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Effect of frying process on some physicochemical properties of some edible oils.

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ABSTRACT

Frying is a popular cooking technique in the world and vegetable oil is widely used as the frying medium in this process. Deep-fat frying produces both desirable and undesirable compounds through various physical and chemical reactions. This research carried out to investigate the effect of frying process on some physicochemical properties of some vegetable oils. For these. Some vegetable oils (olive oil, corn oil, sunflower oil and flaxseed oil) were used chips frying for one hours, the frying was repeated three times and physicochemical tests were done before and after each time. These changes include refractive index, viscosity, density and peroxide value of these vegetable oil during the frying process. The result showed that refractive index and viscosity increased by increasing the frying process, as the unsaturation while the density decreased by progress of frying process, the peroxide value was increased after the 1st frying then the peroxide value decline as the frying process progress.

Introduction

Fats occur in plants and animals. In plant fats are stored mostly in kernels, seeds and nuts whereas in animals fats occur mainly as depots fat under the skin and around kidneys and other organs. The formation of fats in plants and animals is an intricate process by no means full understood. Vegetable fats are obtained by extraction processes, which use either mechanical pressure or solvents. Animal fats are obtained almost exclusively by rendering methods. Deep frying is one of the most common methods used for the preparation of food. Repeated frying causes several oxidative and thermal reactions which results in change in the physicochemical, nutritional and sensory properties of the oil (Che Man and Jasvir, 2000). During frying, due to hydrolysis, oxidation and polymerization processes the composition of oil changes which in turn changes the flavor and stability of its compounds (Gloria and Aguilera, 1998). Fried foods have desirable flavor, color, and crispy texture, which make deep-fat fried foods very popular to consumers (Boskou and others 2006). Frying is a process of immersing food in hot oil with a contact among oil, air, and food at a high temperature of 150 ◦C to 190 ◦C. The simultaneous heat and mass transfer of oil, food, and air during deep-fat frying produces the desirable and unique quality of fried foods. Frying oil acts as a heat transfer medium and contributes to the texture and flavor of fried food.

Vegetable oils are a popular cooking medium in many parts of the world. Despite problems related to the intake of excessive calories and health concerns regarding the ingestion of trans-fatty acids, the flavor and texture of fried food continue to be greatly appreciated. Determining and comparing various physiochemical properties of oil before and after frying gives relevant information on the change in cooking oil quality which can be used to determine its rate and range of degradation. During deep frying different reactions depend on some factors such as replenishment of fresh oil, frying condition, original quality of frying oil and decrease in their oxidative stability (Choe and Min, 2007). 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 (Bhattacharya et al., 2008). Therefore, it is essential to monitor the quality of oil to avoid the use of abused oil due to the health consequences of consuming foods fried in degraded oil, to maintain the quality of fried foods and to minimize the production costs associated with early disposal of the frying medium (Vijayan et al., 1996). However, underfried foods at lower temperature or shorter frying time than the optimum have white or slightly brown color at the edge, and have ungelatinized or partially cooked starch at the center. The underfried foods do not have desirable deep-fat fried flavor, good color, and crispy texture. Overfried foods at higher temperature and longer frying time than the optimum frying have darkened and hardened surfaces and a greasy texture due to the excessive oil absorption. Many of uses of fats and oils depend upon their physical behaviour. Before the use of fat and oil in food preparation it is helpful to consider the physical nature of fats and oils. Their physical characteristics may change during heating and deep-fat frying which involves complex chemical reactions. The product of this reaction has a remarkable effect on the physical characteristics of the oil. Different physical and chemical parameters of edible oil were used to monitor the compositional quality of oils (Ceriani et al., 2008; Mousavi et al., 2012). These physicochemical parameters include iodine value, saponification value, viscosity, density and peroxide value.

The viscosity of edible oils is a parameter used to describe quality. Liquid viscosity is also important regarding design of process equipment for the edible fat- and oil industry. Knowledge of physical properties of fats and oils as a function of temperature and reliable predictive models, is of great practical interest for food, pharmaceutical and chemical engineering. The viscosity of a fat is due to the internal friction between the lipids that constitute it. It is generally high due to the high number of molecules that make up a fat. The refractive index of a substance is defined as the ratio between the speed of light in air and in matter (oil or fat) that is analyzed. The measurement of refractive index of fat in the liquid state is a very useful procedure for several purposes. It can be performed rapidly with small quantity of sample and with high precision when the appropriate equipment is available. The refractive index of fats is related to its molecular structure and unsaturation. However, for the same type of oil, variations due to unsaturation are greater than variation from all other causes (Paul and Palmer, 1972). According to Eckey (1954) oxidation and polymerization tend to raise the refractive index of linseed oils.

