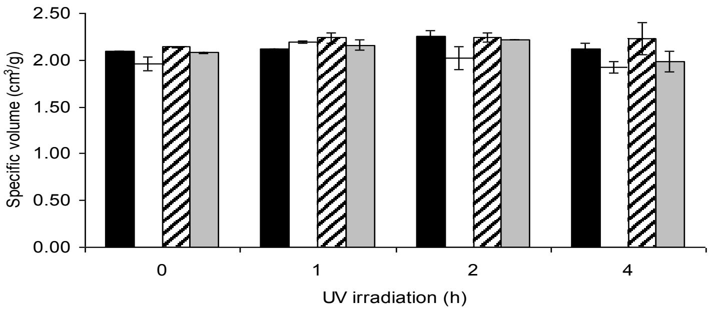

Figure 1 Specific volume of cakes; black bars represent conventional baking (C); white bars represent microwave baking (M); striped bars represent M (2.5) + C (5); grey bars represent M (1.5) + C (13); numbers in parentheses indicate number of minutes applied.

Water activity

It can be observed in figure 2 that both increasing the duration of UV irradiation treatment and incorporation of microwaving to the baking procedures caused decreases in the water activity. Water activity values were found to follow a similar trend as the water content (given in Table 1), both concerning the extent of microwaving and UV irradiation. The decrease in a_w observed with increased incorporation of microwaving to the baking regime can be attributed to the water molecules being the target of microwaves, causing them to be quickly released from the system owing to internal pressure and concentration gradients **(Data, 1990)**. This effect of microwaving is especially significant considering that the total time of the baking procedure required decreases dramatically using microwaves. The decrease of a_w observed with increased UV treatment on the other hand is probably related to the duration of the application, in that these batters had to be treated for the periods of 1, 2 and 4 h. The time that lapsed during the time of UV treatment would have allowed for partial hydration of food polymers, resulting in binding of more of the water molecules, facilitating starch gelatinization and hence restricting water evaporation during the baking procedures.

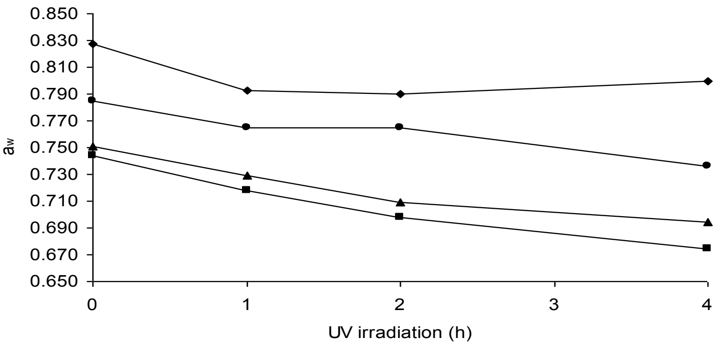

Figure 2 Water activity values of cakes; C (♦), conventional baking; M (■), microwave baking; (▲) M (2.5) + C (5); (●) M (1.5) + C (13); numbers in parentheses indicate number of minutes applied.

Color

Mean values and Duncan's multiple range test results of *L*, *a*, *b* values for the crust and crumb of cakes are presented in table 2. The absence of Maillard browning reactions are a well-known phenomenon in microwave baking, hence cakes baked only in the microwave oven had surfaces which were not browned. This phenomenon is explained by the short baking times and low temperatures involved in microwave processing which is not sufficient to promote browning reactions **(Zuckerman and Miltz, 1997)**. However, surface browning of the cakes was achieved when the combined baking procedure was applied. The crust color of cakes baked with 1.5 min in microwave oven followed by 13 min baking in the conventional oven were similar to the crust color of cakes baked only conventionally. The color values of cakes observed with different durations of UV irradiation treatment were significantly different ($p<0.05$). The *L* and *b* values of the cakes decreased, while the *a* values increased with increased duration of the UV irradiation treatment. While the UV treatment promotes crosslinking of proteins and depolymerization of starch molecules on the surface of the cake batters, it also causes generation of free amino acids and sugars. The results indicate that the increase in concentration of potential Maillard reactants in this way contributes to inducing surface browning reactions. On the other hand, conventional baking following UV irradiation treatment also promotes the browning reactions and so enhances the surface color of cakes. As mentioned before, significant color development could not be observed in microwave baking; but the crosslinked layer on the surface of these cakes was apparent. The *L* values for crumb of cakes treated with UV irradiation were significantly ($p<0.05$) lower than the non-treated cakes. This could be attributed to the diffusion of compounds generated by UV irradiation on the surface to the inside of cakes. This inference can be made overruling the possibility that penetration of UV rays into the batter may cause a compositional change in the crumb because it has previously been reported that UV rays have a penetration depth of only 1 mm **(Guerrero-Beltran and Barbosa-Canovas, 2004)**. The statistical evaluation also revealed the presence of an interaction between the baking procedures and UV applications on the development of surface browning.

