

Effects of Composited Powder Treatment on the Increase of the Useful Life-time of Frying Oil

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Abstract

The useful life of frying oil was increased by treating the frying oil with a composited powder comprising water, citric acid and porous rhyolite carrier. The color darkening and foaming tendency of the oil during frying operation was apparently retarded. Increase rates of polar lipid components, dielectric constant and formation of the conjugated dienes and trienes of the used frying oil were reduced to two thirds of the oil without treatment during 84 hr frying operation. Iodine value and polyenoic index was also much less decreased by treatment. The treatment, however, have no significant effect to inhibit the decrease of smoke point and the increase of viscosity.

Key words: useful life-time, frying oil, composited powder

Introduction

Deep-fat frying is one of the most commonly used cooking method for the preparation of food products. The fast food restaurants which have been growing rapidly in recent years further increase the consumption of fried food.

During deep frying, the oil is continuously or repeatedly used at elevated temperature in the presence of air and moisture. A number of chemical reactions, including oxidation and hydrolysis, occur during this time as do changes due to thermal and oxidative decomposition. As these reactions proceed, the functional, sensory and nutritional quality of the oils changes and may eventually reach a point where it is no longer possible to prepare high quality fried products and the frying oil will have to be discarded. In addition, the volatile and nonvolatile decomposition products which are formed in the frying oils are harmful to human health in their excessive amount⁽¹⁾. Such decomposition products also produce a variety of physical and chemical changes in the frying oils. These include increase of viscosity, polar mate-

rials and free fatty acid content, development of dark color, decrease in iodine value, change in refractive index, decrease in surface tension, and an increased tendency of the oil to foam. Many of these changes are presently used to assess the quality of oils during course of the frying operation. The amount of petroleum ether insoluble oxidized fatty acids is also a good indicator of the deterioration of such oils. According to the quality assessment of used frying fats by the German Society for Fat Research, if the cocentration of oxidized fatty acids is 1.0% or higher, a used frying oil is deteriorated and have to be discarded⁽²⁾. The foaming and the decrease of smok point is often regarded by food processors as an indicator that the frying oil must be discarded. In spite of many assessments to measure the deterioration of used frying oil, no single method is yet to be established to represent all oxidative quality of oil and fat because of the complexity of the reactions involved.

Chemical and physical analysis of the fat and oils commercially used for deep-fat frying⁽³⁾ indicated that the degree of deterioration was independent of their degree of unsaturation, but rather depended upon how they were used.

Some sterols isolated from cereals germ oil were

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found to inhibit destruction of linoleic acid in frying oil⁽⁴⁾. The silicones have been used to minimize oxidative deterioration during heating. These apparently form a film at the air-oil interface which acts as an oxygen barrier⁽⁵⁾. Adding chemicals such as MgO to the deep-fat frying oils could reduce the free fatty acids content⁽⁶⁾. To purify the deep-fat frying oils already used during foods preparation, addition of NaOH, bleaching earth and charcol was found to be effective to reduce peroxide value and addition of SnCl drastically eradicate epoxide while increasing peroxide value⁽⁷⁾.

Recently, treatment of the used frying oil with a composited powder comprising water, citric acid and porous rhyolite carrier have been found to be able to increase the useful lifetime of the frying oil⁽⁸⁾. The composited powder can be added directly to the used hot frying oil and separated by filtering prior to reuse of the oil. This treatment was found to be able to remove or neutralize the effects of certain impurities from the used frying oil, such as soluble food juice and fatty acids which have an adverse effect on frying oil as regards the oil's useful lifetime⁽⁹⁾. Its efficacy in actual use had verified or certified by individual and commercial laboratory⁽¹⁰⁾. However, full understanding of its performance is still far from complete. In order to elucidate the efficacy of the composited powder in protecting an oil quality during frying operation, we have tried a series of investigation to determine exactly what is occurring in oils by the treatment.

The present paper reports the results obtained from the physical and chemical analysis of the used frying oil with or without the treatment of the composited powder in a closely controlled test run with the same conditions of fast food preparation.