Density is always important for any process as it gives enough information about the amount of material being processed and correlates with many other transport and acoustic properties such as viscosity, surface tension, volatility, and speed of sound, among others that are necessary for an efficient design, control, and optimization of operation conditions. For this reason, the knowledge of high-pressure density is required for the adequate performance of high-pressure technology. Although many works have addressed the solubility and provided correlations to predict this parameter, Del Valle et al., 2012. Peroxide value is one of the methods for determination of hydroperoxides as the initial lipid oxidation products. The PV is expressed as milliequivalents oxygen per kg of fat/oil (Nawar, 1996). Since hydroperoxides do not accumulate due to their instability at frying temperature, PV determination is not suitable for assessment of used frying oils (Matthaus, 2006; Suleiman et al., 2006). Lipid oxidation involves the continuous formation of hydroperoxides as primary oxidation products that may break down to a variety of nonvolatile and volatile secondary products. The formation rate of hydroperoxides outweighs their rate of decomposition during the initial stage of oxidation, and this becomes reversed at later stages. Therefore, the peroxide value is an indicator of the initial stages of oxidative change (Ruiz, et al., 2001). However, one can assess whether a lipid is in the growth or decay portion of the hydroperoxide concentration by monitoring the amount of hydroperoxides as a function of time (Shahidi and Botta 2002).

Experimental

Methods:

Vegetable oils:

Virgin olive oil, corn oil, sunflower oil and flaxseed oil were obtained from a local market in El-Bieda city. All vegetable oils were of good quality, as indicated by low initial peroxide value, free fatty acid, and low ansidine value.

Potatoes

Potatoes (Solanum Tuberosum) (18 kg) were purchased from a local market, El-Bieda city.

Preparation of potato chips

Potatoes were peeled, cut into 2 mm thick slices using a rotary slicer (Edelstahl, Rostfrel, England), washed and dewatered prior to frying.

Determination of frying optimum temperature and time

The optimum temperature and time of frying of potato chips were determined according to (Barbary et al., 1999). The optimum temperature and frying time obtained for all oils to produce the best quality of potato chips were 180 ºC and 10 min., respectively.

Procedure:

Physicochemical characteristics including refractive index by using Abbe 60 refractometer and viscosity by using Ostwald-u-tube viscometer of the edible oils were determined according AOAC (2009). The density of edible oils was calculated by mass of the sample per unit of volume.

Density = mass of the oil (g) / volume of the oil (mL).

Peroxide value was determined according to AOCS official methods (2010) (Method Cd8-53) by titration with standard sodium thiosulphate (0.1 N) and was calculated as milliequivalent peroxides per kilogram oil (meq/kg oil).

Results and discussion

Deep frying is a very important method of cooking in the food services industry as it enhances the sensory properties of foods. Fried foods are desired for their distinctive flavor and odor. During frying, the oil is continuously and repeatedly used at elevated temperatures (160-180°C) in the presence of air and moisture. When foods are fried in heated oil, many complex chemical reactions occur resulting in the production of degradation products. As these reactions proceed, the functional, sensory and nutritional quality of the fat/oil changes and may eventually reach a point where it is no longer suitable for preparation of high quality fried products and the frying fat/oil will have to be discarded (Lins et al., 2001 and Maskan. 2003).

Table 1 shows the changes in refractive index of olive, corn, sunflower, flaxseed oils during use in chips frying. The results indicates that as the frying stages increased the refractive increased. The increase in the refractive index of oils due to attributed production of oxidation and polymerization products.

Table (1) changes in refractive index during the frying peroids

Frying peroid	Oil samples			
	Olive oil	Corn oil	Sunflower oil	Flaxseed oil
Fresh sample	1.4670	1.4680	1.4685	1.4700
1st frying	1.4675	1.4695	1.4730	1.4760
2nd frying	1.4690	1.4730	1.4765	1.4785
3rd frying	1.4705	1.4775	1.4785	1.4790

Moreover, this increase is related to the molecular structure and degree of unsaturation. In addition it has been suggested that, for the same type of oil variation in refractive index, due to unsaturation are greater than those of other sources. These results were agreement with Idris. 2008 who studied some physicochemical properties of some vegetable oils in Sudan, the same results were obtained by Godswil et al., (2018) who studied the change in refractive index of sunflower, palm, and sesame oils in Uganda.

