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Use of Date (*Phoenix dactylifera L.*) Palm Seed Carbon as New Filter Aid for Improving the Quality of Fried Sunflower Oil

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Abstract: Filtration is required to remove particles of foods and the oxidized products of oil for re-using. This investigation aimed to evaluate the efficiency of date Palm Seed Carbon (DSC) as natural filter aid in comparison with Magnesol XL as synthetic filter aid and to determinate the optimal dose and contact time of these filter aids. Some physical and chemical parameters such as refractive index, colour, viscosity, acid value, peroxide value, thiobarbituric acid value and polymer content of fresh, fried and fried-treated sunflower oil were determined. The results of this study indicate that the efficiency of 4% DSC for 60 min in removing oxidized products of fried oils was almost equal to the efficiencies of synthetic filter (Magnesol XL). Accordingly, DSC could be is recommended as an effective and cheap adsorbent for removing oxidized products of fried oils.

Key words: Filtration, date palm seed carbon, fried oil, magnesol XL

INTRODUCTION

Deep-fat frying can be defined as the process of drying and cooking through contact with hot oil (Sahin *et al*., 1999). It is widely used in preparation of foods, because the consumers prefer the taste, appearance and texture of fried food products (Rimac-Brncic *et al*., 2004). Vegetable oils undergo extensive oxidative deterioration during storage, marketing, or deep fat-frying. Hydroperoxide, which is the major oxidation product, decomposes to secondary products, such as esters, aldehydes, alcohols, ketones, lactones and hydrocarbons. These secondary products adversely affect flavour, aroma, taste, nutritional value and overall quality of foods. Additionally, certain oxidation products are potentially toxic at relatively low concentrations (Min and Boff, 2001; Nawar, 1996). Several filter aids were used for removing these oxidation products, in this respect (Swientek, 1982) found that synthetic calcium silicate manufactured from diatomaceous silica can maintain free fatty acid levels in oil at below 0.35% with daily doses of approximately 1-2% oil weight. Treatment of used frying oil with Frypowder (Mir Oil, Allentown, PA) was found to be effective in reducing build up of total polar compounds and alkaline contaminant materials, retarding colour darkening foaming tendency, dielectric constant changes and reducing formation of conjugated dienes to ⅔ of the values without treatment (Kim *et al*., 1988). Lin *et al*. (1999) used combination of Britesorb (Br), Hubersorb 600 (HB), Frypowder (Fr) and Magnesol (Ma) for frying oil recovery. The results of this investigation showed that free fatty acids and absorbance at 420 nm were reduced by 82.6-87.6% and by 5.6-8.6%, respectively. The efficiency of diatomaceous earth and kaolin as natural filter aids as well as Magnesol XL as synthetic filter aid was studied by Farag and El-Anany (2006), who found that treatment of fried oils by magnesol XL, diatomaceous earth and kaolin at 1, 2 and 4% led to decreases in refractive index, foam height, colour, viscosity, acid value, peroxide value, conjugated dienes, TBA and polymer contents and no obvious change in iodine value compared with non-fried oils. The efficiency of various filter aids in improving the oil physical and chemical properties was nearly the same. The treatment with 2% level of any filter aid was the level of choice for regeneration of oil quality. Many reports have been appeared on the production of low cost adsorbents using cheaper and readily available materials (Babel and Kurniawan, 2003; El Nemr *et al*., 2008). In this regard (El Nemr *et al*., 2008; Kannan and Thambidurai, 2007), found that date palm seed carbon was an effective adsorbent for the removal of toxic chromium and lead from different kinds of aqueous solution. The current investigation was performed to evaluate the efficiency of date palm seed carbon as natural filter aid in comparison

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with Magnesol XL as synthetic filter aid and to determinate the optimal dose and contact time of these filter aids.

MATERIALS AND METHODS

Sunflower oil: Refined sunflower oil (25 Kg) was obtained from Savola Sime Company, 10th of Ramadan city, Sharkia Governorate, Egypt. The peroxide and acid values of the fresh oil were 1.05 (meq kg^{-1} oil) and 0.08 (mg KOH g^{-1} oil), respectively.

Magnesol XL: Magnesol XL (Hydrous, white, amorphous and odorless synthetic magnesium silicate) was obtained from Magnesol Product Division, Reagent Chemical and Research, Inc. Houston, Texas, USA.