Table 2 Crust and crumb color values of cakes

	Crust color			Crumb color		
	L	*a*	*b*	*L*	*a*	*b*
Baking method						
C(25)	$58.44^c \pm 5.67$	$6.21^a \pm 3.57$	$22.85^a \pm 1.04$	62.87 ± 1.80	$-1.80^c \pm 0.25$	$14.91^c \pm 0.70$
M(1.5)+C(13)	$60.99^b \pm 4.64$	$3.22^b \pm 1.59$	$22.46^a \pm 0.63$	63.39 ± 2.32	$-1.41^b \pm 0.26$	$17.51^b \pm 0.55$
M(2.5)+C(5)	$66.51^a \pm 2.44$	$-1.31^c \pm 0.20$	$18.10^b \pm 0.62$	63.94 ± 1.88	$-1.05^a \pm 0.24$	$18.69^a \pm 0.63$
M(3)	$66.26^a \pm 1.51$	$-1.60^c \pm 0.47$	$17.80^b \pm 0.36$	63.15 ± 1.12	$-1.52^{bc} \pm 0.27$	$18.55^a \pm 0.50$
UV irradiation						
0 h	$67.18^a \pm 2.18$	$-0.27^d \pm 1.61$	$20.49^a \pm 2.06$	$65.81^a \pm 1.28$	-1.45 ± 0.43	$17.83^a \pm 1.79$
1 h	$64.70^b \pm 2.57$	$1.18^c \pm 3.12$	$20.47^a \pm 3.15$	$62.95^b \pm 0.85$	-1.35 ± 0.41	$17.38^{ab} \pm 1.26$
2 h	$61.66^c \pm 4.40$	$2.37^b \pm 4.36$	$20.40^a \pm 2.90$	$62.16^b \pm 1.19$	-1.52 ± 0.28	$16.92^b \pm 1.60$
4 h	$58.65^d \pm 6.23$	$3.23^a \pm 5.00$	$19.86^b \pm 2.13$	$62.43^b \pm 0.83$	-1.46 ± 0.38	$17.52^a \pm 2.04$

Results are presented as the mean ± standard deviation result of ANOVA performed on data obtained by analysis of duplicate samples taken from two replications.
Means not sharing a common letter within the same column and baking method/UV irradiation are significantly different at $p<0.05$.
C-conventional baking, M-microwave baking; numbers in parentheses indicate number of minutes applied.

Texture

Baking always involves the loss of water from the 'raw' material. Therefore, the baking process has a direct impact on the final moisture content of the product and also on its textural properties as well as its eating character. Moistness is directly related to product moisture content and seen as a positive character in cakes, whereas hardness is seen as negative character **(Cauvain, 2005)**. So, if we explain the results according to this statement, both baking method and UV irradiation duration had a notable affect ($p<0.05$) on the textural properties of cakes because the baking and UV irradiation procedures had a significant effect ($p<0.05$) on the moisture content of cakes. The hardness values of cakes are presented in figure 3. The statistical evaluation showed that hardness values of cakes baked in the conventional oven were the lowest (152.43±7.86 g), whereas the same for cakes baked in the microwave oven were the highest (1221.14±593.63 g). Further, decreasing the application time of microwaving in combined methods resulted in decreased hardness values of cakes. The hardness values were also affected significantly ($p<0.05$) by the duration of UV irradiation treatment. Although no significant difference between the non-treated and 1h UV treated or 2h and 4h UV treated cakes was determined, increasing the duration UV treatment resulted in increased hardness values of cakes. There was no significant difference between the springiness values of cakes with regard to baking method (means between 0.86±0.03 and 0.92±0.02) and duration of UV irradiation (means between 0.88±0.06 and 0.92±0.09). The cohesiveness values were similar between the cakes baked using only the conventional oven (with mean value 0.68±0.04) and with combined methods, whereas the value was the lowest (0.58±0.07) in cakes baked with microwaves. A significant interaction of baking methods and UV applications was observed both, with regard to hardness and cohesiveness values. The UV irradiation time had no effect on the resilience values of cakes, but baking methods had a significant effect ($p<0.05$) on this value. The resilience values of cakes baked in the conventional oven were the highest (0.35±0.02), whereas the same for cakes baked in the microwave oven were the lowest (0.23±0.03). It was determined that increasing duration of the microwave application had an adverse effect on the resilience of cakes.

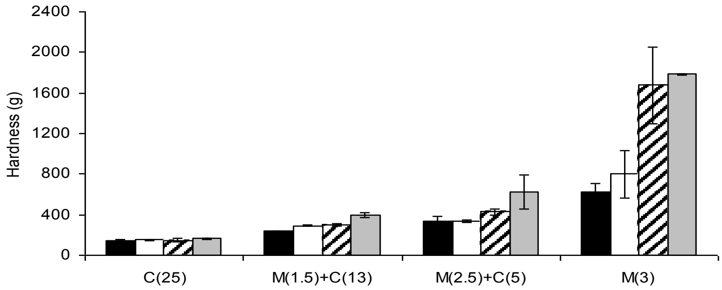

Figure 3 Hardness values of cakes; black bars represent non-treated; white bars represent 1 h; striped bars represent 2 h; grey bars represent 4 h UV treatment. C-conventional baking, M-microwave baking; numbers in parentheses indicate number of minutes applied.

