# Oxidation of Olive Oils during Microwave and Conventional Heating for Fast Food Preparation

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**Abstract**: The oxidation stability of extra virgin and refined olive oils produced in different countries were studied under different conditions of microwave heating (microwave oven Electrolux, 2450 MHz, 500 W) and conventional heating (200°C). Oils were heated in a microwave oven and in a conventional oven for 0, 3, 6, 9, 12, 15, 20, 25, and 30 minutes. The evaluated parameters were peroxide value, content of conjugated dienes, conjugated trienes (determined by absorbance at 233 nm and 274 nm, respectively), and fatty acid composition by GC. During microwave and conventional heating peroxide values and contents of dienoic compounds differed significantly between control and the heated samples. The microwave treatment did not produce significantly greater amount of oxidation products than traditional heating.

**Keywords**: conjugated dienes; conjugated trienes; conventional heating; fatty acids composition; lipid oxidation; microwave heating; olive oil; peroxide value

## INTRODUCTION

Olive oil is a major vegetable oil for several thousands years and has a long history with many biblical references. Its oxidative stability and unique flavour are linked to the fatty acid composition of the oil, particularly its high level of oleic acid, low value of polyunsaturated fatty acids, and to its many minor components still present in virgin (i.e., unrefined) oil. (Angerosa & Basti 2003).

Recently, the utilisation of microwave heating, defrosting or cooking in household, catering, restaurants and fast food preparation is rapidly increasing during the past few decades because of its swiftness, easy of operation, and cost benefits (Yoshida *et al*. 2002; Lee *et al*. 2004). Changes of fats and oils have been intensively studied as the temperature of fat and oils can substantially increase during the operation. The temperature of the fat phase increases twice as fast during the microwave heating than the temperature of water or water containing foods under comparable conditions (Dostálová *et al.* 2005). The effect of microwave heating on the different components in foods can differ significantly from those produced by heating in a conventional oven. For example, free radicals can be formed in high amounts by exposure to microwave energy, especially when high temperature is reached, as is the case when fatty foods are cooked. The possible isomerisation (formation of trans) of the double bonds of fatty acids as a consequence of exposure to microwave energy (Albi *et al*. 1997) can occur.

The objective of this study was to compare the oxidation stability and changes of extra virgin and refined olive oils produced in different countries under different conditions of microwave heating and conventional heating as used for fast food preparation.

## MATERIAL AND METHODS

***Material.*** Oils selected for the experiments were refined olive oil was produced by Unilever

company in Czech Republic (Bertolli Classic) from Italian olives and extra virgin olive oil produced by Al karma Imp& Exp Cairo-Egypt Republic (1 olive oil extra virgin) from Egyptian olive.

***Microwave heating***. Two samples (25.0 g ± 1.0 g) of each treatment were weighed in Pyrex Petri dishes of 14 cm diameter, covered with PVC. The microwave oven (Electrolux, model EMM2005, 2450MHz, manufactured by PRC) operated at 500 W. The samples were heated in a microwave oven in the centre of the rotating plate 27 cm in diameter for 3, 6, 9, 12, 15, 20, 25, and 30 min, two independent series of experiments were carried out under the same conditions. The same operation was cared out in a conventional oven (Bravo, 1200 W, 50 HZ, manufactured by Czech Republic) and the heating was regulated at 200°C. After each heating period, the oil temperature was determined with a digital thermometer and the microwave oven was stopped for 30 min in order to be cooled down before starting the next heating. All the samples were cooled rapidly, and stored in sealed tubes at –18°C till the analysis.

***Analytical methods***. The following standard analytical methods of IUPAC (Paquot & Hautfenne 1987) were used: the peroxide value (Method 2.501) was determined iodometrically, and the results were expressed in meq/kg; conjugated dienoic and trienoic compounds were determined by ultraviolet spectrophotometry, and the results were converted into % using the coefficients suggested by IUPAC (Method 2.206). The fatty acid composition was determined by gas chromatography (Metod 2.302) after conversion into the respective methyl esters (Method 2.301) on the gas chromatography HEWLETT PACKARD. USA, with column Supelco Sp 2560s. The results were expressed in % of areas of methyl ester peaks.

***Statistical methods***. The data were evaluated using the one-way ANOVA and the regression analysis. The software Stat soft, Inc. (USA) modified in STATISTICA-CZ (Software system for data analysis), version 7.1 was used (StatSoft CR).

## RESULTS AND DISCUSSION

Results of the temperature course performed on the oil samples after both microwave and conventional heating are shown in Figure 1, which include at the end of each heating period the results of the statistical analysis as well as. The temperature increased slightly with the increasing heating time and was similar for equivalent heating times (Dostálová *et al.* 2005). The temperature course for microwave heating was relatively lower than conventional heating for both kinds of experimented oils.