Date palm seeds: Date palm seeds were collected from the jam industries of Egypt and washed with tap water, cut into small pieces and dried at 150°C for 48 h. The dried product used for carbonization.

Carbonization of date palm seeds: Dried product was treated with concentrated sulphuric acid (H_2SO_4 98%, Sp.gr. 1.84) at ratio of 2:1 (v v^{-1}). The obtained black product was kept in oven at 200°C for 10 h. The carbonized material was washed with distilled water to remove the free acids and then dried at 105°C. The carbon obtained was ground and sieved to the particle size ≤0.150 mesh and kept in a glass bottle until used.

Frying process: Sunflower oil (25 kg) was placed in a stainless steel pan of electric fryer (45 cm depth × 52 cm length × 40 cm width, Frymaster L.L.C., Shreveport, Louisiana, U.S.A) and heated at 180 ± 5°C. Then 500 g of frozen French fries potato were fried every 30 min during a continuous period of 12 h. The fried oil was left to cool down then stored at -10°C for filtration process.

Filtration process: Date palm seeds carbon at levels 1, 2 and 4 and 2% (w v^{-1}) of Magnesol XL (according to the results of our previous study (Farag and El-Anany, 2006) that the treatment with 2% of magnesol XL was the level of choice for regeneration of oil quality), were added individually to the fried sunflower oil then mechanically stirred for 15, 30 and 60 min at 105°C. The slurry was vacuum filtered through a Whatman No 41 filter paper (Whatman International Ltd, Maidstone, UK). Vacuum filtration facilitated flow of oil through the filter paper. The untreated fried sunflower oil was vacuum filtered through a Whatman No 41 filter paper.

Re-frying process of fried-treated oils: To evaluate the efficiency of adsorbent treatment on used oil recovery. About 1.5 kg of both fried sunflower oil treated with 4% of date palm seeds carbon for 60 min and 2% of Magnesol XL for 15 min was placed in a stainless steel pan of electric fryer (25 cm depth × 30 cm length × 25 cm width, Univest Co., 6th of October city, Industrial zone NO. 3, Giza, Egypt) and heated at 180±5°C. Then 500 g of frozen French fries potato were fried every 30 min during a continuous period of 12 h. Oil samples were taken every 2, 4, 8 and 12 h. The oil samples were left to cool down then stored at -10°C for subsequent determinations.

Quality assurance tests: These tests were conducted on fresh, fried and fried-treated oil samples.

Physical properties

Refractive index: Refractive index of the oil was determined according to the AOAC (2000), using Abbe-refractometer (NYRL-3-Poland).

Colour: Lovibond tintometer (Tintometer Limited Solstice Park, Amesbury, UK) was used to measure the colour of the oil samples under investigation, the yellow glass filter was fixed at 30 and the intensity of red glass colour was measured according to the AOAC (2000).

Viscosity: Brookfield LV viscometer Model TC-500 (Brookfield Engineering Laboratories Stoughton, MA, USA) was used to measure the viscosity of the oil samples at 30°C. According to the method described by Saguy *et al.* (1996).

Chemical properties

Acid value: Acid value was determined according the AOAC (2000), as follows a Known weight (2 g) of the oil was dissolved in a neutral ethyl alcohol (30 mL). The mixture was boiled on a water bath for 2 min and then titrated with potassium hydroxide solution (0.1N).

Peroxide value: The peroxide value was determined according to AOAC (2000), a known weight of the oil sample (2.5 g) was dissolved in a mixture consisted of glacial acetic acid: chloroform (30 mL, 3:2 v v^{-1}) then freshly prepared saturated potassium iodide solution (1 mL) was added. Distilled water (30 mL) was added then titrated slowly with sodium thiosulphate solution (0.1N).

Thiobarbituric acid value (TBA): The method of Sidwell *et al.* (1954) was conducted to determine the TBA value as follows. A known weight of oil (3 g) was dissolved in a carbon tetrachloride (10 mL) followed by the addition of TBA reagent (10 mL, 0.67% TBA in 50% acetic acid). The mixture was transferred to a separatory funnel and the aqueous layer was drawn into a test tube and immersed in a boiling water bath for 30 min The absorbance of the developed pink colour was then recorded at 532 nm against a blank reagent.

