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Effect of Reheating on Thermophysical Properties of Edible Oil at High Temperature

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Abstract: *This paper is focused on the evaluation of thermophysical properties of unheated oil and multiple times heated oils to study the thermal degradation of edible oil which is reheated for very long time and hence assess the quality of reheated oil being used in different first food shops and restaurants. The purpose of this study is to evaluate the changes in different thermophysical properties such as total energy, refractive index and conductivity of reheated edible oils that take place during the reheating of oils, in order to find an easy and cost effective technique for quality testing of edible oils. Study reveals that the refractive index and conductivity of reheated edible oil have increased and the total energy of edible oil has decreased due to reheating at high temperature for long time. Study also indicates that the presence of food contents during the heating of edible oil, affect the thermophysical parameters in some extent.*

Key words: *Reheated oil, thermophysical property, energy, refractive index, conductivity.*

1. INTRODUCTION

Edible oils are vital constituents of our daily diet, which provide energy, essential fatty acids and serve as a carrier of fat soluble vitamins. Edible oils (e.g. palm oil, soybean oil or vegetable oil) are continuously used for deep-fat frying in fast-food shops and restaurants for 12 to 40 hours at temperatures of about 200 to 220 degree centigrade causes several oxidative and thermal reactions which results in change in the thermophysical, chemical, nutritional and sensory properties over a time period during frying [1, 2]. The degree of these reactions depends on duration, method of heat treatment, frying medium and type of product [3, 4]. Reused oils could affect the shelf-life and nutritional quality of fried foods due to the development of rancidity in the frying oil taken up by the products [5, 6]. High frying temperature, associated with the presence of air and moisture, lead to production of breakdown products that include volatile and nonvolatile and toxin compounds. These products result from oxidation of unsaturated fatty acids, lipid hydrolysis, and transformation of linear fatty acids in cyclical compounds and fatty acid or lipid polymerization [7]. The volatile products such as aldehydes are lost during the frying process; the non-volatile fraction remains in the frying medium and is absorbed by the fried food. Some of these remaining products have been implicated in producing adverse health effects as they destroy vitamins, inhibit enzymes and could cause mutations or gastrointestinal irritations [8]. Highly oxidized oils may also produce polyaromatic hydrocarbons, which have carcinogenic effects [9].

Repeated heating of oils lead different thermodynamical reactions such as hydrolysis, oxidation and polymerization processes and as a consequence the composition of oil changes which in turn changes the flavor and stability of its compounds [10] and it also produces free radicals that are potentially harmful for human body [11] by attaching themselves with the healthy cells and leads to diseases. Atmospheric oxygen reacts instantly with lipid and other organic compounds of the oil to cause structural degradation in the oil which leads to loss of quality of food and is harmful to human health [12]. Another research found transition metals, such as iron, which is present in meat, increased the rates of oxidation and thermal degradation of oil [13].

Several researchers studied the impact of temperature on the stability, viscosity, peroxide value, and iodine value to assess the quality and functionality of the oil [14, 15, and 16]. Different physical and chemical parameters such as iodine value (IV), saponification value (SV), viscosity, density and

peroxide value (PV) of edible oil were used to monitor the compositional quality of oils [18, 19]. Here, in this work, thermophysical properties such as energy, refractive index, and electrical conductivity of reheated and unheated cooking oils, continuously being used in different first food shops and restaurants, were investigated as a part of the study.

2. SAMPLE COLLECTION

Unheated (i.e., Fresh) and multiple times heated edible oils were collected from the 20 different fast food joints and restaurants located in and around the Dhaka city. During the deep frying process these samples were heated for very long time (i.e., reheated for as much as 6 to 8 times and in total 50 hours) at high temperature (i.e., about 170˚C-220˚C). Some samples also have prepared in our laboratory by reheating fresh (or unheated) oil at 220˚C for several times with the help of a magnetic stirring electric heater. Before every test, sample was filtered and stirred very well to remove the food leftover from the reheated oil. All samples were divided into two different categories: samples prepared at laboratory as category A and samples collected from different first food outlets or restaurants as category B.