The effect of microwave and conventional heating were measured according to the effect of heating time on changes of the peroxide value which are shown in Figure 2. Differences between the duplicate series of experiments were not statistically significant. The peroxide value increased at high rate only after the end of induction period, after 9 min heating in the case of extra virgin and refined olive oils, when the temperature reached about 140°C. For extra virgin olive oil used in this experiment, therefore, the original peroxide value was relatively higher than in refined olive oils, but it changed only a little because of the low content of linoleic acid and the presence of phospholipids

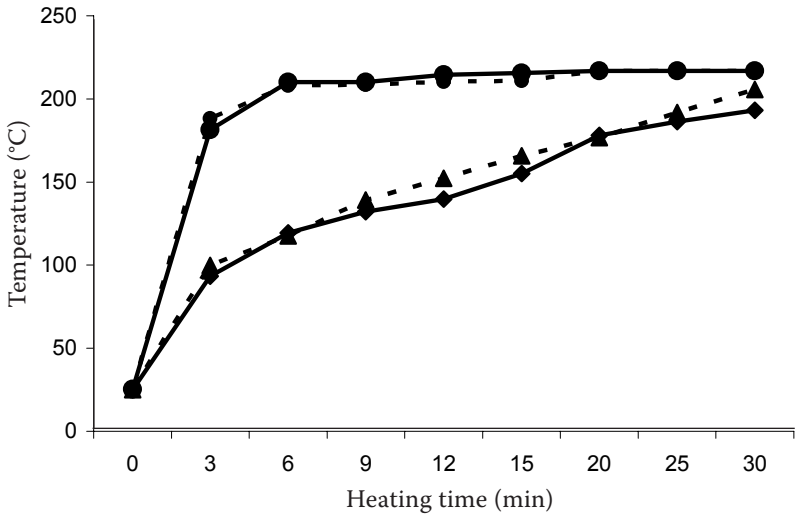


Figure 1. Course of temperature for extra virgin and refined olive oils during microwave and conventional heating

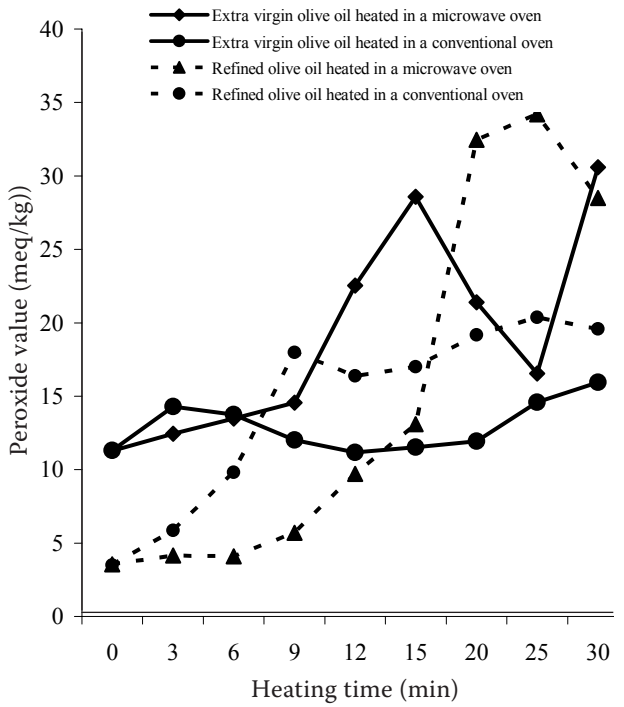


Figure 2. Changes of peroxide value (meq/kg) of extra virgin and refined olive oils during microwave and conventinal heating

which accelerate the hydroperoxide decomposition. Changes of olive oil due to microwave and conventional heating were only small because of low contents of polyenoic acids and relatively high contents of natural antioxidants especially in virgin oils (Boskou 2002). Peroxide value was not a good index for measurement of oxidation because hydroperoxides are unstable on heating at high temperatures. In general, Levels of peroxide value were higher in extra virgin olive oil than in refined olive oils during microwave heating, however, lower after 15 min during conventional heating.

The content of conjugated dienoic bonds is shown in Figure 3. Absorptivity at 233 nm increased gradually with the increase in microwave and conventional exposure heating time. Conjugated trienoic bonds were present only in traces below 0.05 and 0.07% for extra virgin and refined olive oils in microwave and conventional heating, respectively. Therefore, their content is not shown. A significant increase in absorptivity at 270 nm started from 6 min of heating. This would be in agreement with the results of Albi *et al*. (1997), who found greater values of absorptivity at 270 nm in olive and sunflower oils heated for 120 min (170°C) in a microwave oven. UV scanning detected alterations in the spectrum of microwaved samples. As regards the effect of the different heating methods, the higher extent of oxidative degradation was found in microwaved than in conventionally treated oils.