Table 2 shows the change in the viscosity of olive, corn, sunflower and flaxseed oils as a result of frequent use in chips frying. The result indicated that there are increased in viscosity as the frying process progress. The increasing was very sharp after the 1st frying. The oil deterioration was monitored by the changes in viscosities during repeated use of oils in frying process. The results showed a sharp increase in the viscosity after the second frying, the viscosity and refractive index of flaxseed oil is more increasing than sunflower oil, then corn oil and finally olive oil.

The increase in viscosity indicates that a new compound is formed as a result of polymerization. The repeated uses of oils lead to an increase of polymer compounds which raised the viscosity of these oils. Increasing in viscosity of oils as a result of repeated use in food frying was reported earlier by Huang (1981) and Elkabashi (2000) in sunflower corn, cottonseed, and groundnut oil. These results were agreement with Idris. 2008 while, they differs on the results of Zahir et al., (2017) who studied physicochemical properties of corn and mustard oils.

Table (2) changes in viscosity during the frying peroids

Frying peroid	Oil samples			
	Olive oil	Corn oil	Sunflower oil	Flaxseed oil
Fresh sample	33.5	39.4	47.3	48.7
1st frying	42.7	48.7	59.2	66.7
2nd frying	99.2	103.38	112.0	125.1
3rd frying	184.1	195.6	204.6	224.8

Table (3) shows effect of frying process on the density of some vegetable oils. The results revealed that the density decreased by increasing the frying process. As the oil samples had more unsaturation fatty acids the density increased.

Table (3) changes in density during the frying peroids.

Frying peroid	Oil samples			
	Olive oil	Corn oil	Sunflower oil	Flaxseed oil
Fresh sample	0.9143	0.9579	0.9878	0.9928
1st frying	0.8157	0.8397	0.8405	0.9781
2nd frying	0.7273	0.7994	0.8375	0.8685
3rd frying	0.6524	0.7291	0.7742	0.6911

Zahir et al., (2017) suggested that the densities of corn and mustard oils were decreased with the rise in temperature as well as when using the same oil for frying three times with a piece of potato The densities of oils were related to the standard range of 0.898–0.907 g/ mL approved by the Standard Organization of Nigeria (SON, 2000).

Table (4) changes in peroxide during the frying peroids

Frying peroid	Oil samples			
	Olive oil	Corn oil	Sunflower oil	Flaxseed oil
Fresh sample	0.571	0.627	0.687	1.35
1st frying	8.52	9.12	9.51	9.85
2nd frying	5.63	6.14	6.34	7.98
3rd frying	4.98	4.85	4.28	3.87

These results were disagreement of Alajtal et al., (2018) who studied some collected some edible oil samples before and after frying from some food supply markets in Libya and home kitchen uses. They found that the peroxide values ranged from 12.5 to 55 meq/Kg in fresh oils and from 37.5 to 150 in frying oils were to exceed the permitted value of 20 meq/Kg for olive oil and 10 meq/Kg for other edible oils in nearly half the analysed samples.

Conclusions

We conclude that refractive index and viscosity increased by the increasing of the frying process, while the density decreased by increasing the frying process, the increased was very sharp after the 1st frying process. The peroxide value increased by increasing the frying process, after the 1st frying these values were decreased by progress of frying, but not exceed the permitted value of 20 meq/Kg for olive oil and 10 meq/Kg for other edible oils

