INFLUENCE OF DIFFERENT MICROWAVE SEED ROASTING PROCESSES ON THE CHANGES IN QUALITY AND FATTY ACID COMPOSITION OF TEHINA (SESAME BUTTER) OIL

Feramuz ÖZDEMİR[1] Muharrem GÖLÜKCÜ[2] Mustafa ERBAŞ[1]

[1]Department of Food Engineering, Faculty of Agriculture, Akdeniz University, 07059 Antalya
[2]West Mediterranean Agricultural Research Institute, PK: 35, 07100 Antalya
Correspondence addressed E-mail: feramuz@akdeniz.edu.tr

Abstract

The quality characteristics of tehina prepared at different roasting powers (399, 665, 931, 1330 Watt) for different exposure periods (3-50 min.) and depths of sesame seeds (1-2 cm) using a domestic home microwave oven (BKMD 1550) were compared with those prepared in a conventional tehina sample. The fatty acid showed erratic fluctuations for all treatments and there were significant ($p<0.05$) differences in composition of fatty acids in tehina oils processed by microwave roasted methods. The acid value decreased with increasing roasting power between 399 and 1330 watts. A longer roasting time in each applied power resulted in more acid value; however the acid value of oil of tehina roasted in the conventional method was much less than the acid value of oil of tehina roasted through microwave treatments. The acid value of oil from microwave roasted seeds occurred in relation to increasing the depth of seeds in a dish from 1 cm to 2 cm. There was no pronounced difference in peroxide value for the oils of tehina from seeds roasted using different powers of the microwave oven or roasted conventional methods. The peroxide value was erratically affected by the powers of the microwave oven. The peroxide value increased ($p<0.05$) with longer roasting and storage, but increases were more pronounced during the first two weeks of storage.

Keywords: *Sesamum indicum*, microwave, tehina, fatty acid composition, quality

Susam Kavrulmasında Farklı Mikrodalga Uygulamalarının Tahin Yağının Kalitesi ve Yağ Asidi Bileşimi Üzerine Etkisi

Özet

Ev tipi mikrodalga fırının (BKMD 1550) farklı güçlerinde (399, 665, 931, 1330 Watt) ve her güçte farklı sürelerde (3-50 dak.) ve farklı yığın yüksekliklerinde (1-2 cm) kavrulan susamlardan elde edilen tahinin kalite karakteristikleri geleneksel yöntemle üretilen örnekle karşılaştırılmıştır. Örneklerin yağ asitleri bileşimi düzenli olmamakla birlikte mikrodalga uygulamaları arasında birbirinden önemli derecede ($p<0.05$) farklılık göstermiştir. Örneklerin serbest yağ asitliği uygulamada kullanılan mikrodalga fırının güçlerindeki artış ile birlikte azalmıştır. Tüm mikrodalga güçlerinde örneklerin asitliği artan kavurma süreleri ile birlikte artış göstermiştir. Bununla birlikte geleneksel yöntemle üretilen tahinin serbest yağ asitliği mikrodalga uygulaması ile üretilen tüm örneklerin serbest yağ asitliğinden daha düşük olmuştur. Mikrodalga fırında artan yığın yüksekliği uygulaması örneklerin asitliğinde artışa sebep olmuştur. Geleneksel yöntemle ve mikrodalga fırında kavurarak üretilen tahinlerin peroksit değerleri birbirinden açık bir farklılık göstermemiştir. Örneklerin peroksit değerleri farklı mikrodalga gücü uygulamaları arasında da düzenli bir farklılık göstermemiştir. Örneklerin peroksit değerleri artan kavurma süresi ve depolama periyodu ile birlikte önemli oranda ($p<0.05$) artış göstermiştir.

Anahtar Kelimeler: *Sesamum indicum*, Mikrodalga, Tahin, Yağ Asidi Bileşimi, Kalite

1. Introduction

Sesame (*Sesamum indicum* L.) is one of the world's most important oil seed crops and it is produced mainly in India, China, Sudan, Burma and Argentina (Salunkhe et al., 1992). Sesame seed is used extensively in baked goods and confectionary products. Not only is it a source of edible oils, the seed itself provides a nutritious food source for human consumption (Yoshida, 1994). In some Eastern countries, sesame seeds are used mainly for preparing tehina (a sesame paste product similar to peanut butter) and halva (Abou-Gharbia et al., 1997).

