PALM OIL DEGRADATION UNDER MICROWAVE TREATMENT

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Abstract

In this paper we present the results of our research on the degradation of palm oil 5, 10, 15, 20, and 25 minutes after microwave treatment. We have determined and quantified the following quality indices: refractive index, saponification index, relative density, and concentration of malonaldehyde. Refractive index increased significantly 5 minutes after palm oil microwave treatment, then it remained almost constant 25 minutes after treatment. Saponification index decreased from 190 (mg KOH/g oil) to 158 (mg KOH/g oil), undeniable evidence that degradation of palm oil treated in a microwave oven for 25 minutes is quite significant. Acid value increased in sample 2 (held for 10 minutes in the microwave) from 0.18% to 0.76% peaking after 20 minutes of microwave treatment. Density variation is negligible and ranged within permissible limits. Malonaldehyde concentration of palm oil samples treated for over 15 minutes in the microwave increased quite significantly 25 minutes after treatment initiation.

Keywords: palm oil, irradiation, oxidation compounds, degradation, microwave

Introduction

Elaies guineensis originating from West Africa was first introduced in Brazil and other tropical countries in the 15th century by the Portuguese. However, its propagation did not take off until the 19th century when the Dutch brought seeds from West Africa to Indonesia resulting in four seedlings planted in Bogor in 1848. Like in all oils, triglycerols (TGs) are the major constituents of palm oil. Over 95% of palm oil consists of mixtures of TGs, that is, glycerol molecules, each esterified with three fatty acids. During oil extraction from the mesocarp, the hydrophobic TGs attract other fat- or oil-soluble cellular components. The minor components of palm oil are: phosphatides, sterols, pigments, tocopherols, tocotrienols, and trace metals. Other components of palm oil are the metabolites of the biosynthesis of triglycerols and the products of lipolytic activity. These include monoglycerols, diglycerols, and free fatty acids. [1-10]

Palm fruit (*Elaies guineensis*) yields palm oil, a palmitic-oleic acid rich semi-solid fat containing fat-soluble minor components, vitamin E (tocopherols, tocotrienols), carotenoids, and phytosterols.

Palm oil's rich content of saturated and monounsaturated fatty acids has actually been turned into an asset in view of current dietary recommendations aimed at zero *trans* content in solid fats such as margarine, shortenings, and frying fats. Using palm oil in combination with other oils and fats facilitates the development of a new generation of fat products that can be tailored to meet most current dietary recommendations. The wide range of natural palm oil fractions, differing in their physic-chemical characteristics, the most notable of which is the carotenoid-rich red palm oil, further assists this. Palm vitamin E (30% tocopherols, 70% tocotrienols) has been extensively researched upon for its nutritional and health properties, including antioxidant activities, cholesterol lowering, anti-cancer effects, and protection against atherosclerosis. These are attributed largely to its tocotrienol content. A relatively new output from the oil palm fruit is the water-soluble phenolic-flavonoid-rich antioxidant complex. This has potent antioxidant properties coupled with beneficial effects against skin, breast and other cancers. [1-10]

Materials and Methods

The experimental procedures were performed with Mohr-Westphal hydrostatic balance to determine the relative gravity of the oil in question. For the determination, the balance is adjusted correspondingly by: equilibrating balance with air float device, equalizing the temperature of the oil and the air float, rebalancing and reading from the graduated scale. Determination of refractive index was performed with an Abbé refractometer. [11]

The acid index in oil represents the number of mg of KOH required to neutralize free acids in a gram of sample. Reactants used to determine the acid index were the following: ethyl alcohol 96% pa Bucharest Reagent, potassium hydroxide 0.1 N and 0.5 (Sigma), and phenolphthalein (Sigma). Acid value is calculated with the formulas:

$$AI = \frac{5.61 \cdot V_{0.1N}}{m} \text{ (mg KOH/g)}; \qquad AI = \frac{28.05 \cdot V_{0.5N}}{m} \text{ (mg KOH/g)}$$

where:

$V_{0.1N}$ – volume of KOH 0.1N required for titration (ml);
$V_{0.5N}$ – volume of KOH 0.5N required for titration (ml);
m – mass of oil used (g). [11]

To determine the saponification index, we used ethyl alcohol 96% Bucharest reagent 0.5N, hydrochloric acid (reagent Bucharest) 0.5 N, potassium hydroxide and phenolphthalein, both Sigma. Saponification index was determined by the relation:

$$SI = \frac{(V - \mathrm{V1}) \cdot 28 \cdot f}{m} \qquad \text{(mg KOH/g)}$$

where:

V = volume of HCl 0.5 N required for titration stock sample (ml);
V_1 = volume of HCl 0.5 N required for titration second sample (ml);
f = solution factor of HCl 0.5 N (ml);
m = mass of sample (g). [11]

Results

Irradiation significantly reduces the number of pathogenic microorganisms, but as for the milk pasteurization process, it doesn't eliminate all bacteria. For example, irradiated poultry still require refrigeration, and it is safer for longer periods of time than not-treated poultry. Irradiated strawberries can be stored for 2-3 weeks in the refrigerator, compared to untreated ones that can be kept only for a few days. Thus, irradiation complements, but does not replace, the need for proper handling of food by participants in the goods – money circuit. Since the irradiation process can be used for large or small amounts, it has a wide range of potential uses: a serving of poultry can be irradiated for use in space flight, or a large quantity of potatoes may be treated to reduce sprouting during storage in the warehouse. Irradiation may not be used for all foods, because it can cause unwanted taste changes in dairy products and tissue softening in some fruits like peaches or nectarines.

Table 1. Variation of physico-chemical indices of treated palm oil in the microwave

	Palm oil treatment in the microwave					
Physico-chemical index	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Refractive index ($20^{O}C$)	1.467	1.467	1.467	1.4671	1.467	1.4421
Saponification index (mg KOH / g oil)	190	189	184	166	158	167
Acid index (%)	0.15	0.27	0.35	0.39	0.76	0.67
Relative density (g / cm3)	0,899	0.887	0.891	0.889	0.903	0.934

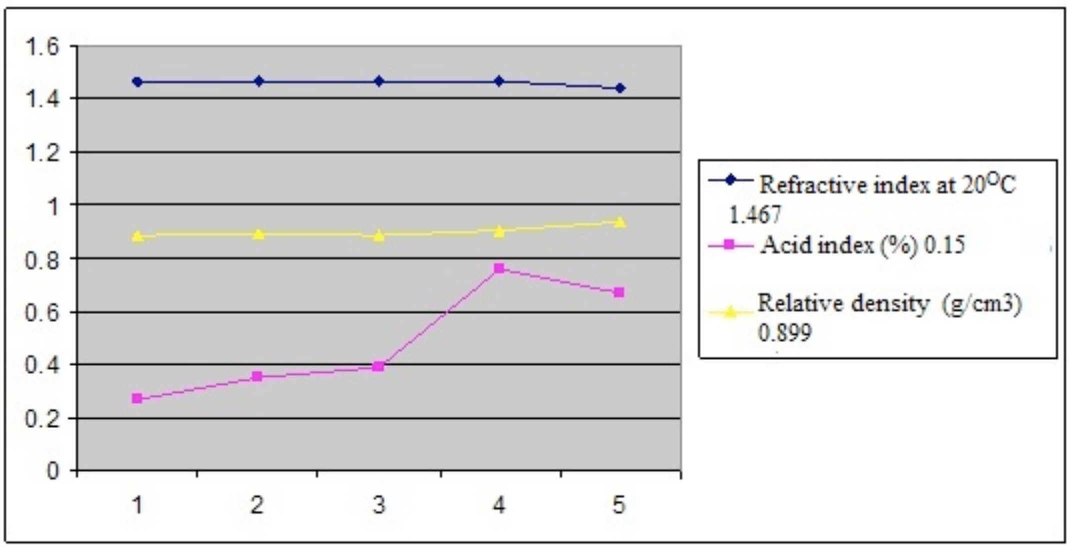

Figure 1. Variation of the refractive and acid indices of the palm oil treated in the microwave

