



Interaction of Antioxidants coupled with peanut oil and physico-chemical variables during repeated deep fat frying of purees

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ABSTRACT

*Peanut (*Arachis hypogaea* L.) oil alone and in combination with one synthetic [butylated hydroxy anisole (BHA)] and two natural [β -carotene and ascorbyl palmitate (AP)] antioxidants were evaluated in two concentrations for their interaction of deep fat frying of purees with physico-chemical characteristics (peroxide value, acid value, viscosity, color and oil absorption). Among the antioxidants, β -carotene and ascorbyl palmitate added to peanut oils used for repeated deep fat frying of puree preparations significantly increased the stability and acceptability. The interaction of different variables and antioxidants varied during 60h frying time.*

Key words: Peanut oil. Interaction of physico-chemical parameters and antioxidants. Butylated hydroxy anisole (BHA). β -carotene. ascorbyl palmitate (AP). deep-fat frying. purees

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INTRODUCTION

Use of diverse types of edible oils and their repeated frying collectively promote a series of complex chemical reactions and scission products such as non-volatile oxidized derivatives and dimeric and polymeric substances resulting in quality deterioration and affecting the stability by lipid oxidation in reducing the taste, flavor, aroma and nutritional value of food products (Rossell, 2001; Bouregghda et al., 2012). The free-radicals formed by fatty acids react with oxygen to generate peroxides that decompose giving secondary products viz., aldehydes, alcohols, ketones, acids, lactones, hydrocarbons and other polymerized fats (Arafat et al., 2008; Basuny et al., 2011). The main cause of oil degradation is a cumulative effect of oxidation, thermal treatment, and oil food interaction at high temperatures. The supplementation of antioxidant additives impacts the delay in lipid oxidation of fats and oils due to the fact that at ambient temperatures autoxidation reactions taking place through low-chain reactions of free-radicals and formation of predominant products of hydroperoxides, whose concentrations increase until advanced stages of oxidation. These conditions promote the activity of primary antioxidants due to their ability to donate hydrogen to the lipid-free radicals preventing a new lipid molecule from entering in the chain to be oxidized. However, the oxidation at higher temperatures during frying is far more complex because both oxidative and thermal reactions are concurrently involved. At high temperatures, the formation of new compounds is very rapid, reduces oxygen pressure, and expedites the decomposition of hydroperoxides (Dobarganes, 1998; Dobarganes and Marquez-Ruiz, 2007). There is a growing interest in the replacement of synthetic antioxidants by natural ones that has fostered research on the use of natural antioxidants for stabilizing vegetable oils. This has enabled to focus the present research on their effect in repeated deep-fat frying of peanut oil.

MATERIALS AND METHODS

Sample preparation

The effect of antioxidants on the stability of pure refined peanut oil obtained from the market was utilized as a frying medium (control). A synthetic [butylated hydroxy anisole (BHA @ 100 and 200 ppm)], and two natural (β -carotene and ascorbyl palmitate (AP) (@ 250 and 500 ppm) antioxidants were used as admixtures in peanut oil. Butylated hydroxy anisole and AP dissolved individually in 10 mL peanut oil

were heated, and diluted for required concentrations in large amount of warm peanut oil. While β -carotene dissolved in 95% alcohol was supplemented to peanut oil and heated for the evaporation of alcohol before frying.

Puree preparation

Purees rolled from the dough made by mixing wheat flour (850g), water (630 mL), and salt (20g) and were divided into 180 small balls, which were pressed in a 'Puree Press' to attain a circular shape. They were deep-fat fried at $180 \pm 5^\circ\text{C}$ in batches of 3h in circular concave open aluminum pans. Care was taken to clean the same pan thoroughly and dried after use for frying in order to keep the size, shape, and metallic base constant throughout the experiment.

Frying process

Samples of oil and purees were drawn at 3h intervals, after each batch of frying, for quality evaluation. The frying process was repeated at 3h intervals, over a period of 60h; and the loss of oil was replenished, due to absorption by purees, with fresh peanut oil added antioxidants in the residual oil so as to maintain an optimum level @ 500 mL at the beginning of each stage of frying. From each oil sample of different deep-fat frying batches, 40 mL samples and purees were drawn separately to determine the physico-chemical changes for quality characteristics viz., peroxide and acid values, viscosity, color, oil absorption capacity, and sensory evaluation score (organoleptic determination).

Statistical analysis

The data collected in triplicate was subjected to factorial analysis of variance with independent variables such as antioxidants; their concentration and frying time was used to study their interacting effects on the physico-chemical characteristics upon deep-fat frying (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Peroxide value: At 60h frying, the β -carotene added oils recorded the least peroxide values followed by AP (500 ppm), BHA (100 and 200 ppm), and AP (250 ppm). The data showed highly significant variability not only between the antioxidants, their concentrations and interactions including the frying time but also influenced the peroxide values at deep-fat frying (**Table.-1**). However, the interaction between the antioxidant variability and their levels did not affect the peroxide values significantly, and are similar with initial control samples.

During frying, vegetable oils will undergo a series of chemical reactions such as hydrolysis, oxidation and polymerization resulting in quality deterioration with respect to their nutritive value (Anwar et al., 2010). While oil quality and stability are principally affected by lipid oxidation that results in generation of off-flavor and reduction in nutritional value (Giuffrida et al., 2007).