The dehulled roasted sesame seeds are used extensively in The Middle East for production of tehina. Tehina is generally served as an appetizer or dressing, after being hydrated with 1-2 volumes of water in order to form a thin oil in water emulsion (Lindler and Kinsella, 1991).

Sawaya et al. (1985) reported that halva is prepared by the incorporation of 50% sugar (sucrose alone or glucose) into tehina. In Turkey, halva is made by adding sugar, cacao, vanilla, pistachio nut, and soapwort (*Gypsophia stratium*) root extract into tehina to produce different halvas.

Sesame oil has a mild, pleasant taste and is used as a salad oil requiring little or no winterizing. An important characteristic of sesame oil is its resistance to oxidative deterioration. Sesame oil from roasted sesame seeds has a distinctive flavor and a long shelf life (Manley et al., 1974; Kikugawa et al., 1983), and is used as cooking oil, in shortenings and margarines.

The conventional method for preparation of tehina involves dehulling, roasting and grinding. Roasting is the key step because color, composition, taste and quality of tehina are influenced by conditions of roasting. Roasting conditions also affect the quality of oil. A higher roasting temperature, used to provide a strong flavor, results in oil of lower quality (Yen et al., 1986). The conventional method for roasting sesame seeds is to roast seeds in a circular-moving cauldron on a gas flame for about 4-5 hours.

Microwave ovens are an energy efficient means of heating and a rapid method for reheating foods (Mudgett, 1989). Microwaves have great penetrating power, and food products heated by them have little temperature gradient. Foods, which are high in fat and moisture content are quickly cooked or baked in microwaves. The application of microwave processing for both home and institutional meal preparation has increased because of its speed and convenience (Mudgett , 1988).

Few studies concerning the influence of roasting on composition and quality of sesame oil have been reported (Fukuda et al., 1986; Yen and Shyu, 1989; Yen, 1990; Yoshida and Takagi 1997). Moreover, little has been reported about how microwave roasting affects the quality of the sesame oil (Yoshida and Kajimoto, 1994; Abou-Gharbia et al., 1997). To our knowledge, there are no reports on the effect of different microwave powers and exposure periods on the stability of tehina oil.

The objective of this study was to investigate the change in composition and quality of tehina oil produced from sesame seeds which were roasted at different powers and temperatures for different times in a microwave oven.

2. Material and Methods

The sample of sesame seeds (*Sesamum indicum* L.) in this study was a white species which was grown in Antalya, Turkey. Seeds were purchased from a local store during harvesting season.

Tehina was prepared by dehulling, drying, roasting and grinding the sesame seeds. The seeds were soaked in water for 8 hours, dehulled by mechanical abrasion, and separated from the hulls flotation on brine (5% salt concentration on weight base). After washing with water to remove the salt, the dehulled wet sesame seeds were spread to dry on the laboratory bench at a depth of 1 cm and left to dry in an ambient temperature and breeze. Dried seeds were spread on the glass plate of a domestic-size Beko microwave oven (BKMD 1550) capable of generating 1330 watt powers at 2450 MHz. The microwave oven used operates at a frequency of 2450 MHz, with 1330, 931, 665 and 399 watts of output with power levels of high, medium high, medium and defrost, respectively. Each time the plate of the microwave oven contained about 180 grams of seeds with a depth of 1 cm, and about 360 grams of seeds with a depth of 2 cm. After roasting, the seeds were allowed to cool to ambient temperature before being processed into tehina. The experimental design for this study is shown in Table 1.

For production of tehina, each sample of dehulled and microwaved seed was ground in a blender (Waring). To cool the seeds when they were being ground, cold water was placed around the blender in plastic bags. Seeds were ground for 30 s followed by a quiescent period of 2 minutes. This process was repeated 6 times to prepare the paste known as tehina. Subsequent analyses were carried out on the paste. Tehina samples were stored in glass jars in a dark room.

Table 1.The experimental design of microwaving sesame seeds.