Materials and Methods

Materials

The refined, bleached and deodorized soybean

oil was purchased from local market and used for frying oil. Potato slices prefried and frozen for french fried potato was purchased from local market and stored in a deep freezer (-20°C) until deep fat frying. The composited powder was obtained from commercial source (Miroil life powder, Mir Oil Co., U.S.A.). According to the supplier, the powder was prepared by mixing 24 lb of porous rhyolite, 33.4 lb of water and 2.5 lb of citric acid in a ribbon blender. All reagents were of analytical grade unless otherwise specified.

Deep fat frying conditions and sampling method

Deep fat frying was conducted in two identical Sunbeam batch fryers (nominal volume 4.51) which were filled with 3000kg of soybean oil and heated at 185 + 2°C for 7 hr periods with overnight cooling to room temperature. During the heating, 200g of the potato slices was repeatedly deep-fat fried for 3 min at the intervals of one hour. After final frying every day, 14g of the powder was directly added to the hot oil of one fryer and then filtered to remove the powder residues and cooled to room temperature. The oil of the other fryer was only filtered and cooled after 7th frying operation. Fifty ml aliquots were removed from both fryers for each sampling of treated and control oil, respectively. Refills of fresh oil were not made after the sampling.

Analytical methods

The color of the oil was measured by using Lovibond Tintometer (Model E) with a 5.25" cell. Foaming of the oil was measured as a maximum foam height in a graduated glass tube according to a modified method of Fritsch *et al.*⁽¹³⁾. The glass tube was filled with the sample oil and one piece of potato slice and placed in the fryer heated to the desired temperature. Viscosity of the oil was measured by using Brookfield Viscometer LV type (Model LVH) with spindle number 4 at 30 rpm and 35°C and the read out data were converted to centipoise by using the conversion table

supplied. Smoke point, acid value, and iodine value of the oil were measured according to the standard methods of AOCS⁽¹²⁾. Refractive index was measured at 37°C by using Abbe 2L refractometer (Baush & Lomb Co., Rochester, New York). Dielectric constant was measured by using Foodoil Sensor NI-20(Northern Instruments Corp., Lino Lakes, Minnesota). Before measurement of dielectric constant of oils, the instrument was calibrated according to Fritch *et al.*⁽¹³⁾ with test oils whose readings were between 0.0 to 4.0. Conjugated diene and triene contents of the oil were determined by spectrophotometry according to IUPAC method⁽¹⁴⁾. Polar lipid content of the oil was determined by separation with Silica gel column according to the method of Billek *et al.*⁽⁸⁾. The fatty acids composition of the oil was analyzed by gas chromatography. The methyl ester of fatty acids were prepared by using 14% BF₃-MeOH and separated in dry ester by AOCS method⁽¹²⁾.

Results and Discussion

Evaluation of functional properties

The changes in the color, foam height, smoke point and viscosity of the oils during frying operation was presented in Fig. 1,2,3, and Table 1, respectively. The color darkening and foaming

Table 1. Changes of viscosity of cooking oil during intermittent heating period at 185±2°C

(unit: CPS)		
Oils	With composited powder	Without composited powder
Time (hr)		
0	53	53
14	60	67
28	545	535
42	1232	1236
56	1388	2088
70	2280	2480
84	5000	6400

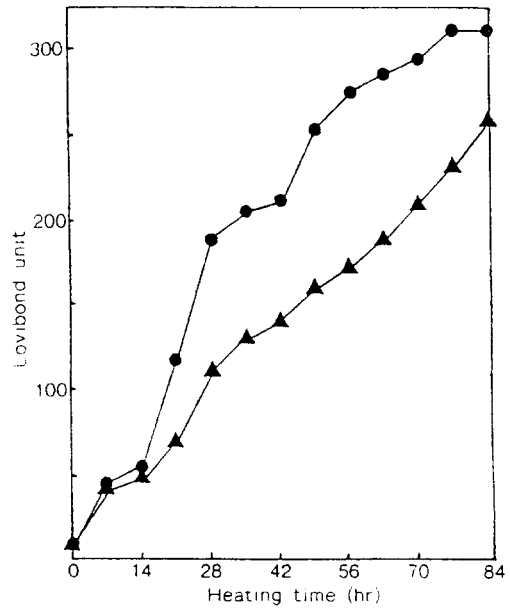


Fig. 1. Changes of color of cooking oil during intermittent heating period at 185±2°C (▲) with and (●) without composited powder.