3. ANALYTICAL RESULTS

In this section three thermophysical characteristic properties such as total equivalent energy (TEE), conductivity, and refractive index of the oil samples (category A and B) is evaluated by the standard laboratory methods and analyzed accordingly.

3.1. Energy Evaluation

Long time heating of edible oils at high temperature produce different types of byproducts, and based on the original hypothesis, chemical compositions affect the energy (i.e., heats of combustion) of oils and it vary among the different oil types because of their compositional differences. Total equivalent energy (TEE) for all the oil samples (category A and category B) are measured using bomb calorimeter (Model Parr-600) and the changes in the characteristic property of total energy are analyzed in this section.

From the experimental results it is found that for every sample of category A and B, the quantity of total energy of edible oils is decreased as a consequence of repeated heating at high temperature for long time. Experimental results also indicates (shown in figure-1) that the amount of decrease of average energy is much higher (almost 12%) for category B sample than the category A (only about 1%).

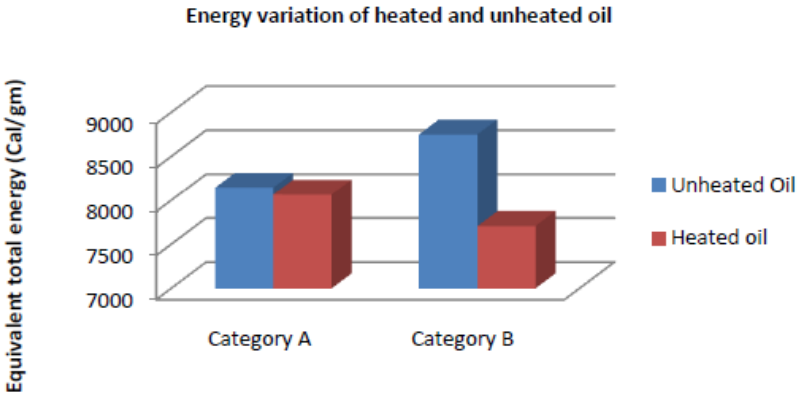

Figure1. *Changes in energy values for unheated and heated edible oil*

3.2. Refractive Index Evaluation

Refractive index is an important optical parameter to analyze the light rays traversing through materials medium. Refractive index can be used as a quality control technique to identify the adulteration of edible oils [20]. In this study, the refractive index of heated and unheated oils are evaluated and analyzed for both category-A and category-B samples using Abbe's refractometer. From the experimental results it is found that refractive index of the long time heated edible oil have increased for the both types (i.e., category-A and category-B) of samples, though, the amount of changes is very small. Average values of refractive index for heated and unheated oil samples are demonstrated by bar diagram (figure-2).

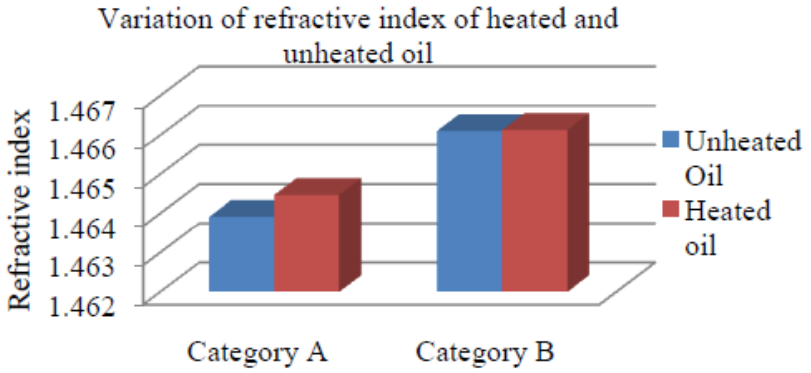

Figure2. *Changes in Refractive Index for unheated and reheated edible oils*

It is also illustrated that the refractive index of samples of category-A is slightly lower than the category-B samples and the changes in the value of refractive index due to long time heating is higher for the samples of category-A than the samples of category-B.