To notice that the relative refractive index and the density remain within permitted limits; the acid value increases, influenced by the time of the microwave treatment of the palm oil, exceeding in the 2^{nd} sample (treated 10 minutes in the microwave) the value of the acid index, which no longer ranges within maximum admitted limits (a maximum of 0.76%) (Figure 1).

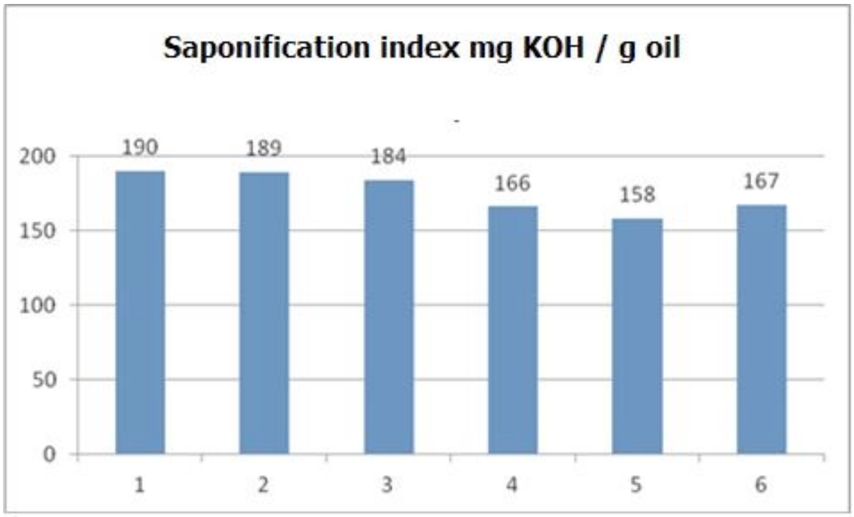

Figure 2. Saponification index variation in the palm oil treated in the microwave

Figure 2 shows that the saponification index has decreased in the 3rd sample (treated 15 minutes in the microwave). The saponification index decreased from maximum value (184 mg KOH/g oil), and reached, after 20 minutes of microwave treatment, a value of 158 (196-199% optimum ranges).