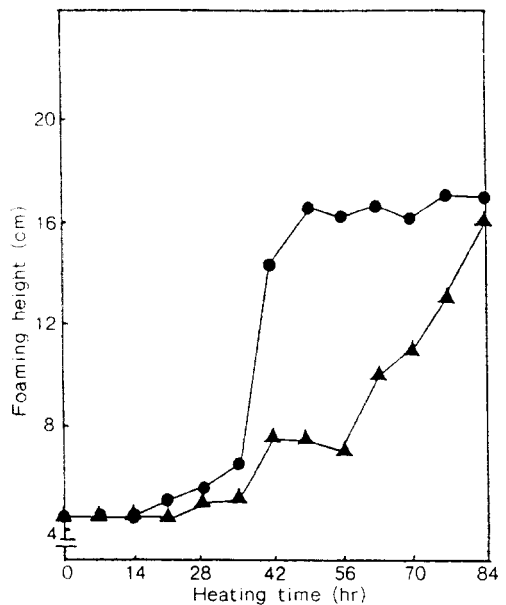


Fig. 2. Changes of foam height of cooking oil during intermittent heating period at 185±2°C (▲) with and (●) without composited powder.

tendency of the oil during frying operation was apparently retarded by the treatment of the composited powder as shown in Fig. 1 and 2. The period to reach 250 Lovibond unit of color intensity and 16cm of foaming height was 7 days(49 hrs) for control, but the period for the treated oil was retarded to 12 days (84 hrs). The treatment of composited powder, however, did not affect the smoke point and viscosity of frying oils. As shown in Fig. 3, the smoke points of treated oil after 7 day frying operation were rather lower than those of control.

Physico-chemical changes

The polar lipid content in the used frying oil was a good indicator of the deterioration. According to recommendation for the quality assessment, a used frying oil is deteriorated if the concentration of the polar lipid component is 27% or higher⁽²⁾. Oxidized polar lipid components of both oils increased as the frying time increased, however, the increase

rate was significantly reduced by the composited powder treatment (Fig. 4). The polar lipid content for the control oil was increased to the limit value of 27% after 7 days (49 hrs) frying operation, whereas the polar lipid content of the treated oil reached the limit value after 11 days (77 hrs). Dielectric constant and conjugated diene and triene contents of oils were increased as frying time increased (Fig. 5 and 6). The treatment of composited powder also retarded the increase of dielectric constant and conjugated diene and triene contents in the used frying oil to the same extent for the polar lipid content. The increasing modes of both indicators were very similar with the increase of polar lipid contents in the both oils, respectively. The relationship between indicators of frying oil quality showed in Table 2. The highly significant correlation coefficients obtained for relationships between polar components and conjugated diene and between polar components and dielectric constant are noteworthy. There were no

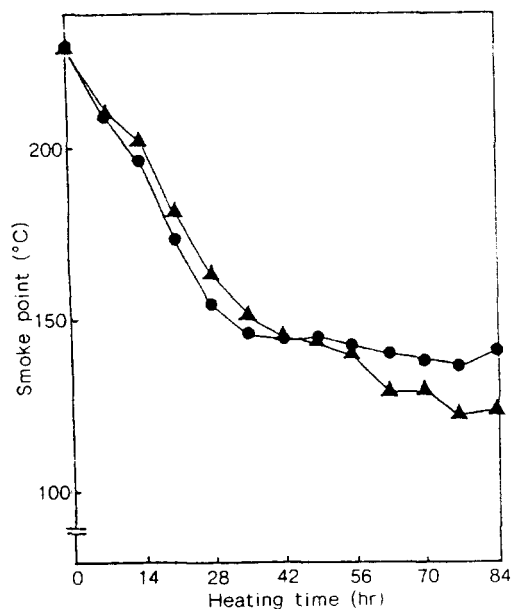


Fig. 3. Changes of smoke point of cooking oil during intermittent heating period at $185 \pm 2^\circ\text{C}$ (▲) with and (●) without composited powder.