Insoluble polymer content: The insoluble polymers were determined according to the method outlined by Wu and Nawer (1986) as follows: 1 g of oil was added to methanol (125 mL) containing 1% H_2SO_4. The mixture was boiled under a reflux condenser for 2 h and cooled to room temperature. The methanol insoluble were filtered and washed with methanol until no sulphuric acid remained. The washed insoluble polymers were dissolved in petroleum ether (25 mL) and transferred to a pre-weighed flask. The solvent was then evaporated under a stream of nitrogen and the flask was again weighed.

Statistical analysis: The data of the present research (except sensory evaluation data) were subjected to analysis by 2 ways ANOVA (Completely randomized design factorial arrangement), $p \leq 0.05$ were considered significant (Cochran and Cox, 1992).

RESULTS AND DISCUSSION

Effect of various levels of Date palm seed carbon (DSC) and Magnesol XL for 15, 30 and 60 min on some physico-chemical properties of fried sunflower oil.

Refractive index: Results presented in Table 1 shows that fried sunflower oil after 12 h of continuous frying had relatively high refractive index was 1.4740. This increasing in refractive index after 12 h of continuous frying is in confirmation with the fact that refractive index of conjugated compound are higher than that of non-conjugated. It is well known that frying process caused conversion some of the non-conjugated double bonds into conjugated ones. This reaction led to an increase in the refractive index. Filtration process with filter aids under investigation caused significant ($p<0.05$) decease in refractive index values of fried sunflower oil. No significant differences ($p>0.05$) were observed between various level of both DSC and Magnesol XL for 15, 30 and 60 min. This decreasing in refractive index values due to the absorption of unsaturated compound that was formed during frying process on the surface of these filter aids. The obtained results are in a good agreement with the findings by Farag and El-Anany (2006), they found that the treatment of fried oils with 2% of Magnesol XL, diatomaceous earth or kaolin caused significant decrease in refractive index values.

Colour: The colour of the fried potatoes and potato chips is one of the most important quality factors of acceptance for fried products. Table 1 indicates that fried sunflower oil with continuous frying period 12 h had high value of colour was 17.83 as red slid reading. Filtration process with DSC and Magnesol XL caused significant ($p<0.05$) decrease in red colour, this decrease increased with the increasing of the level of DSC and its contact time. Fried sunflower oil treated with 2% DSC for 60 min and 4% DSC for 30 and 60 min had significantly the lowest colour value was 2.5 as red slid reading. No significant differences were observed between fried sunflower oil treated with 2% of DSC for 15 and 30 min, 4% of DSC for 15 min and those samples treated with 2% Magnesol XL for 15, 30 and 60 min. It is of interest to note that 4% of DSC for 30 and 60 min was more efficient in removing the coloured materials from fried sunflower oil. These results are in good agreement with those data obtained by McNeill *et al.* (1986), they found that the treatment of fried oils with mixture of activated carbon and silica was effective in reducing its photometric colour by 38.3%. Mancini-Filho *et al.* (1986) found that the treatment of fried oil with an adsorbent mixture of 4.5% clay, 0.5% charcoal, 2.5% magnesium oxide and 2.5% Celite had significant reduction in darkness by 58%. Farag and El-Anany (2006) found also that the treatment of fried sunflower oil with 2% of Magnesol XL, diatomaceous earth or kaolin caused significant decrease in colour level as red slid of Lovibond tintometer by 72.2, 52.9 and 77.41%, respectively.

Viscosity: Table 1 shows the viscosity of fried and fried-treated sunflower oil with various levels of magnesol XL and DSC for different contact times. The viscosity of sunflower oil fried at 180±5°C for 12 h continuous frying was 88.67 cps. Filtration treatment with DSC and magnesol XL significantly lowered the viscosity value of fried sunflower oil. Fried sunflower oil treated with 4% of DSC for 60 min had significantly the lowest viscosity value was 37.00 cps followed by fried sunflower oil treated with 2% Magnesol XL for 30 and 60 min as well as 4% DSC for 30. Farag and El-Anany (2006), found that the treatment of fried sunflower oil with 2% of Magnesol XL, diatomaceous earth or kaolin caused significant decrease in viscosity by 67.8, 66.4 and 65.0%, respectively.