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References

Alajtal, A, I., Sherami, F, E and Elbagermi, M, A. (2018). Acid, peroxide ester and saponification values for some vegetable oil before and after frying. Journal of materials. 4(2): 43-47.
AOC. O.American Oil Chemists Society (2009) Official methods and recommended practices. Am. Oil Soc. Champgain.
AOCS .American Oil Chemists Society (2010) Official methods and recommended practices. Am. Oil Soc. Champgain.
Godswill. A, C., Ikechukwu O. Amagwula, Igwe S. Victoryand Allan Isiaga Gonzaga. (2018). Effect of repeated deep frying on refractive index and peroxide value of selected vegetable oils. International Journal of Advanced Academic Research | Sciences, Technology & Engineering. Vol. 4, (4): 105-119.
Barbary, O.M., Zeitoun M.A.M. and. Zeitoun .M. (1999).Utilization of corncobs as a natural adsorbent material for regeneration of sunflower oil during frying . J.Agric.Sci. Mansoura Univ.24:6659.
Bhattacharya, A, B.., Sajilata, M. G., Tiwari, S. R and Singhal, R. 2008. Regeneration of thermaly polymerized frying oil with adsorbents. Food chem. 110. 562-570.
Boskou G, Salta FN, Chiou A, Troullidou E, Andrikopoulos NK. 2006. Content of trans, trans-2,4-decadienal in deep-fried and pan-fried potatoes. Eur J Lipid Sci Technol.
Ceriani, R., Paiva, F. R., Alves, C. B. G. Batista, E. A. C., Meirelles, A. J. A. 2008. Densities of vegetable oils of nutritional value. J. Chem. Eng. Data. 53 (8), 1846-1853.
Cheman, Y. B., Jasvir, I., (2000). 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.
Choe, E and Min, D. B. 2007. Chemistry of deep-fat frying oils. J. Food Sci. 72, 77-86.
Del Valle, J. M.; De la Fuente, J. C.; Uquiche, E. A refinedequation
Eckey, E, W. 1954. Vegetable fats and oils. Reinhold publishing, New York.
Ekwu, F. C., Nwagu, A. 2004. Effect of processing on the quality of cashew nut oils. J. Agric. Food Tech Environ. 4, 105-110.
Elkabashi, A. T. (2000). Effect of frequent frying and storage on quality of Sudanese edible oils. M. Sc. Thesis, Department of Food Science and Technology, Faculty of Agriculture, University of Khartoum, Sudan
Guillen, M. D., Cabo, N., 2000. Some of the most significant changes in the Fourier transform infrared spectra of edible oils under oxidative conditions. J. Sci. Food Agric. 80, 2028-2036.
Huang, A. S.; Hsich, O. A. and Chang, S. S. (1981). A comparison of the stability of sunflower oil and corn oil. J. Am. Oil Chem. Soc. 58: 997-1001.
Idris. A. M. A. (2008). Effects of Repeated Frying on the Composition of some Vegetable Oils. M sC in Department of Chemistry Faculty of Science, University of Khartoum
Knez, Z. e.; Ilic, L.; S ́ ̌kerget, M.; Kotnik, P. High-Pressure Solubility Data for Palm Oil−SF6 and Coconut Oil−SF6 Systems. J.
Lin, S., Akoh, C. C., Reynolds. A. E. 2001.. Recovery of used frying oils with adsorbent combinations: refrying and frequent oil replishment. Food Research International..34: 159-166.
Masken, M., 2003. Changes in color and rheological behavior of sunflower seed oil during and after adsorbent treatment of used oil. Food Research Technology. 218. 159-166.
Matthaus, B. (2006). Utilization of high-oleic rapeseed oil for deep-fat frying of French fries compared to other commonly used edible oils. European Journal of Lipid Science and Technology 108, 200-211.
Mousavi, R., Paiva, F. R., Alves, C. B. G., Batista, E. A. C., and Meirelles, A. J. A. 2008. Densities and packaging on quality of edible oils in Iran. Adv. Environ, Biol. 6(2). 694-701
Nawar, W.W. (1996). Lipids. In: Fennema, O.R. (Ed.) Food Chemistry. (3th edition), Marcel Dekker, Inc., New York, USA, pp. 225-319.
Paul, P. C. and Palmer, H. H. 1972. Food theory and applications. John Wiley & sons, INC, New York.
Ruiz, M. J. Ayora-Canada, and B. Lendl, (2001). Analyst, 126, 242–246.
Shahidi, F. and Botta. J. R. (2002) . Sea food chemistry processing technology and quality .Ed Blackie Academic and professional.London.
Son, 2000. Standard Organization of Nigeria. Standard for edible refined palm oil and its processed form. Pp. 2-5.
Suleiman, A.E-R.M, El-Makhzangy, A. and Ramadan, M.F. (2006). Antiradical performance and physicochemical characteristics of vegetable oils upon frying of French fries:

Apreliminary comparative study. Journal of Food Lipids 13, 259-276.

Vijayan, J., Slaughter, D. C., Paul, S. R. 1996. Optical properties of corn oil during frying. Int. J. Food. Sci. Technol. 31. 353-358.

Zahir. Erum, Rehana Saeed, Mehwish Abdul Hameed, Anjum Yousuf (2017). Study of physicochemical properties of edible oil and evaluation of frying oil quality by Fourier Transform-Infrared (FT-IR) Spectroscopy. Arabian Journal of Chemistry. 10. S3870-387.