3.3. Conductivity evaluation

Long time heating of edible oils at high temperature produce different types of byproducts (such as free radicals) and these free radicals attach themselves to healthy cells and lead to carcinogenic diseases. The oxidation byproducts (free radicals) produced due to the repeated high temperature treatment (thermal decomposition) of oils affect the electrical properties as they are the major charge carriers and therefore increase the electrical conductivity (i.e., ionic current) of the oil [21]. The detection of these reactive species (free radicals) in oil may, in principle, provide useful information for monitoring oil degradation [22]. In this study conductivity of unheated and repeatedly heated edible oils were measured using conductivity meter (SensION EC5) with 95% accuracy at 25˚C temperature. Each and every oils sample was filtered properly and the probe of the conductivity meter was cleaned and dryied with methanol carefully before every reading had taken. From the table-3 (shown below), it is seen that the average conductivity of the reheated samples is increased for both laboratory prepared sample and restaurant's samples. From the figure-3 it is also clear that the average conductivity of the laboratory prepared sample is much higher than the conductivity of the samples collected from different first food shops and restaurants. Type A samples shows about 41% increment in electrical conductivity whereas type B samples shows relatively less increment in electrical conductivity (i.e., only 1.32%). It indicates that, it might be occurred due to cook foods take away the byproducts and left very small number of free radicals with the discarded oils.

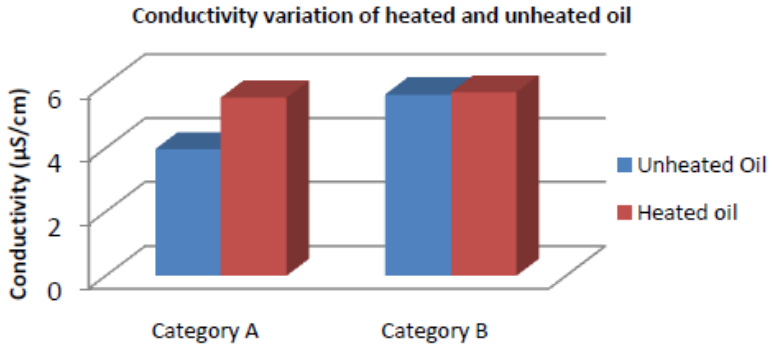

Figure3. *Changes in conductivity for unheated and reheated edible oils*

4. CONCLUSION

Thermophysical properties of edible oils have greatly affected by long time heating at high temperature. Total equivalent energy of the samples of category-A have decreased in less amount compared to the samples of category-B. On the other hand, conductivity of the long time heated samples of category-A shows much higher increased than the samples of category-B. It might be occurred due to the compositional difference of different oils: three different brand oils were taken as sample of category-A whereas samples of category-B usually are non-brand and bad quality oils (found in open market) used by most of the first food shop's owners. Another cause might be due to different heating process: category-A samples were heated in a control way in laboratory environment

without the presence of any food contents whereas the samples of category-B were heated in the presence of various food items under the open sky. Characterization of these thermophysical properties corresponding to different heating time and heating temperature could be the potential area of study. Further research is also necessary to explore the correlations among these three thermophysical parameters and therefore develop an appropriate technique for quality checking of edible oil.

REFERENCES

[1] Boskou G, Salta FN, Chiou A, Troullidou E and NK Andrikopoulos, **Content of trans, trans-2,4-decadienal in deep-fried an pan-fried potatoes,** *European Journal of Lipid Science and Technology*, 2006; 108: 109-115.

[2] Che Man, Y.B., Jasvir, **Effect of rosemary and sage extracts on frying performance of refined, bleached and deodorized (RBD) palm olein during deep fat frying,** Food Chem. 69, 301–307, 2000.

[3] Blumenthal M M, **A new look at the chemistry and physics of deep-fat frying.** *Food Technology*, 1991; 45: 68–71.

[4] Stevenson SG, Vaisey-Genser M and NAM Eskin, **Quality control in the use of deep frying oils,** *Ibid*, 1984; 61: 1102–1108.

[5] Che Man YB and I Jasvir, **Effect of rosemary and sage extracts on frying performance of refined, bleached and deodorized (RBD) palm olein during deep fat frying**, *Food Chemistry*, 2000; 69: 301–307.

[6] Rani M and GS Chauhan, **Effect of intermittent frying and frying medium on the quality of potato chips,** *Food Chemistry*, 1995; 54: 365–368.