Acid value: Data tabulated in Table 1 shows that the fried sunflower oil had relatively high content of free fatty acid was 1.31% as oleic acid. It is apparent from these results that filtration process caused significant ($p<0.05$) decrease in free fatty acids level. This decreasing increased with increasing the levels of DSC and Magnesol XL and their

Table 1: Effect of various level of Date palm seed carbon (DSC) and Magnesol XL for 15, 30 and 60 min physico-chemical properties of fried sunflower oil

Contact time (min)							
		1% (DPSC)			2% (DPSC)		
Parameter	Fried oil (12h)	15	30	60	15	30	60
Physical properties							
Refractive index (20°C) LSD = 0.10014	1.4740^{a}±0.00	1.4660^{b}± 0.00	1.4660^{b}± 0.00	1.4650^{b}±0.00	1.4660^{b}±0.00	1.4660^{b}±0.00	1.4650^{b}±0.00
Colour (Red Lovibond unit) LSD = 0.0447	17.83^{a}±0.050	4.00^{b}±0.05	3.50^{c} ±0.05	3.50^{c}±0.05	3.00^{d}±0.05	3.00^{d}±0.05	2.50^{e}±0.05
Viscosity (cps) LSD = 1.3960	88.67^{a}±0.480	54.67^{d} ±0.48	53.33^{b}±0.48	50.00^{c}±0.48	44.00^{d}±0.48	41.00^{e}±0.48	40.00^{e}±0.48
Chemical properties							
Acid value (mg KOH g^{-1} oil) LSD = 0.0344	1.31^{a}±0.010	0.49^{b}±0.01	0.46^{bc}±0.01	0.44^{c}±0.01	0.40^{d} ±0.01	0.38^{d}±0.01	0.37^{de}±0.01
Peroxide value meq (peroxides Kg^{-1} oil) LSD = 0.3095	10.75^{a}±0.110	3.68^{b} ±0.11	3.46^{bc}±0.11	3.19^{cd}±0.11	3.18^{cd} ±0.11	3.12^{d}±0.11	2.95^{de}±0.11
Thiobarbituric acid value (Absorbance at 535 nm) LSD = 0.03272	0.94^{a} ±0.01	0.48^{b}±0.01	0.45^{b} ±0.01	0.41^{c}±0.01	0.32^{d} ±0.01	0.31^{de}±0.01	0.29^{ef} ±0.01
Polymer content (%) LSD = 0.0312	1.86^{a}±0.010	0.71^{b}±0.01	0.62^{c} ±0.01	0.57^{d}±0.01	0.48^{e}±0.01	0.43^{f}±0.01	0.39^{g}±0.01
		4% (DPSC)			Magnesol XL (%)		
Parameter	Fried oil (12 h)	15	30	60	15	30	60
Physical properties							
Refractive index (20°C) LSD = 0.10014	1.4740^{a}±0.00	1.4660^{b}±0.00	1.4650^{b}±0.00	1.4650^{b}±0.00	1.4670^{b}±0.00	1.4660^{b}±0.00	1.4660^{b}±0.00
Colour (Red Lovibond unit) LSD = 0.0447	17.83^{a}±0.05	3.00^{d}±0.05	2.50^{e}±0.05	2.50^{e}±0.05	3.00^{d}±0.05	3.00^{d}±0.05	3.00^{d}±0.05
Viscosity (cps) LSD = 1.3960	88.67^{a}±0.48	39.00^{f}±0.48	38.00^{fg}±0.48	37.00^{g}±0.48	39.00^{f}±0.48	38.00^{fg}±0.48	38.00^{fg}±0.48
Chemical properties							
Acid value (mg KOH g^{-1} oil) LSD = 0.0344	1.31^{a}±0.01	0.35^{e} ±0.01	0.30^{e}±0.01	0.28^{fg}±0.01	0.28^{fg}±0.01	0.26^{fg}±0.01	0.26^{fg}±0.01
Peroxide value meq (peroxides Kg^{-1} oil) LSD = 0.3095	10.75^{a}±0.11	2.74^{ef} ±0.11	2.67^{ef}±0.11	2.61^{f} ±0.11	2.57^{f} ±0.11	2.35^{f}±0.11	2.50^{f}±0.11
Thiobarbituric acid value (Absorbance at 535 nm) LSD = 0.03272	0.94^{a} ±0.01	0.26^{f} ±0.01	0.23^{g} ±0.01	0.18^{h} ±0.01	0.18^{h} ±0.01	0.17^{h}±0.01	0.16^{h}±0.01
Polymer content (%) LSD = 0.0312	1.86^{a}±0.01	0.39^{g}±0.01	0.36^{g}±0.01	0.36^{g}±0.01	0.31^{h}±0.01	0.31^{h}±0.01	0.31^{h}±0.01