Sensory evaluation

The baking method and UV irradiation duration exhibited a significant ($p<0.05$) influence on sensory attributes of cakes (Tab 3). It can be stated that UV irradiation led to a greater appreciation by panelists in terms of appearance. However, increasing UV irradiation previous to baking resulted in significantly lower texture, taste and odor scores. Results indicate that degradation induced on the surface of the cakes by the application of UV influenced the taste and odor scores. **Koutchma *et al.* (2009)** reported that UV light causes the degradation of proteins which results in detectable organoleptic changes and off-flavors in foods. Free radicals which are formed by lipid rancidity as a result of UV irradiation are also an important contributor to the development of off flavors. The depreciation in taste and odor attributes that developed with increasing duration of UV irradiation may have been as a result of both of these mechanisms. Further studies could provide a better understanding of this phenomenon.

Table 3 Sensory evaluation of cakes

	Appearance (Color)	Texture (Hardness)	Taste (Sweetness)	Odor (Typical)
Baking method				
C(25)	$5.83^{a} \pm 1.81$	$6.67^{a} \pm 0.65$	$5.98^{a} \pm 1.11$	$5.81^{a} \pm 1.16$
M(1.5)+C(13)	$5.56^{a} \pm 0.52$	$5.79^{b} \pm 0.82$	$5.75^{a} \pm 1.00$	$5.65^{a} \pm 0.89$
M(2.5)+C(5)	$5.48^{a} \pm 0.52$	$5.06^{bc} \pm 1.14$	$5.15^{b} \pm 0.73$	$4.83^{b} \pm 1.04$
M(3)	$4.25^{b} \pm 0.96$	$4.30^{c} \pm 1.01$	$3.70^{c} \pm 1.08$	$4.33^{c} \pm 0.93$
UV irradiation				
0 h	$4.75^{b} \pm 1.13$	$6.17^{a} \pm 0.79$	$6.45^{a} \pm 1.05$	$6.57^{a} \pm 0.84$
1 h	$5.46^{a} \pm 0.52$	$5.54^{ab} \pm 1.24$	$4.96^{b} \pm 0.94$	$5.19^{b} \pm 0.41$
2 h	$5.64^{a} \pm 1.03$	$5.25^{b} \pm 1.33$	$5.06^{b} \pm 1.02$	$4.65^{c} \pm 0.84$
4 h	$5.27^{ab} \pm 1.82$	$4.86^{b} \pm 1.39$	$4.10^{c} \pm 1.13$	$4.20^{d} \pm 0.76$

Each parameter was graded with points ranging from 1 to 9 (1 reflected a very low and 9 a very high score).
Results are presented as the mean ± standard deviation result of ANOVA performed on data obtained from six panelist evaluations taken from two replicate analyses.
Means not sharing a common letter within the same column and baking method/UV irradiation are significantly different at $p<0.05$.
C-conventional baking, M-microwave baking; numbers in parentheses indicate number of minutes applied.

Cakes baked with combined methods (M + C) had similar values for appearance as cakes baked only conventionally. This could be because increased browning reactions resulted in higher scores to be given by the panelists. Regarding the other sensory attributes, similar scores were obtained for cakes baked both only conventionally and with the combined method in which 1.5 min microwave and 13 min conventional baking was used (denoted as M(1.5) + C(13)). Again, using only microwaves to bake the cakes caused them to receive the lowest scores for texture, taste and odor. In microwave baking owing to low temperatures, flavors generated as a result of browning reactions are absent **(Whorton and Reineccius, 1990)** and the panelists expressed opinions of the aroma profile of microwave baked cakes to have a raw character similar to that of batter. The presence of interaction between the baking procedures and UV treatments was observed for the sensory evaluation of appearance and texture. This result is also reflective of the interactions observed for surface color development and hardness/cohesiveness values.

CONCLUSION

It can be concluded that the physical, chemical, textural and sensory properties of cakes changed depending on the UV irradiation treatment applied prior to baking as well as the baking method itself. Some cake properties were positively affected by the applications, while there were other properties which were negatively affected. Although the changes in crust and crumb color of baked samples have been presented, further analysis regarding determination of reducing sugar and free amino acid content are needed to establish relationships between the UV irradiation duration and browning reactions. The combined method consisting of 1.5 min microwave and 13 min conventional baking could be applied to obtain cakes with comparable sensory characteristics to conventionally baked products. Thus, baking with combined methods could be a processing option for commercial bakers to save time and energy with minimal deviation from the quality of conventional baking. Applying limited times of UV irradiation on the other hand may be considered to obtain increased volume and improved sensory properties.

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