[7] Chang SH, Peterson R and CT Ho, **Chemical reactions involved in deep fat frying of foods,** *Journal of American Oil Chemists Society*, 1978; 55: 717–728.

[8] Clark LW and GW Serbia, **Safety aspects of frying fats and oils,** *Food Technology*, 1991; 45: 84–94.

[9] **Dietary fats and oils in human nutrition. In: FAO. Food and Nutrition Series,** No. 20. Food and Agricultural Organization of the United Nations, Rome, 1988:1–44.

[10] Gloria, H., Aguilera, J.M., 1998. J. Agric, **Assessment of the quality of heated oils by differential scanning calorimetry,** Food Chem. 46,1363–1368.

[11] Shastry C.S, Patel Narendrakumar Ambalal, Joshi Himanshu & Aswathanarayana B.J, **Evaluation of effect of reused edible oils on vital organs of wistar rats.**

[12] Bhattacharya, A.B., Sajilata, M.G., Tiwari, S.R., Singhal, R, **Regeneration of thermally polymerized frying oils with adsorbents,** 2008.. Food Chem. 110, 562–570.

[13] William E. Artz, Patricia Osidacz, Aline R. Coscione, **Acceleration of the thermoxidation of oil by heme iron,** Journal of Oil & Fat Industries, 07/2005; 82(8):579-584. DOI: 10.1007/s11746-005-1112-3

[14] Farhoosh, R., Moosai, S.M.R., Sharif, A, **Investigation on frying oils quality in terms of color index, refractive index and viscosity during frying process,** 2008. J. Food Sci. Tech. 5 (1), 13–19.

[15] Li, H., Zhou, G., Zhang, H., He, Y, **Chemical constituents and biological activities of saponin from the seed of Camellia oleifera,** 2010. Sci. Res. Essays 5 (25), 4088–4092.

[16] Jinfeng, P., Huixing, S., Juan, Y., Yong, K.L, **Changes in physiochemical properties of Myofibrillar protein from Silver Carp (Hypophthalmichthys mollitrix) during heat treatment,** 2011. J. Food Biochem. 35, 939–952.

[17] Ceriani, R., Paiva, F.R., Alves, C.B.G., Batista, E.A.C., Meirelles, A.J.A., J, **Densities and viscosities of vegetable oils of nutritional value,** Chem. Eng. Data 53 (8), 1846–1853, 2008.

[18] Ariponnammal S, **A Novel Method of Using Refractive Index as a Tool for Finding the Adultration of Oils,** Research Journal of Recent Sciences, Vol. 1(7), 77-79, July (2012).

[19] J. S. N'Cho, L. Loiselle, I. Fofana, A. Beroual and T. Aka-Ngnui, Parameters Affecting the Electrical and Thermal Properties of Transformer Oils.

[20] Abdolall, K, **Feasibility of free radical detection for condition assessment of oil/paper insulation of transformers. In Proceedings of the Conference Record of the 2008 IEEE International Symposium on Electrical Insulation (ISEI),** June 2008; pp. 182–186.

[21] L. A. Bronshtein, Yu. N. Shekhter, V. M. Shkol'nikov, **Mechanism of electrical conduction in lubricating oils (review),** Chemmotology of Fuels and Lubricants, Chemistry and Technology of Fuels and Oil, May 1979, Volume 15, Issue 5, pp 350-355

[22] Erum Zahir, Rehana Saeed, Mehwish Abdul Hameed, Anjum Yousuf, **Study of physicochemical properties of edible oil and evaluation of frying oil quality by Fourier Transform-Infrared (FT-IR) Spectroscopy.**

[23] Roberta Ceriani, Fernanda R. Paiva, Cintia B. Gonçalves, Eduardo A. C. Batista and Antonio J. A. Meirelles, **Densities and Viscosities of Vegetable Oils of Nutritional Value.**

[24] Diop A, Sarr SO , Ndao S, Cissé M, Baldé M, Ndiaye B, and YM Diop, **Effect of deep fat frying on chemical properties of edible Vegetable oils used by senegalese households,** Volume 14, No. 6, October 2014.

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