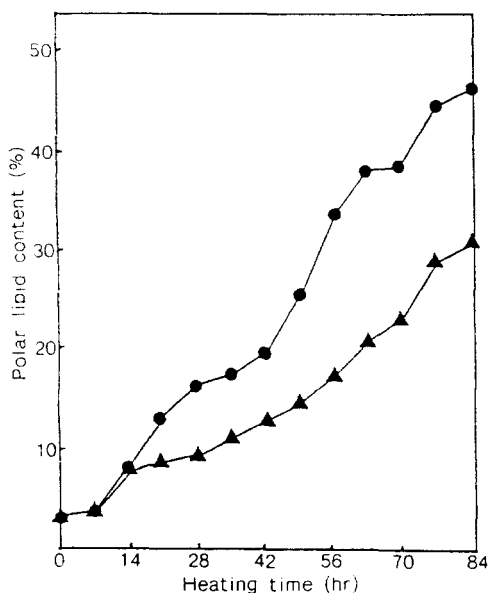


Fig. 4. Changes of polar lipid of cooking oil during intermittent heating period at $185 \pm 2^\circ\text{C}$ (▲) with and (●) without composited powder.

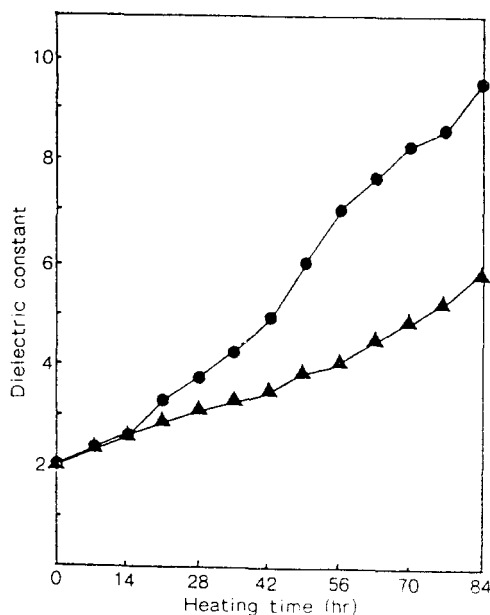


Fig. 5. Changes of dielectric constant of cooking oil during intermittent heating period at $185\pm 2^\circ\text{C}$ (▲) with and (●) without composited powder

significant differences ($p < 0.05$) between the slopes of regression lines for control and treated oil as to the relationships between polar lipid and conjugated diene and between polar lipids and dielectric constant. The highly significant correlation coefficients obtained in this study is in a good agreement with the results that polar lipid contents, dielectric constant, and conjugated diene and triene content of heated oil were shown to have a high correlation between every two measur-

Table 2. Relationship between indicators of frying oil deterioration in heating

System	Equation	Correlation coef.
% polar component versus conjugated dienes		
with	$Y = 0.682x + 5.01$	0.981
without	$Y = 0.631x + 4.81$	0.978
% Polar component versus dielectric constant		
with	$Y = 0.131x + 1.819$	0.989
without	$Y = 0.131x + 1.901$	0.993

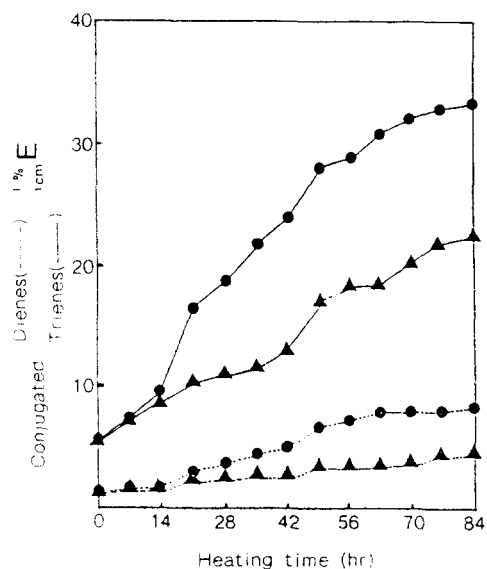


Fig. 6. Formation of conjugated dienes & trienes in cooking oil during intermittent heating period at $185\pm 2^\circ\text{C}$ (▲) with and (●) without composited powder.

ments for oil deterioration^(15,16). This means that the treatment of the composited powder for the used frying oil was able to prolong 1.5 times the useful lifetime of frying oil.