Depth of seed	1 cm				2 cm			
Power (watt)	1330	931	665	399	1330	931	665	399
Exposure time (min)	3, 4, 5	4, 6, 8	10, 12, 14	30, 40, 50	3, 4, 5	4, 6, 8	10, 12, 14	30, 40, 50

Tehina from each treatment was homogenized with petroleum ether at 4 °C in a Waring blender. The ether layer was separated, and extracts were evaporated using a vacuum rotary evaporator at 35 °C.

Before microwave and conventional roasting, saponification number, iodine number and refractive index value of the sesame oil were analysed (Nas et al., 1998) Quantitative changes in peroxide and acid value of the samples were performed by the AOAC (1990) method. The fatty acid methyl esters prepared using methyl alcohol, benzene, 2,2-dimetoksipropan and n-heptan. For direct derivatization of lipids, approximately 10 mg sample was weighed int 15 x 100 mm test tubes. 3 ml reaction mixture and two ml n-heptan and was added next. Sample tubes were screw-capped and then transferred into water bath maintained at 85 °C and allowed to heat for 2 hours. Reaction mixture was prepared using methyl alcohol, benzene, 2,2-dimetoksipropan and sulphuric acid (Garces and Mancha, 1993). After cooling to room temperature, 3 µl of the upper phase was injected to gas chromatography instrument. The analysis was performed on a Fison Inst. HRGC Mega 2 gas chromatography equipped with a 25 m x 0.25 mm fused silica capillar column. The flame ionization detector (FID) and injector parts were maintained at 260°C. Column heating was performed starting from 150°C and increasing to 200 °C at 5 °C per minute. The flow rate of helium carrier gas was 1 ml/min, hydrogen 30 ml/min, air 300 ml/min. Peaks were identified by comparison of retention times with authentic compounds (Özdemir et al., 2003).

Tehina preparation was replicated two times, chemical and instrumental measurements were duplicated, and mean values were reported. Analysis of variance and Duncan's Multiple Range Test were performed at a level of $p<0.05$ to evaluate the significance of differences between values, however storage tests were not replicated.

3. Result and Discussion

Proximate duplicated analyses using Aoac (1990) procedures showed composition of the seeds before microwave and conventional roasting to be as follows: acid value 0.79%, peroxide value 0.59 meqg/kg, iodine number 109, saponification number 187 and refractive index n_D^{20} 1.465. Furthermore, the fatty acids in the oil of unroasted seeds were palmitic acid (10.35%), stearic acid (4.54%), oleic acid (42.05%) and linoleic acid (43.06%).

3.1. Fatty Acids

The fatty acid composition of oils extracted from tehinas produced from sesame seeds roasted in the microwave oven at four powers (1330, 931, 665 and 399 watts) and different exposure times (3 to 50 min) in each power in depth of 1 cm and 2 cm of seeds, is summarized in Table 2.

Although significant ($p<0.05$) differences existed for the fatty acids of tehina oils from different treatments, no specific trends were evident for the basic compositional changes. A linear relationship did not occur between fatty acid composition and exposure-time or power setting. (Figure 1). In addition, the fatty acid composition and each fatty acid individually were not affected by the depth of seeds exposed in the microwaves (Figure 2).

Yoshida and Kajimoto (1994) found that the fatty acid composition of sesame oil remained unchanged after 8 min of microwave heating but exhibited a significant ($p<0.05$) reduction in its linoleic acid content after 12 min of microwaving; however, similar results were not obtained in this study. This must be because different treatments were applied in the present study. Yoshida and Takagi (1997) reported that there was almost no change in fatty acid composition of the sesame oil when prepared by roasting below 200 °C. However, the higher the roasting

Table 2. The percentage of mean fatty acid values of tehina oils obtained from seeds roasted at different power levels and exposure times with different depth using a microwave oven and the conventional method [a].

