Study of the behavior of some vegetable oils during the thermal treatment

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Abstract Large quantities of vegetable oils are consumed in food preparation, cooking and frying. The evaluation of the quality of vegetable oils is based on the measurement of their phisyco-chemical properties such as density, refractive index, viscosity, acid and iodine numbers. The aim of this paper is to evaluate the variation of vegetable oils quality as a result of thermal treatment. The evaluation is based on the measurement of some important phisyco-chemical properties of vegetable oils, before and after thermal treatment: density, viscosity, refractive index, acid number. Commercialy available olive oil, sunflower oil and corn oil were used in the study. Based on this experimental investigation, there can be predicted the changes in the vegetal oils characteristics and also there can be made correlation between their properties.

Keywords: vegetable oil, thermal treatment, physico-chemical properties.

1. Introduction

At present, vegetable oils are mainly employed in food area, but, as a result of enquiries regarding environment pollution, increased quantities are used as raw materials for biodiesel production [1, 2]. In food area, the quality of all ingredients is very important. Vegetable oils are often used in frying processes. The quality of oil is altereted during this processes. Spoilt oils may cause health problems [3].

Vegetable oils are mixtures of glycerides, fatty acids and some other compounds in small quantities, like hydrocarbons, alcohols, phenols, tocopherols, phospholipides [4 - 7]. The quality of vegetable oils is evaluated by the means of their physico-chemical properties such as density, viscosity, refractive index, acid number, iodine number [6 – 9].

In this study there was investigated the variation of some physico-chemical properties of vegetable oils as a result of thermal treatment. The density, refractive index, viscosity, acid number and colour for three different types of vegetable oils were determined before and after thermal treatment. The aim of this study was to investigate what is the behavior at thermal treatment, like the treatment during cooking-frying, of different types of vegetable oils ussually used in food thermal preparation.

2. Experimental

Three types of vegetable oils, commercialy available, were used in this study. All oils are of food grade. The olive oil was from the Italian trademark Costa d'Oro, the sunflower oil was from the Hungarian trademark UNISOL, and the corn oil was from the Romanian trademark SC MAN RO SRL. The main properties of these vegetable oils are presented in Table 1. Since all three vegetable oils have close density, refractive index and viscosity, they differ from acid number and colour. Corn oil has the greatest acid number and colour number, followed by olive oil and sunflower oil. This indicates sunflower oil is more refined and more stability is expected during the thermal treatment.

The density, refractive index, viscosity, acid number, and colour were determined for each oil sample, before and after thermal treatment. The mean temperature during thermal treatment was 210^{o}C, and the duration of the treatment was 240 minutes.

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Table 1. The main properties of the vegetable oils

Vegetable oil	Density [g/cm^3]	Refractive index	Acid number [mg KOH/ 100 ml]	Viscosity [mm/s^2]	Colour [Lovibond units]
Corn oil	0.9180	1.4706	150.487	32.85	3
Sunflower oil	0.9188	1.4735	40.9042	31.90	0.5
Olive oil	0.9119	1.4646	78.2735	37.85	1

The determination of physico-chemical properties of the vegetable oils were done at 30 minutes time intervals.

The density were determined by picnometer method. The viscosity was determined using an Ubbehlode viscometer. The refractive index was determined with an Abbe refractometer ATAGO 3T type.

The acid number was determined by titration with an alcoholic KOH solution.

The colour was determined with an Lovibond colorimeter.

It could be observed that the density, viscosity, refractive index of originale vegetable oils are comparable with that of thermal treated oils, indicating that the degradation process occurs with a slow rate. There are registered differences regarding the behavior of the three types of oils during thermal treatment.

In **Fig. 1** is represented the density variation of the vegetable oils as a result of the thermal treatment.

As one can see from Fig.1, the density of oils has small variations around the initial value, this indicating that the thermal treatment does not affect sensible the density as a result of relatively short periods of thermal treatment. The yield of degradation products is too small to have an important influence on the density. The density of oils tends slowly to increase after a long period of thermal treatment.

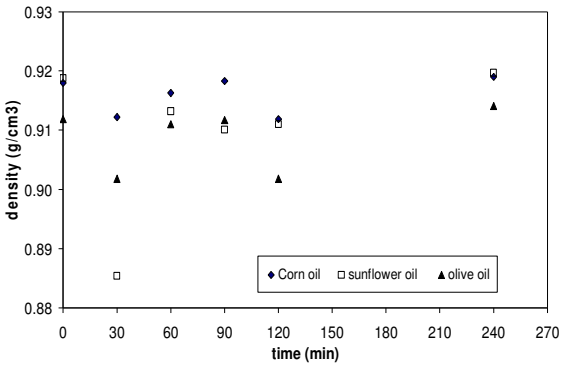

Fig. 1. Variation of the density of the vegetable oils during thermal treatment

All oils posses a high viscosity as a consequence of their long fatty chain structure. Olive oil has the greater viscosity between the three studied types of oils. For all three oils, it was observed a slow increasing of the viscosity in the first part of the treatment (up to 120 minutes), and a sharp increasing in the last part.

