Oxidation Changes of Vegetable Oils during Microwave Heating

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Abstract: Oxidation changes of different types of vegetable oils were studied during microwave heating. Samples of vegetable oils (rapeseed, sunflower, soybean and corn oil), commercially available at the market in the Czech Republic, were heated in a microwave oven. Parameters as peroxide value, conjugated dienes and trienes levels were determined in oil samples before and after heating in the period from 3 to 30 minutes.

Keywords: microwave heating; peroxide value; conjugated dienes and trienes; vegetable oils

INTRODUCTION

The use of the microwave heating as the culinary technique is now widespread. Advantages of microwave heating include savings in time and energy and easy to use. These advantages make it one of the most attractive cooking methods.

Mechanism of microwave heating is different from the conventional heating. It represents the conversion of electromagnetic field energy to thermal energy, which arises in the field by polar water molecules in food. Bipolar water molecules are rotated in accordance with changes in the alternating electromagnetic field, which leads to the intermolecular friction and overcoming intermolecular forces, thus creating heat and leads to rapid heating of material. Microwave can penetrate to the depth of material, according to the dielectric parameters, thereby heating the material at the same time, both inside and on the surface (Sumnu 2001).

Many studies have been conducted to investigate the nutritional properties of food treated in a microwave oven, specifically in vegetable oils and fatty foods. The unpleasant flavour of oxidized oils has been attributed to the secondary products of unsaturated fatty acids (Vieira & Regitano-D'Arce 2001). The primary products of lipid oxidation are hydroperoxides that are generally referred to as peroxides. It was found that the rate of quality deterioration, such as oxidation, depends on the polyunsaturated fatty acid content (Yoshida *et al.* 1990). Oxidation of polyunsaturated fatty acids is accompanied by an increase in the ultraviolet absorption: lipids with dienes or polyenes show a shift in their double-bond positions due to isomerization and conjugation formation, and the resulting conjugated dienes exhibit an intense absorption at 232–234 nm. The levels of free fatty acids also increased in vegetable oil heated in microwave oven (Yoshida *et al.* 1992).

In this work, the objective was to study the influence of microwave heating on the four selected oils often used in our country: sunflower, soybean, rapeseed and corn oils. The traditional parameters as peroxide value and conjugated dienes and trienes were determined.

MATERIAL AND METHODS

Material. Vegetable oils were bought on the Czech retail (soybean oil Coroli, corn oil Carapelli, sunflower oil Vegetol gold and rapeseed oil obtained from Setuza company).

Analytical methods. Peroxide value was determined according to the ISO 3960: Animal and vegetable fats and oils – Determination of peroxide value. The values were expressed as meq O_2/kg.

Conjugated dienes and trienes were determined by ultraviolet spectrophotometry using spectrophotometer Cary 100 Bio (Varian, Palo Alto, USA) and results were converted into % using the coefficients suggested by IUPAC Method 2.206.

Microwave heating. Sample of oil (25.0 g ± 1.0 g) was weighed into the petri-dish with inner diameter 14 cm. This dish was placed alone in the middle of the rotating plate of the microwave oven Electrolux, model EMM 2005. Oils were heated in the microwave oven for 3, 6, 9, 12, 15, 20, 25, and 30 minutes. Two independent series of experiments were carried out under the same conditions. After heating and cooling were samples kept in plastic bottles in refrigerator till analysis. Temperatures in the oven reached approximately 100, 120, 150, 165, 185, 200, 210, and 220°C at the respective heating periods. Changes of the temperature during the microwave heating of oils were very similar (the differences of the temperature between different kinds of oils did not exceed 4%, between the same oils were differences less than 2%).

RESULTS AND DISCUSSION

The peroxide value was taken as a measure for the degree of oxidation during the microwave heating of oil samples. The results are graphically represented in Figure 1.

It can be seen the rate of peroxide formation in rapeseed oil is lower than that in other oils during microwave heating. Accordingly, it seems that the rates of peroxide formation in the tested oils are arranged in following ascending order: rapeseed oil > corn oil > soybean oil ~ sunflower oil. The highest peroxide value of soybean oil was also found in the work published by Naz *et al*. (2004) and by Hassanein *et al.* (2003). It was observed that the peroxide value of these oils increased gradually as microwave heating is progressing till they reached the highest values. These oils showed different behaviours according to fatty acid composition.