	Power (Watt)	Exposure time (Min.)	16:0	16:1	18:0	18:1
Depth of Seeds (1 cm)	1330	3	10.66	4.22	42.47	42.61
		4	10.37	3.77	41.04	43.77
		5	9.98	4.32	42.38	43.32
	931	4	10.63	4.07	42.18	43.05
		6	10.72	4.38	42.81	43.10
		8	10.61	3.84	42.01	43.49
	665	10	9.86	4.60	42.49	43.04
		12	10.17	4.68	42.15	43.00
		14	11.42	4.43	42.17	41.92
	399	30	10.72	4.71	42.41	42.13
		40	10.69	3.82	42.51	42.96
		50	10.70	4.32	42.19	42.78
Depth of Seeds (2 cm)	1330	3	10.66	3.97	43.07	42.32
		4	10.14	4.33	42.56	43.04
		5	10.57	4.46	42.81	42.17
	931	4	11.44	4.18	42.32	42.12
		6	10.24	4.42	42.38	43.02
		8	10.01	4.46	42.36	43.19
	665	10	10.77	4.25	41.93	43.04
		12	9.85	4.51	42.22	43.43
		14	10.88	4.29	42.09	42.76
	399	30	10.09	4.08	42.40	43.43
		40	10.34	3.83	42.33	43.50
		50	10.50	4.13	42.07	43.30
Conventional Method			10.06	4.13	42.23	43.51

[a] Values are the averages of two replications and analyzed in parallel.

temperature and the longer the roasting time, the greater was the percentage of palmitic acid and oleic acid, and the lesser was that of linolic acid. In particular, the total fatty acid contents of sesame oils obtained through roasting at over 220°C, demonstrated a more pronounced trend. In this present study the temperature of sesame seeds was not over 170 °C. A small but significant difference ($p<0.05$) occurred infatty acid composition between treatments because roasting temperatures were less than 200°C. Moreover there were no significant differences between the fatty acid composition of tehina oils obtained from microwaved seeds and tehina oil from the conventional roasting method. Results showed that the microwave method of heating sesame seeds to process tehina is possible and a new method to utilize (Figure 2).