This effect was more evident in the case of olive oil (**Fig. 2**). In this case, the viscosity increased from 38cSt to 40 cSt in the first 120 minutes, then increased to 47cSt in the next 120 minutes. After 200 minutes of thermal treatment, there was observed a solid deposit formed in the olive oil.

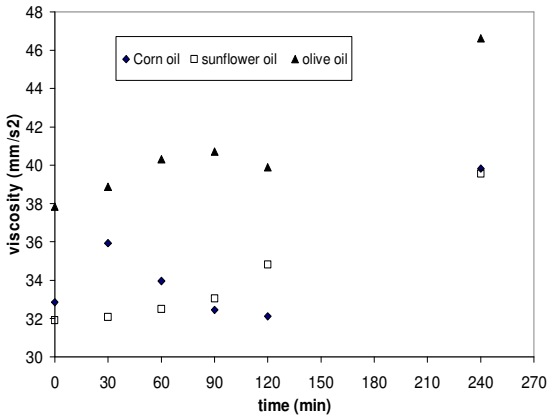

Fig. 2. Viscosity variation during thermal treatment

This behavior could be related to the polimerization process that occurs at elevated temperatures, resulting an increase in the amount of larger triglycerides [10] that have the ability to form long-range structural interactions. This process is slower in the first 120 minutes of thermal treatment and accelerated afterwards.

The refractive index of the vegetable oils is also increasing during thermal treatment (fig. 3). Biggest influence on the refractive index was observed at the corn oil, followed by the olive oil, and the most stable was the sunflower oil. The increasing of the refractive index seems to be in correlation with the refining process of the oils prior to the thermal treatment.

The vegetable oils could be considered to be formed by two key components corresponding to the most abundant group of compounds represented by triglycerides and free fatty acids [11]. The free fatty acids give information about oil degradation and this content is expressed in terms of acid number. The acid numbers characterizing the vegetable oils studied and their variation during thermal treatment is presented in fig.4. The acid number is rather stable during the heating for the corn and olive oils, and only the sunflower oil has an increasing towards the end of the process. This could be explained by the fact that this oil, due to its refining, was resistant to oxidation up to a point of the heating. After a prolonged treatment, this oil has the tendency of oxidation greater than the others unrefined oils.

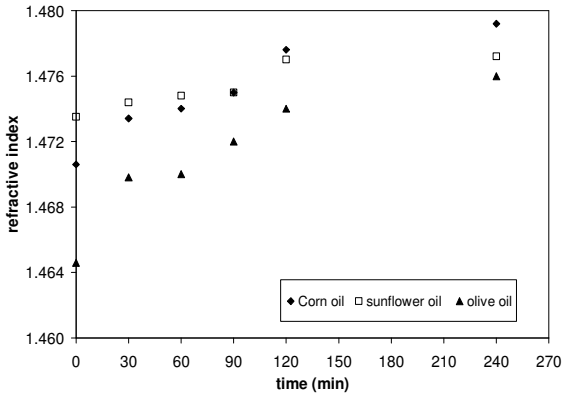

Fig.3. Refractive index variation during thermal treatment

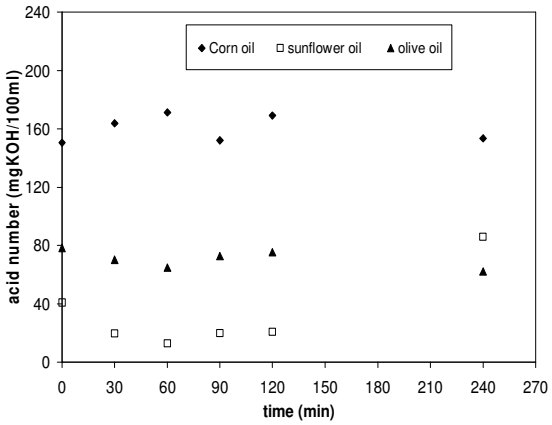

Fig.4. Acid number variation during thermal treatment

The color of the sunflower oil remained constant during thermal treatment, while the color of corn oil and olive oil was characterized by increasing Lovibond units during treatment.

The color of the corn oil varied from 3 to 2 Lovibond units after 240 minutes of treatment, while the color of the olive oil varied from 1 to 1.5 Lovibond units. The degradation that occurs during thermal treatment of the vegetable oils is reflected in the variation of their properties: density, viscosity, refractive index, acid number.

4. Conclusions

In this study three food grade vegetable oils were thermal treated and some of their physico-chemical properties were determined.

During thermal treatment there can be observed a normal degradation of the vegetable oils reflected by the variation in their properties: density, viscosity, refractive index, acid number and colour.

Under frying temperatures, the viscosity of the vegetable oils increased quickly. Olive oil was found to be more sensitive to thermal treatment than sunflower oil and corn oil, undergoing greater changes in its properties, especially in viscosity and colour.

The values of these characteristics could be used to predict vegetable oil stage of degradation as a result of thermal treatment.

5. References

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