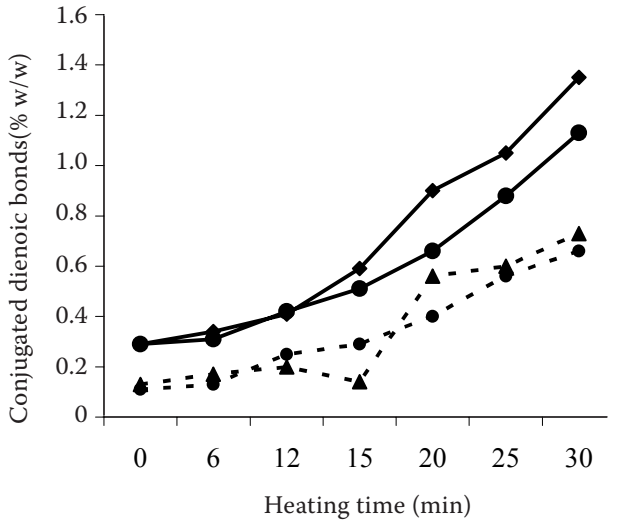


Figure 3. Changes of conjugated dienoic bonds (%) for extra virgin and refined olive oils during microwave and conventional heating

As evident from Table 1 the most abundant fatty acids found in extra virgin and refined olive oils were palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1n-9c), linoleic acid (C18:2n-6c) and linolenic acid (C18:3n-3). However, refined olive oil had higher levels of the C18:2 polyunsaturated fatty acid (Boskou 2002). Microwave and conventional heating for 30 min affected both experimental oils. The observed changes were not similar for the different fatty acids because some fatty acids decreased, some increased and others did not change. Isomerisation (formation of trans C18:1) of fatty acids as a consequence of exposure to microwave and conventional energy is possible. These differences might be due to the different energy transmission and subsequent heat generation in the two types of heating system. (Caponio *et al*. 2002).

## CONCLUSIONS

Effect of heating in a microwave oven is only insignificant in comparison with a conventional oven. These difference might be due to the different energy transmission and subsequent heat generation in the two types of heating systems (Caponio *et al*. 2002). The oxidative state of li-

Table 1. Fatty acid composition (% of total fatty acids) after heating for 30 min of extra virgin and refined olive oils submitted to different cooking methods

| Fatty acids | Extra virgin olive oil | | | Refined olive oil | | |
|---|---|---|---|---|---|---|
| | control | microwave | conventional | control | microwave | conventional |
| C:8 | n.d | 0.05 | 0.05 | n.d | 0.05 | 0.02 |
| C:12 | 0.02 | n.d | 0.03 | n.d | n.d | n.d |
| C:14 | 0.02 | n.d | 0.03 | n.d | 0.03 | nd |
| C:16 | 11.23 | 11.99 | 12.30 | 10.94 | 11.55 | 11.33 |
| C:17 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 | 0.14 |
| C:18 | 2.56 | 2.91 | 2.91 | 2.70 | 2.83 | 2.83 |
| C:20 | 0.46 | 0.50 | 0.49 | 0.51 | 0.53 | 0.52 |
| C:22 | 0.16 | 0.17 | 0.17 | 0.23 | 0.24 | 0.24 |
| C:24 | 0.06 | 0.06 | 0.06 | 0.08 | 0.09 | 0.08 |
| ∑SFA | 14.65 | 15.81 | 16.17 | 14.59 | 15.45 | 15.17 |
| C 6:1 | 0.83 | 0.81 | 0.87 | 0.80 | 0.75 | 0.75 |
| C17:1 | 0.08 | 0.08 | 0.08 | 0.11 | 0.11 | 0.11 |
| C18:1 | 76.32 | 76.23 | 75.74 | 72.21 | 72.71 | 72.58 |
| C20:1 | 0.31 | 0.31 | 0.31 | 0.33 | 0.33 | 0.32 |
| C22:1 | 0.55 | 0.31 | 0.26 | 0.21 | 0.15 | 0.17 |
| ∑MUFA | 78.10 | 77.75 | 77.25 | 73.66 | 74.06 | 73.93 |
| C18:2 | 6.48 | 5.70 | 5.76 | 10.66 | 9.44 | 9.81 |
| C18:3 | 0.75 | 0.52 | 0.54 | 0.74 | 0.57 | 0.61 |
| ∑PUFA | 7.22 | 6.23 | 6.30 | 11.40 | 10.01 | 10.43 |
| C18:1 T | n.d | 0.22 | 0.23 | 0.26 | 0.39 | 0.38 |
| C18: 2T | n.d | n.d | n.d | 0.03 | n.d | n.d |
| ∑Trans | n.d | 0.22 | 0.23 | 0.30 | 0.39 | 0.38 |
| ∑TFA | 99.97 | 100.01 | 99.95 | 99.95 | 99.91 | 99.91 |
| SFA/PUFA | 2.03 | 2.54 | 2.57 | 1.28 | 1.54 | 1.45 |

SFA – saturated fatty acid; MUFA – monounsaturated fatty acid; PUFA – polyunsaturated fatty acid; TFA – trans fatty acids; n.d. – not detected

pids after microwave heating under conditions commonly used in culinary technology for use in household and catering leads to the conclusion that, in most cases, deteriorative changes are only small so that lipids after heating of up to 30 minutes may be considered as still suitable for fast food and catering consumption.

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