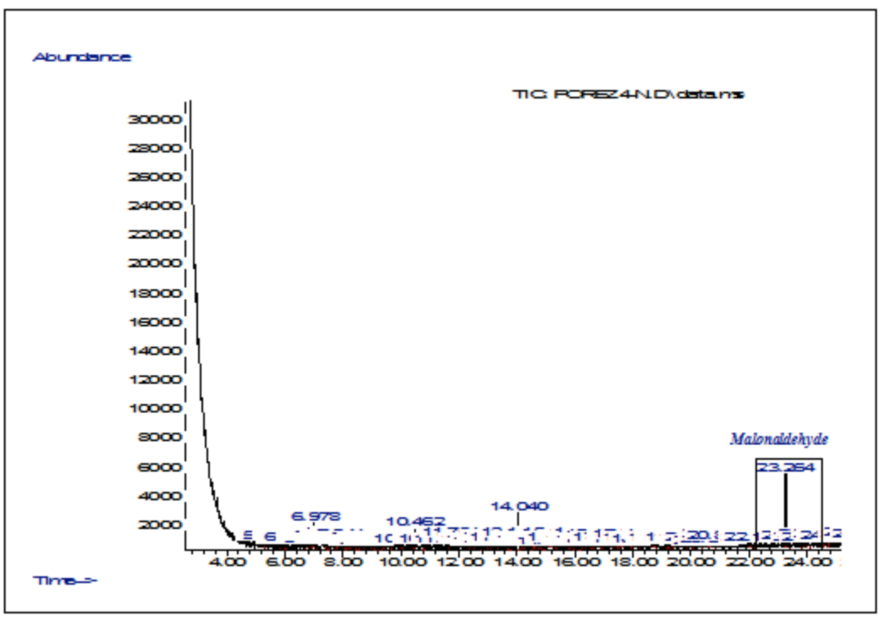

Figure 3. Gas chromatography from the GC-MS analysis of the palm oil treated for 20 minutes in the microwave

Table 2. GC-MS identification, retention times Kovats and concentration for malonaldehyde from the samples of the palm oil treated in the microwave

No.	MS identification	KI	S1	S2	S3	S4	S5
1	***Malonaldehyde, bis(dimethyl acetal)***	***885***	***0***	***0***	***0.05***	***0.15***	***0.27***

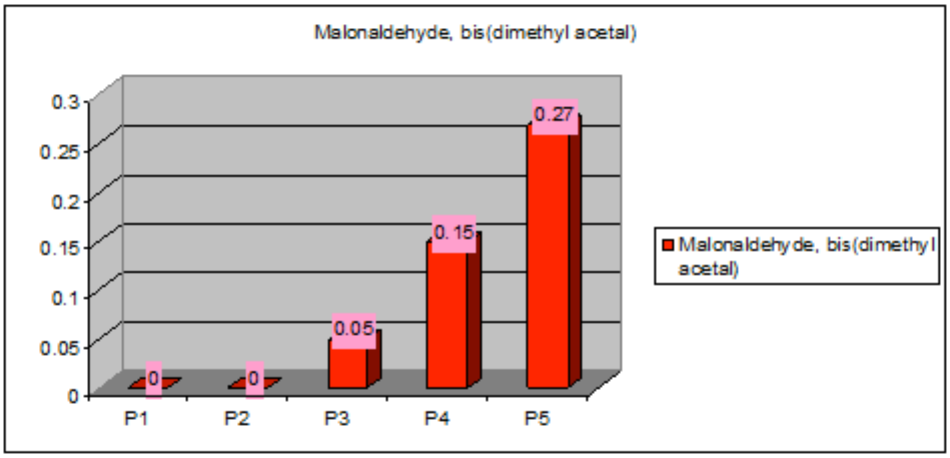

Figure 4. Concentration of malonaldehyde from the palm oil samples treated in a microwave

One can notice an increase in the malonaldehyde concentration of palm oil samples treated over 15 minutes in the microwave (concentration increased quite significantly 25 minutes after treatment).

Discussion

Research undertaken in this work led to the following conclusions:

- In some environments, there is the possibility of introducing antioxidant agents (usually synthetic compounds sterically-hindered phenols class), the trend being to appeal to natural antioxidants, with low toxicity, that are added to the media mentioned, or pre-existing in food matrices;
- Some compounds of oxidation of the bioactive molecules may lead, when accumulation in the human body occurs, to the appearance of various diseases, of which the major adverse effects are neoplastic diseases (various forms of cancer). From the resulting oxidation compounds, or the ones that generate free radicals in the body (responsible for reactions *in vivo* leading to various forms of mutagenesis), hydroperoxides and epoxides have a special place in terms of toxicity: they are very active both in synthesis chemicals and in the human body, binding to the DNA, RNA or to proteins;
- Following degradation of palm oil samples by repeated microwave treatments, we were able to identify a series of degradation products, especially compounds which

are part of the following classes: aldehydes (oxidation), epoxides, and vicinal dihydroxylated acids;
- Of the aldehydes identified as products of oxidation of palm oil, or other derivatives present in the sample, which were derivatized to the corresponding dimethyl acetals, malondialdehyde was found in increasing concentration in samples 3, 4 and 5.

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