It was found that as microwave heating was progressing, the amount of conjugated dienes

Table 1. Changes of the content of conjugated dienes (% w/w) during microwave heating

	Heating time (min)	Oil			
		rapeseed	sunflower	soybean	corn
Series 1	0	0.24	0.29	0.21	0.24
	3	0.25	0.29	0.21	0.24
	6	0.27	0.30	0.25	0.26
	9	0.28	0.45	0.33	0.25
	12	0.31	0.65	0.37	0.37
	15	0.47	0.75	0.51	0.44
	20	0.54	1.39	0.75	0.64
	25	0.75	1.80	0.99	1.03
	30	0.85	2.10	1.33	1.35
Series 2	0	0.24	0.30	0.22	0.23
	3	0.25	0.30	0.23	0.24
	6	0.25	0.31	0.26	0.26
	9	0.28	0.47	0.32	0.29
	12	0.31	0.63	0.40	0.36
	15	0.47	0.74	0.54	0.43
	20	0.53	1.39	0.78	0.63
	25	0.74	1.73	0.98	1.09
	30	0.85	2.09	1.36	1.40

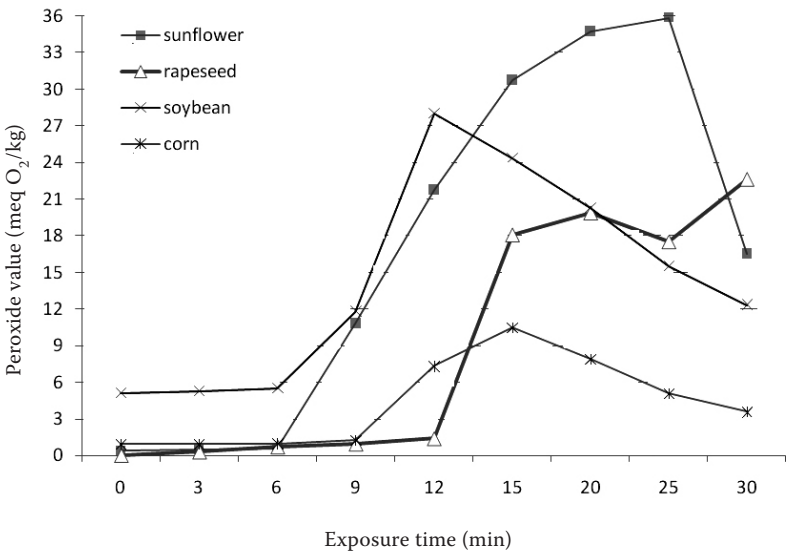

Figure 1. Relationship between peroxide value and heating time during microwave treatment

and trienes gradually increased. The changes of conjugated dienes are shown in Table 1.

The amount of conjugated dienes increased at rapeseed oil from 0.2 to 0.9%, at soybean and corn oil from 0.2% to 1.4% and at sunflower oil from 0.3% to 2.1%. The absorbance at 232 nm, due to the formation of conjugated dienes, was a good index for measuring the degradation of microwave heated samples.

Conjugated trienes were measured at wavelengths 262, 268, and 274 nm. The amounts of

Table 2. Changes of the content of conjugated trienes (% w/w) during microwave heating

	Heating time (min)	Oil			
		rapeseed	sunflower	soybean	corn
Series 1	0	0.03	0.09	0.01	0.05
	3	0.03	0.09	0.02	0.07
	6	0.04	0.09	0.02	0.08
	9	0.04	0.10	0.02	0.09
	12	0.05	0.12	0.02	0.08
	15	0.08	0.14	0.02	0.05
	20	0.12	0.09	0.03	0.09
	25	0.14	0.04	0.06	0.10
	30	0.16	0.04	0.06	0.09
Series 2	0	0.03	0.09	0.01	0.05
	3	0.03	0.09	0.02	0.07
	6	0.04	0.09	0.02	0.08
	9	0.05	0.10	0.02	0.09
	12	0.06	0.11	0.02	0.08
	15	0.08	0.14	0.02	0.05
	20	0.12	0.09	0.03	0.09
	25	0.14	0.04	0.06	0.10
	30	0.17	0.04	0.06	0.09

trienes were in range from 0.01 to 0.14 as is shown in Table 2. The conjugated dienes were formed at higher levels than the conjugated trienes which corresponded with results published by Dostálová (2005).

CONCLUSION

The most suitable vegetable oil for heating in microwave oven is rapeseed oil. The changes of conjugated dienes and changes of peroxide value were very small during first 12 min of heating in this oil.

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