3.2. Acid Value

The acid values of tehina oils obtained from microwaved seeds at different

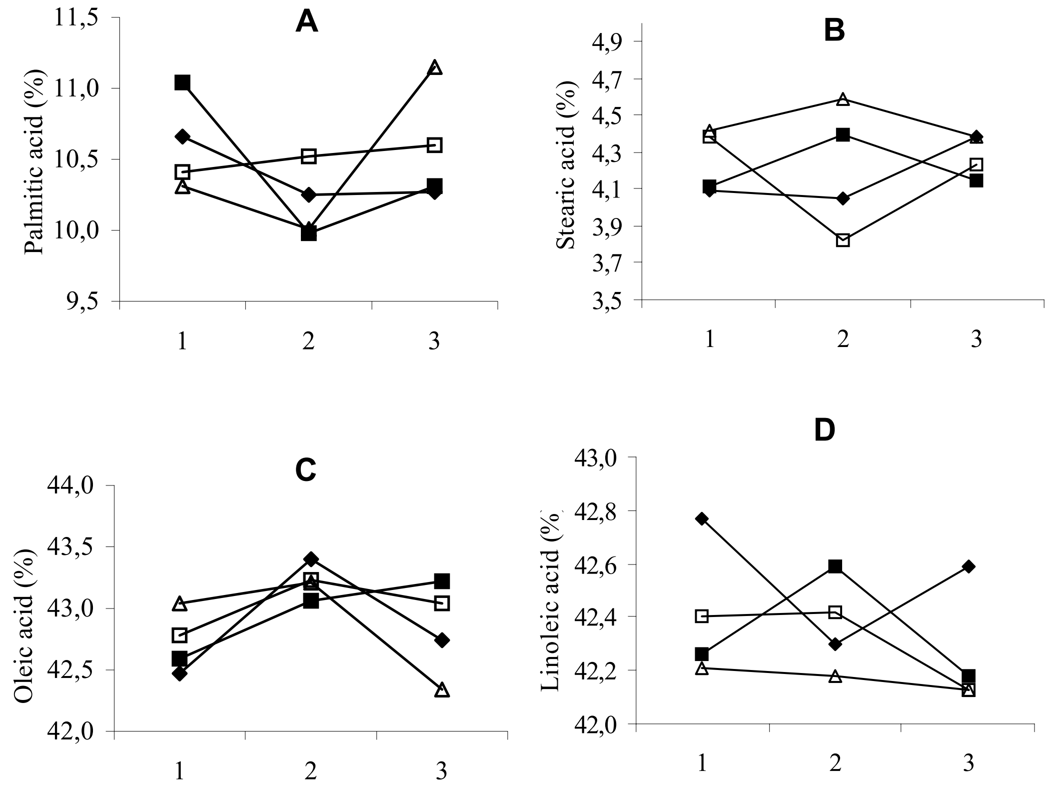

Figure 1. Changes in the fatty acids of tehina oils prepared from sesame seeds roasted in a microwave oven [at a frequency of 2450 MHz with the power of 1330 W (—♦—), 931 W (—■—), 665 W (—Δ—) and 399 W (—□—), for different exposure time (see Table 1 about experimental design: 1, 2 and 3 on the x-axis of the graphs represent the 1st, 2nd and 3rd exposure times of each power), n = 4)].

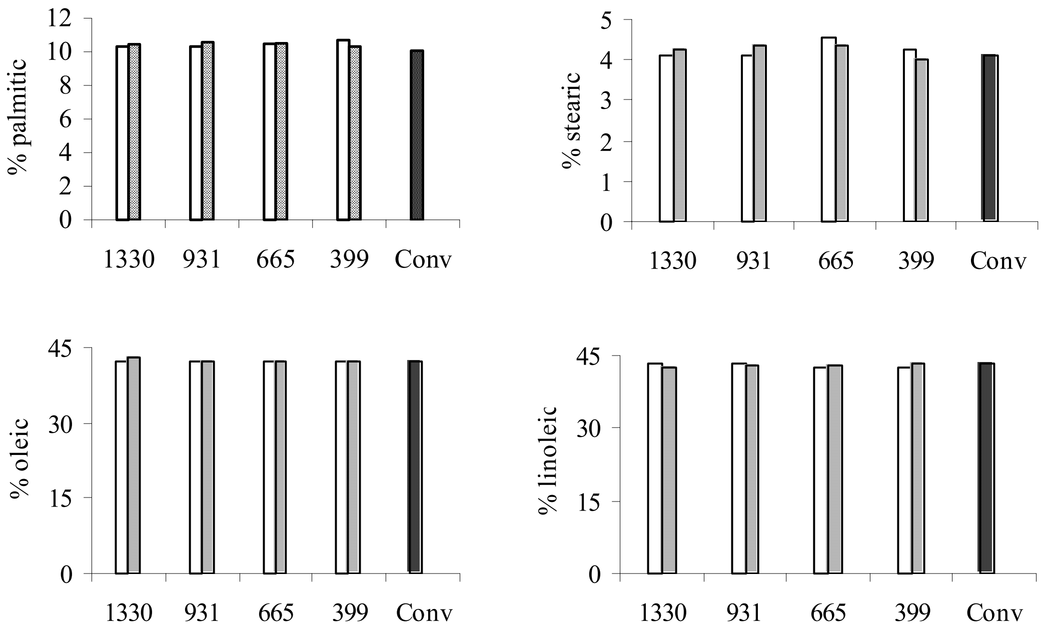

Figure 2. Relationships between the depth of seeds (□ 1 cm, ▩ 2 cm) and fatty acids of tehina oils prepared from sesame seeds roasted in a microwave oven [at a frequency of 2450 MHz with the powers of 1330, 931, 665 and 399 watt for different exposure time (3-50 min)) and conventional methods (Conv), n=6].

Çizelge 3. Mean acid values (% oleic) of tehina oils obtained from seeds roasted at different power levels and exposure times with different depth using a microwave oven and the conventional method [a].

Power (Watt)	Exposure time (Min.)	Depth of seeds (1 cm)	Depth of seeds (2 cm)
	3	0.41	0.62
1330	4	0.66	0.86
	5	0.70	0.93
	4	0.67	0.93
931	6	0.91	1.15
	8	1.05	1.25
	10	0.77	0.97
665	12	1.13	1.32
	14	1.54	1.73
	30	1.33	1.52
399	40	1.41	1.62
	50	1.54	1.79
Conventional Method		0.19	

[a] Values are the averages of two replications and analyzed in parallel.