Values are expressed as the mean of triplicate determinations; Values in the same row followed by different letter are significantly different at ($p<0.05$)

contact time. No significant ($p>0.05$) differences were observed between fried sunflower oil treated with 4% of DSC for 60 min and those samples treated with 2% MagnsolXL for 15, 30 and 60 min. The reduction in free fatty acid level due to scavenging capacity of filter aids under study. These results indicate, the efficiency of DSC in adsorption of free fatty acids that were formed during frying process. These results in good correlation with the results that were obtained by Lin *et al*. (2001), they reported that the treatment of fried oil with the combinations of 2 absorbent F (3% Hubersorb 600, 3% Magnesol XL and 2% Fry powder) and B (2% Hubersorb 600, 3% Magnesol XL and 2% Britsorb) were effective in reducing FFA by 78.3 and 68%, respectively. A mixture of activated carbon and silica reduced acid value by 53.9% (McNeill *et al*., 1986). Mancini-Filho *et al*. (1986) found that the filtration of fried oil with an adsorbent mixture of 4.5% clay, 0.5% charcoal, 2.5% magnesium oxide and 2.5% Celite had significant lowering in free fatty acids level by 14%. In this respect (Farag and El-Anany, 2006) found that the treatment of fried sunflower oil with 2% of Magnesol XL, diatomaceous earth or kaolin caused significant decrease in free fatty acids level by 61.3, 62.2 and 64.1, respectively.

Peroxide value: The results presented in Table 1 show the effect of filtration process on peroxide value of fried sunflower oil. Fried sunflower oil had relatively high peroxide value was 10.75 meqO^{2} kg^{-1} oil. Significant ($p<0.05$) differences in peroxide value were observed between fried sunflower oil (12 h of continuous frying) and fried sunflower oil treated with DSC and Magnesol XL. However, there was no significant ($p>0.05$) difference between fried sunflower oil treated with 4% of DSC for 60 min and fried sunflower oil treated with 2% of Magnesol XL for 15, 30 and 60 min. These results indicate that DSC can be used in removing the primary products of lipid oxidation. These results are consistent with finding of Lin *et al*. (2001), they reported that the treatment of fried oil with the combinations of 2 absorbent F (3% Hubersorb

600, 3% Magnesol XL and 2% Frypowder) and B (2% Hubersorb 600, 3% Magnesol XL and 2% Britsorb) were effective in reducing the primary products of lipid oxidation. The results obtained by Farag and El-Anany (2006) indicated also that the peroxide value of the fried sunflower oil was about 4.80, 3.68 and 5.43 fold greater than that of fried-treated sunflower oil with 2% of diatomaceous earth, kaolin and Magnesol XL, respectively.

Thiobarbituric acid value: The results of TBA test (Table 1) indicate that fried sunflower oil for continuous frying period 12 h) had relatively high TBA value was 0.94 as absorbance at 532 nm. Filtration process caused significant ($p<0.05$) lowering effect in the amount of TBA reacting substances. This decreasing increased with the increasing the level of DSC and its contact time. Fried sunflower oil treated with 4% DSC for 60 min and 2% Magnesol XL for 15, 30 and 60 min had significantly the lowest TBA value ranged from 0.16-0.18 as absorbance at 532 nm. These results are consistent with finding of Taylor and Gallavan (1988) that the treatment of fried oils with a mixture of gel-derived alumina and activated clay or magnesium silicate caused significant decrease in the amount of aldehydes and ketones compounds. Lin *et al.* (1999) found that the treatment of fried oil with combinations of Britesorb, Hubersorb, Frypowder and Magnesol XL reduced the absorbance at 460 nm by 5.6-8.6%. Farag and El-Anany (2006), also found that the treatment of fried sunflower oil with 2% of Magnesol XL, diatomaceous earth or kaolin caused significant decrease in the absorbance at 532 nm by 68.4, 76.1 and 77.6, respectively.

Polymer content (%): The results presented in Table 1 illustrates that fried sunflower oil for continuous frying period 12 h had significantly the highest level of polymer was 1.86%. The treatment of fried sunflower oil with various level of Magnesol XL and DSC for 15, 30 and 60 min induced significant ($p<0.05$) decreased in the polymer content. This reduction increased with the increasing the level of DSC and its contact time. Fried sunflower oil treated with 2% Magnesol XL for 15, 30 and 60 min had significantly the lowest level of polymer was 0.31% followed by those samples treated with 2% DSC for 60 min and 4% DSC for 15, 30 and 60 min ranged from 0.36-0.39%.