Acid value: The factorial analysis indicated highly significant differences not only between antioxidants and their concentrations for the acid value but also the interaction between antioxidant x concentration, antioxidant x frying time, antioxidant concentration x frying time, and antioxidant concentration x frying time (**Table.-1**).

The acid values proportionately increased with the frying time due to incorporation of water from the purees in peanut oil combinations during frying and the resulting hydrolysis at the elevated temperatures of frying. There is a proportionate increase in free fatty acid content with the number of fryings in palmolein oil (Subbulakshmi et al., 1991), sunflower oil (Sanchez-Muniz et al., 1993), soybean oil (Young-Hee Lim, 1993), *sevia*n made from rice flour and *Colocasia* (Kulkarni et al., 1994), and other vegetable oils (Gumskesan and Kavas, 1993).

Viscosity: Viscosity of oils is a measure of resistant power in the arrangement of the molecules, and often used for lubricating and fuel purposes (Tyagi and Kakkar, 1991) and has been used to determine the oxidative stability (Sarmiento et al., 2006; Okoye et al., 2009; Ali, 2010; Valantina et al., 2010). As such, it is considered as an important quality factor in puree and other semi-liquid pasty products (Joslyn, 1970). Present results suggest that the supplementation of antioxidants play a significant role by delaying the formation of polymers and resins and the increased viscosity values can be attributed to the formation of cyclic compounds and nonvolatile decomposition products during frying, but these reactions are mostly temperature-dependent. Similar results of increased viscosity with the frying time have been reported involving palmolein (Subbulakshmi et al., 1991), soybean (Goburdhan and Jhuree, 1995), and other vegetable oils (Aggelousis and Lalas, 1997; Sandal and Kalia, 2000).

Highly significant differences were observed between the antioxidants, their concentration, frying time affecting the viscosity values. Similarly, the interaction between antioxidant x concentration, frying time; concentration x frying time, and antioxidant x concentration x frying time also showed highly significant differences for the viscosity of oils (**Table 1**).

Color: In view of repeated deep-fat frying, the color of purees was darkened. The β -carotene supplemented oils, at both the concentrations, gradually increased from 6h and reached a peak at 60h by turning the purees to orange color.

Highly significant differences for the color was noticed in between antioxidants, concentrations, frying time, and interactions between antioxidant x concentration, frying time, concentration x frying time, and antioxidant x concentration x frying time (**Table 1**).

Table-1. Factorial analysis of different variables and their interactions of antioxidants coupled with peanut oil in puree preparations.

Source of variation	DF	Mean sum of squares					
		Peroxide value	Acid value	Viscosity	Color	Oil absorption	Sensory score
Antioxidant (A)	2	86.96**	0.43**	123.98**	1.00**	3.01	0.47**
Concentration (C)	1	42.60**	0.64**	16.03**	0.47**	0.12	2.46**
Frying time (FT)	22	719.44**	18.61**	1355.50**	1.24**	7.98**	4.37**
A x C	2	8.87	0.39**	49.02**	0.13**	3.55	0.01
A x FT	40	117.63**	0.17**	30.38**	1.14**	1.04	0.04
C x FT	20	82.15**	0.17**	16.46**	0.06**	2.11	0.09*
A x C x FT	40	88.41**	0.12**	11.98**	0.07**	1.36	0.04
Error	252	9.96	0.04	0.40	0.00008	2.49	0.76

*and ** indicates significant at 5% and 1%, respectively.

The development of dark color with the frying time in the present investigation may be due to the ability of antioxidants to block peroxide formation at the double bonds in the unsaturated fatty acids of triglycerides.

Oil absorption: The oil absorption capacity of purees was significantly higher only after frying time. Among the antioxidants, β -carotene (500 ppm) and BHA (200 ppm) showed significantly high and lower absorption values, respectively. While the antioxidants and their concentrations did not show any significant effect on oil absorption. This indicates that oil absorption depends only on frying time and not by other factors. The interaction between antioxidant x concentration, frying time, concentration x frying time, and antioxidant x concentration x frying time did not show any significant differences (**Table 1**).

The increase in peanut oil absorption of purees with the frying time may be due to increased oil viscosity. And the amount of fat absorbed during frying increased probably due to slower drainage of the more viscous oil and reduced heat transfer from oil to the fried product. These findings are in agreement with Mathews and Patwa (1969), who reported that the recurrent use of same fat is a primary factor with the amount of fat supplemented in the puree dough preparation. Other reports also strongly support the present observations indicating oil absorption increased in relation to frying time of potato chips (Reddy and Das, 1993), Indian traditional snack, *Urd vada* (Indira, 1996), and *Tortilla* chips (Moreira et al., 1997).

CONCLUSION

Considering the increased concern among the consumers and scientific community on the indiscriminate use of synthetic food additives including synthetic antioxidants in foods, the present investigation suggests greater potential to stabilize the frying peanut oil combined with natural antioxidants (β -carotene and AP) over BHA. And selection of antioxidants for use in frying, attention need to be focused on the amount of active antioxidant remaining after frying and protecting the fried foods during storage. This depends on the type of antioxidant and its concentration in the frying medium at the time of each frying operation.

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