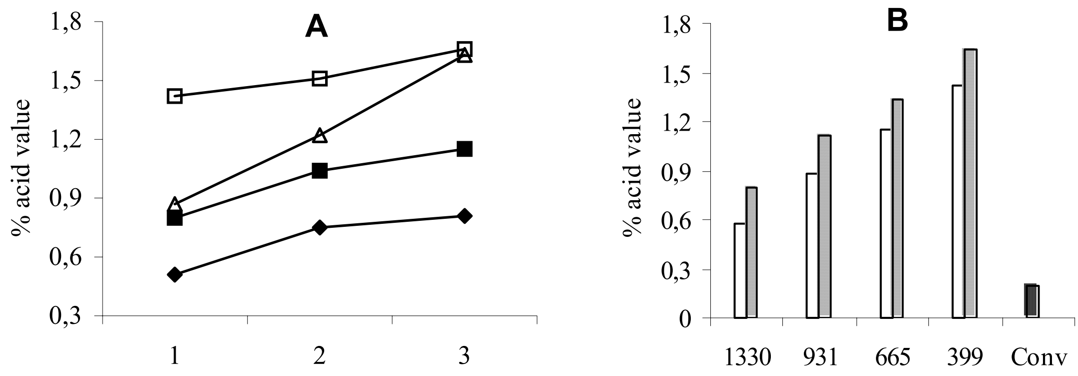

Figure 3. A: Changes in the acid value of tehina oils prepared from sesame seeds roasted in a microwave oven [at a frequency of 2450 MHz with the power of 1330 W (—♦—) , 931 W (—■—), 665 W (—Δ—) and 399 W (—□—), for different exposure time (see Table 1 about experimental design: 1, 2 and 3 on the x-axis of graphs represent the 1st, 2nd and 3rd exposure times of each power), n =4], B: Relationships between the depth of seeds (□ 1 cm, ▩ 2 cm) and acid value of tehina oils prepared from sesame seeds roasted in a microwave oven [at a frequency of 2450 MHz with the powers of 1330, 931, 665 and 399 watt for different exposure time (3-50 min)) and conventional methods (Conv.), n=6].

power and exposure times were between 0.41- 1.79 % as oleic acid. The acid value of tehina oil from conventional roasted seeds was 0.19 % (Table 3). There were substantially greater differences ($p<0.01$) with roasting power, exposure time and depth of seed on the acid value of oils.

When the microwave oven power was decreased from 1330 watt to 399 watt, theacid value of tehina oils increased linearly with the decrease in roasting power. This is due to the high temperature of the oven,because when used at a low power for a longer period, the microwave oven produced more energy. Additionally, when the exposure time was increased, the acid value of oils increased with the increase roasting time (Figure 3). This again related to the level of energy which was produced and transmitted to seeds in the oven.

Yoshida and Kajimoto (1994) reported that the acid value of sesame oils increases with a roasting time which is longer than 20 min. Yen (1990) reported that the acid value of sesame oils increased linearly with roasting temperatures from 180-200 °C. In this present study, the acid value of tehina oils at different roasting depths increase with decreasing the microwaves power. The acid values of tehina oils from the seeds roasted in depth of 2 cm were higher than those of roasted in the depth of 1cm. The acid value of tehina oils from microwaved seeds was much higher than those of prepared in conventional tehina samples (Figure 3b).

3.3. Peroxide Value

Mean peroxide values of tehina oils obtained from seeds roasted at different power levels and exposure times with different depth using a microwave oven and the conventional method during storage was given in Table 4. Peroxide values of tehina oils from microwave roasted seeds were significantly ($p<0.01$) affected by microwave power, exposure period and depth of sesame seeds. The peroxide value decreased gradually when increasing the microwave power; however, when the exposure period was increased, the peroxide value increased significantly ($p<0.05$) (Figure 4a). The peroxide values were also

Table 4. Mean peroxide values of tehina oils obtained from seeds roasted at different power levels and exposure times with different depth using a microwave oven and the conventional method during storage (meqg/kg oil).