Several studies indicated the effect of frying process on the physico-chemical and sensory properties of fried oil. In this respect (Clark and Serbia, 1991; White, 1991; Tyagi and Vasishtha, 1996) reported that frying oils used continuously or repeatedly at high temperatures in the presence of oxygen and water from the food being fried, are subject to thermal oxidation, polymerization and hydrolysis and the resultant decomposition products adversely affect flavour and colour. Deterioration of frying oils is generally followed by changes in Free Fatty Acid (FFA) level, colour of the used oil, or an increase in polarity of the oil (Paradis and Nawar, 1981; Tan *et al.*, 1985; Orthoefer, 1988; White, 1991; Melton *et al.*, 1994; Orthoefer *et al.*, 1996). Normally, frying oils undergo extensive degradation and complex chemical transformations when heated. The presence of air and water introduced as steam during the frying process can accelerate the deterioration of frying oil (Clark and Serbia, 1991). As oil thermally and oxidatively breaks down, there is an increase in the number of polar molecules, which directly increases the dielectric constant (Fritsch *et al.*, 1979; Graziano, 1979; White, 1991). The results of the current study are in harmony state with the data of previous researches.

In the same time, the activity of DSC as filter aid due to it had high values of bulk density, surface area, porosity, decolourizing power and ion exchange capacity were 0.67 g m L^{-1}, 184.60 m^2 g^{-1}, 12%, 15.00 mg g^{-1} and 0.19 m Equiv g^{-1}, respectively (Kannan and Thambidurai, 2007).

Changes of some physico-chemical properties of fried sunflower oil treated with DSC: Refrying experiment was conducted to evaluate the efficiency of fried sunflower oil after treatment by DSC for 60 min. Data presented in Table 2 shows the changes in foam, colour (red slid reading) and viscosity of the fried-treated sunflower oil with 4% of DSC. Generally, the foam height, colour and viscosity values were gradually and significantly ($p\leq 0.05$) increased towards the end of the frying period. These data showed also that the treated fried sunflower oil behaved as a fresh oil and can be used for further frying purposes without any caution. Concerning the changes in acid value, peroxide value, TBA value and polymer content of refried sunflower oil treated with 4% DSC. In all cases, these values were gradually and significantly ($p\leq 0.05$) increased during frying period. It is of interest to report that, after 8 h of continuous frying period at 180°C for treated sunflower oil with DSC. The above mentioned values were within the permissible limits of oils used for human consumption. Accordingly, one could report that sunflower oil treated with 4% DSC was quite efficient in removing the degradation products resulted from frying process. Therefore, the treated sunflower oil can be used for another frying process without any notice (Table 2).

Table 2: Changes of some physico-chemical properties of fried sunflower oil treated with 4% of Date palm seed carbon (DSC) for 60 min

Frying period (h)	Refractive index (20°C)	Colour (red lovibond unit)	Viscosity (cps)	Acid value (mg KOH g^{-1} oil)	Peroxide value (meq peroxides Kg^{-1} oil)	Thiobarbituric acid value (Absorbance at 535 nm)	Polymer content (%)
0	1.4650a±0.00	2.50a	37.00a	0.28a±0.01	2.61a±0.11	0.18a±0.01	0.36a±0.01
4	1.4655a±0.00	5.50b	54.21b	0.55b±0.02	4.52b±0.21	0.38b±0.04	0.58b±0.01
8	1.4662a±0.00	10.00c	70.54c	0.77c±0.04	7.32c±1.01	0.65c±0.06	0.87c±0.01
12	1.4737b±0.00	15.50d	93.00d	1.30d±0.01	10.65d±0.91	0.99d±0.03	1.65d±0.01
LSD	0.10016	0.0386	1.645	0.028	0.3564	0.02942	0.02851

Values are expressed as the mean of triplicate determinations; Values in the same row followed by different letter are significantly different at ($p<0.05$)

CONCLUSION

It is apparent from the current study that the efficiency of 4% DSC for 60 min in removing oxidation products of fried oils was almost equal to the efficiencies of synthetic filter (Magnesol XL). Since, the raw material date palm seed is freely available in large quantities as a waste in jam industries, the treatment method seems to be economical. Based on the above good results this relatively cheap, low-cost DSC is recommended as an effective and cheap adsorbent for removing oxidation products of fried oils.

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