The refractive index for the control oil increased slowly for the first 14 hr and more rapidly after 14 hr frying, and the increase did also stop after 56 hr frying, while that for the treated oil decreased continuously as frying time increased (Fig. 7). During deep fat frying of potato slices, which were pre-fried in palm oil and its oil content was 14.9%, the frying oil must be adulterated with the palm oil exudated. It is well known that RI of highly unsaturated oil such as soybean oil was higher than that of lower saturated oil such as palm oil. In case of the treated oil, the extent of the RI decrease by the adulterated palm oil was enough or high above to offset the extent of the RI increase by thermal decomposition in the soybean oil component which might be inhibited by treatment of the composited powder. Changes in iodine

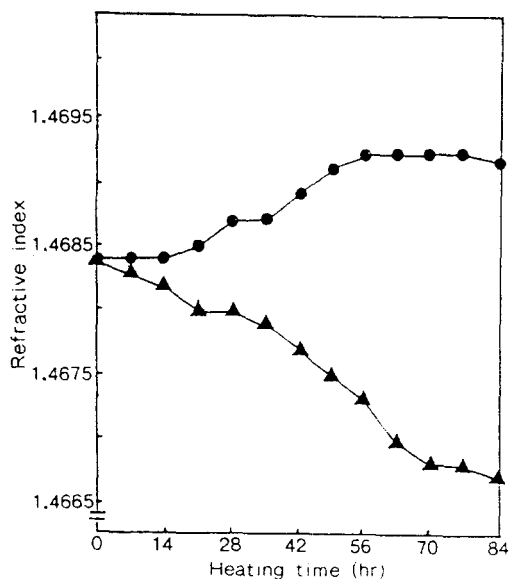


Fig. 7. Changes of refractive index of cooking oil during intermittent heating period at $185\pm 2^\circ$ (▲) with and (●) without composited powder.

value and mono and polyenoic fatty acids contents was determined (Table 3 and 4). As expected, monoenoic fatty acid was more stable against thermal decomposition than polyenoic fatty acids. The treatment of composited powder showed a significant effect to retard the decrease of iodine value and unsaturated fatty acids content in the

Table 3. Changes of iodine values of cooking oil during intermittent heating period at $185\pm 2^\circ\text{C}$

Oils Heating time(hr)	With composited powder	Without composited powder
0	131.0	131.0
14	127.7	127.0
28	123.2	120.7
42	118.3	113.0
56	110.1	101.2
70	106.0	93.0
84	98.1	80.9

used frying oil.

The results obtained from this investigation showed that the treatment of frying oil with the composited powder comprising water, citric acid and porous rhyolite carrier was able to increase the useful life-time to one and half times. The temperature of the oil during treatment is high enough to cause steaming and releasing of the water and citric acid in the powder. This steaming in turn causes to allow good contact between the citric acid and oil and counteract the adverse effect of thermal or oxidative decomposition products. The detailed mechanism as to how the composited powder inhibit the polymerization of peroxide products will be reported in the future.

Table 4. Changes of monoenoic and polyenoic index of cooking oil during intermittent heating period at $185\pm 2^\circ\text{C}$

Oils Heating time(hr)	With composited powder		Without composited powder	
	Monoenoic ^a index	Polyenoic ^b index	Monoenoic ^a index	Polyenoic ^b index
0	1.55	4.19	1.55	4.19
14	1.48	3.62	1.47	3.64
28	1.37	3.02	1.35	2.86
42	1.29	2.56	1.27	2.29
56	1.21	2.12	1.16	1.61
70	1.12	1.63	1.05	1.11
84	1.04	1.16	0.95	0.68

a: Ratio of monoenoic fatty acid area to saturated fatty acid area in gas chromatograms

b: Ratio of polyenoic fatty acids area to saturated fatty acid area in gas chromatograms

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튀김유의 수명연장을 위한 복합처리제제의 처리효과

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대두유를 튀김유로 사용하여 french fried potato 를 185°C에서 제조하면서, 1일 7시간씩 총 56시간동안 가열 및 튀김후 composited powder (citric acid, 물, rhyolite 혼합물)를 처리한 대두유와 처리하지 않은 대두유의 기능성, 발연점, 기포성 및 점도와 물리화학적 성질을 비교 분석하였다.

Composited powder 를 처리하면 극성지질의 생성을 억제하고, 불포화 지방산의 가열산패를 억제시켜, 튀김유의 수명을 약 50% 증가시켰음을 확인하였다. 그러나, 산가증가의 억제 및 발연점 저하의 억제에는 효과가 없었다.