	Exposure time (Min.)	Storage period (days)						
		0	15	30	45	60	75	90
Depth of Seeds (1 cm)	3	3.83	4.64	4.78	4.90	5.02	5.10	5.15
	4	4.95	5.79	5.92	6.02	6.19	6.30	6.40
	5	5.11	5.91	6.03	6.10	6.16	6.21	6.31
	4	3.51	4.52	4.63	4.73	4.80	4.90	5.03
	6	5.34	6.02	6.14	6.23	6.34	6.42	6.52
	8	6.22	6.86	6.96	7.02	7.13	7.23	7.31
	10	5.39	6.24	6.36	6.42	6.52	6.59	6.66
	12	5.91	6.58	6.70	6.78	6.86	6.91	6.98
	14	7.44	7.91	7.96	8.02	8.12	8.22	8.31
	30	5.26	6.25	6.32	6.40	6.49	6.55	6.63
	40	6.21	6.92	6.98	7.04	6.82	6.90	6.95
	50	6.80	7.37	7.40	7.44	7.50	7.57	7.64
Depth of Seeds (2 cm)	3	4.74	5.32	5.47	5.56	5.64	5.72	5.79
	4	5.12	5.87	5.99	6.09	6.21	6.32	6.36
	5	5.61	6.10	6.14	6.21	6.30	6.35	6.42
	4	3.76	4.64	4.74	4.898	4.95	5.05	5.14
	6	5.63	6.41	6.49	6.60	6.66	6.73	6.83
	8	6.31	7.02	7.08	7.14	7.21	7.31	7.37
	10	4.40	5.02	5.14	5.25	5.33	5.45	5.56
	12	5.26	6.39	6.50	6.59	6.67	6.72	6.78
	14	6.99	7.62	7.72	7.80	7.88	7.97	8.05
	30	5.62	6.10	6.24	6.33	6.46	6.55	6.62
	40	6.26	6.89	7.01	7.15	7.22	7.33	7.42
	50	7.15	7.75	7.82	7.93	8.02	8.07	8.15
Conventional Method		7.31	7.62	7.77	7.81	7.84	7.92	7.99

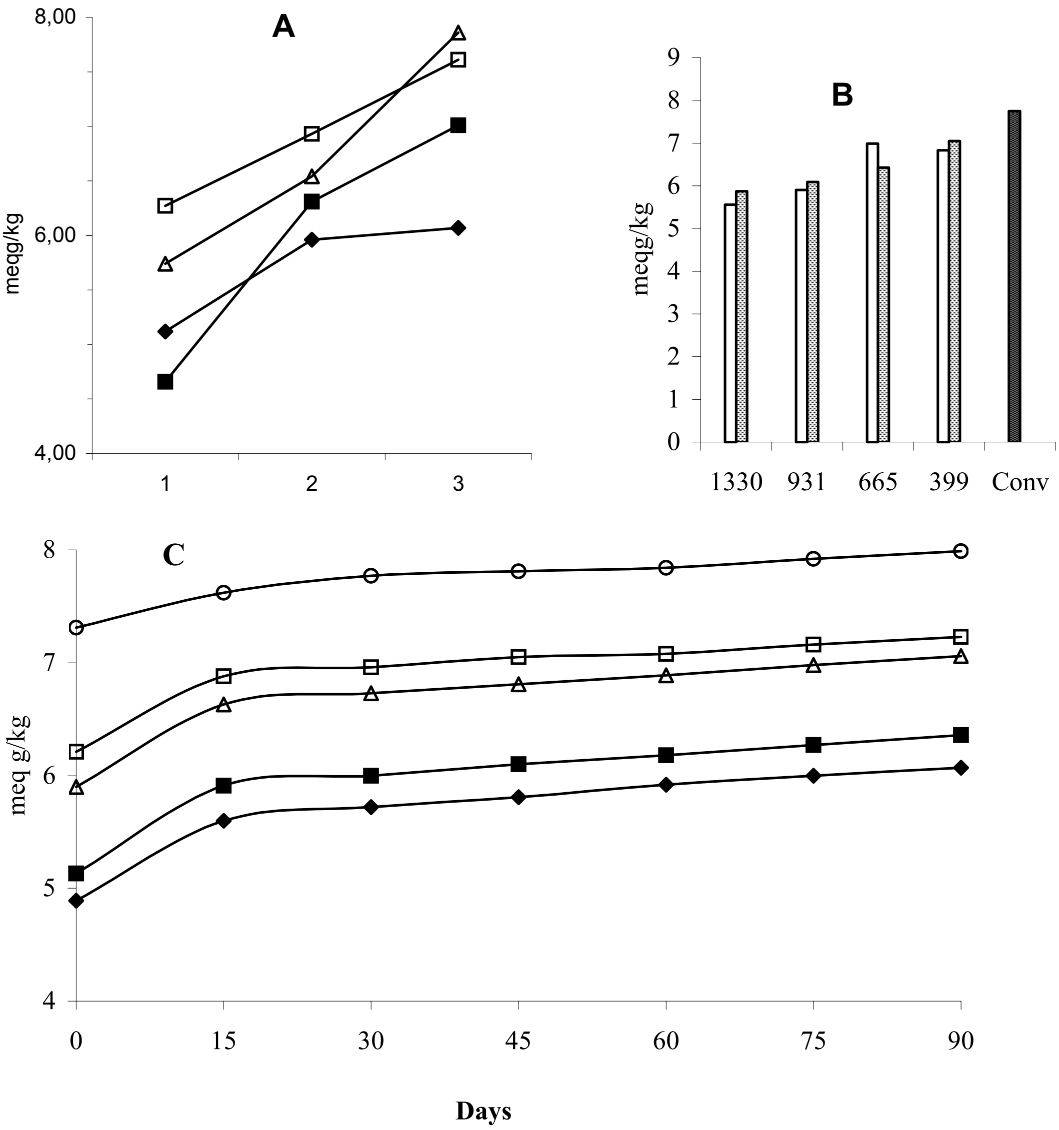

Figure 4. A: Changes in the peroxide value of tehina oils prepared from sesame seeds roasted in a microwave oven [(see footnote Figure 1), n =4], B: Relationships between the depth of seeds (□ 1 cm ▩ 2 cm) and peroxide value of tehina oils prepared from sesame seeds roasted in a microwave oven [(see footnote Figure 2) and conventional methods (Conv.), n=6], C: Changes in the peroxide value during storage (—♦— 1330 W, —■— 931 W, —Δ— 665W, —□— 399 W, —o— Conv.).

affected ($p<0.05$) by the depth of the microwaved seed. The PV of tehina oils from microwaved seeds at 399, 931 and 1330 watts, at a depth of 2 cm, was significantly ($p<0.05$) higher than those exposed to the microwave at a depth of 1 cm (Figure 4b). The peroxide value of tehina oil from seeds which were roasted by the conventional method was higher than that of those seeds roasted by microwaves.

The PV values of tehina oils from microwave roasted and conventionally roasted significantly ($p<0.05$) increased during the 3 month storage period. However, the increase in PV values occurred especially quickly during the first two weeks of the storage time. The PV values increased more gradually during the storage period after first two weeks (Figure 4c).

Yoshida and Kajimoto (1994) reported that PV increased gradually with the increasing time of microwave heating.

Yoshida and Takagi (1997) roasted sesame seeds in an electric oven and they found that the PV of oils increased with increasing roasting temperature and time. They reported that there were only minor increases ($p<0.05$) in PV in the sesame oils roasted for 25 min. Hydroperoxide is the primary product of lipid oxidation; therefore, the determination of peroxide value can be used as an oxidative index for the early stage of lipid oxidation (Yen and Shyu, 1989). Abou-Gharbia et al. (1996) reported that sesame oils prepared under different processing conditions, exhibited an increase in their PV with storage time.

4. Conclusions

When sesame seeds were roasted at different powers and for different times in a microwave oven, their quality was as good as that of those which were prepared by conventional heating. It is possible to roast sesame seeds from 3 to 50 minutes depending on the power setting. If the applied power is low, the exposure time has to be longer, so that the energy transmitted to the seeds will increase. When 399 watts were used for longer than 40 min. the seeds became brown due to maillard reactions and phospholipid degradation. The roasting temperature of seeds in all powers and exposure times was not more than 170°C. The quality of sesame oil can be protected if the roasting temperature is below 200°C.

A microwave roasting is both a quick and simple method for preparing tehina of good quality. It is also possible to prepare tehina with a continued microwave roasting system.

In conclusion using microwaves to roast sesame seeds to produce tehina is possible, and this method is simple, fast and practical.

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