Effect of repeated intermittent deep-fat frying and interaction of peanut oil coupled with natural and synthetic antioxidants on Sensory parameters 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 influence of deep fat frying of purees on sensory score. 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 natural antioxidants are effective and can be compared with the synthetic antioxidant, BHA. Higher concentrations of these antioxidants resulted in reaching significantly higher sensory score providing their acceptability in the preparation of purees. The color of the oils was significantly higher for beta carotene added oil. Sensory score of purees were evaluated by panelists and concluded that the control oil sample recorded least sensory score that was followed by AP, β-carote, and BHA added oils at lower concentrations.

Keywords: Peanut oil, antioxidants, Butylated hydroxy anisol (BHA), β-carotene, ascorbyl palmitate (AP), deep-fat frying, purees

1. Introduction
Deep-fat frying is used commonly in restaurants and fast food outlets as a preparation method for foods which is a cooking method that includes immersing the food product in oil at a temperature usually between 320° and 374° F (160 and 190°C) [1]. Deep fat frying finds a major place in the culinary art because of its low cost and high demand, since it produces convenient food of high acceptability. Food service industry standards for deep-fat frying include oil temperatures typically between 350-375°F [2]. During deep fat frying, oxidation and hydrolysis change the chemical, sensory and nutritional properties of oil. Though, synthetic antioxidants are widely used to stabilize frying oils, concern for safety has shifted the focus to replace them with safer natural counterparts. 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 [3, 4]. 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. The high temperatures, the formation of new compounds are very rapid, reduces oxygen pressure, and expedites the decomposition of hydroperoxides [5, 6].

The present study was undertaken to determine the effect of continuous deep fat frying, the effect of added synthetic antioxidants and naturally occurring reducing substances and the concentration of such antioxidants added on the stability of vegetable oil used for repeated deep fat frying and to determine the maximum period of frying up to which fried products prepared using such antioxidants added oils are organoleptically accepted.

2. Materials and methods
2.1 Sample preparation
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.

2.2 Puree preparation

Purées rolled from the dough and deep-fat fried at 180 ± 5°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.

2.3 Frying process

Samples of oil and purées 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 purées, 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 purées were drawn separately to determine the sensory evaluation score (organoleptic determination).

2.4 Sensory score

Sensory evaluation is the measurement of product quality based on information received from the five senses: sight, smell, taste, touch and hearing. Sensory methods of measuring food quality appear to lack the precision that is desirable in scientific research because of the variability from person to person and variability from hour to hour and day to day in likes and dislikes of each person.

Sensory evaluation is an important aspect of product development. It is the best method for evaluating texture of new types of foods in the early stages of development, especially fabricated foods, and for providing a basis on which instrumental methods might later be designed for use as a quality measure and production control.

Changes in quality of purées fried in different oils at different frying intervals were analyzed by sensory evaluation by method given by Ranganna [7]. The hedonic rating test was used to measure the consumer acceptability of purées. A six member, untrained but experienced panel consisting of students, faculty and staff of the University evaluated colour lightness, characteristic puree flavor, oxidative rancidity and off-flavor of the puree with descriptive analysis after each frying. Panelists evaluated 3-6 samples in each session. Panelists rinsed their mouths with room temperature water between samples to evaluate the sensory quality of purées, three samples were served to trained panelists at one session. All the samples were served to six panelists. The panelists were asked to rate the acceptability of the products on a scale of nine points ranging from “like extremely” equivalent to score nine to “dislike extremely” equivalent to score one. Separate cards were used for each panelist for each frying interval.

2.5 Statistical analyses

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. The means were separated using least significant difference (LSD) test @ (P = <0.5 and <0.1%) [8].

3. Results and discussion

3.1 Sensory score

Colour

One of the most pleasing attributes of a food is its colour and there is much to be said for the statement, “we also eat with our eyes”. Food colour not only helps to determine quality, it can tell us many things. Colour is commonly an index of ripeness or spoilage. Most crude oils are coloured, usually with an orange hue due to the presence of dissolved carotenoids. Occasionally brown shades can be present, usually as a result of oxidation. Mean colour values of groundnut oil without antioxidants (control), with BHA lower level (100 ppm), BHA higher level (200 ppm), β-carotene lower level (250 ppm), β-carotene higher level (500 ppm), ascorbyl palmitate (250 ppm) and ascorbyl palmitate (500 ppm) on intermittent deep fat-frying purées for 60 hrs are presented in Fig. 1 shows the change in colour of the seven oils used in this study on deep fat-frying.

The data shows that the colour of oil used for repeated deep-fat frying purées darkened as the frying time increased. The colour value of the oils ranged from 0.028 to 4.22 before frying. The maximum colour value was for β-carotene added oils due to its red-orange colour when mixed to the oil. It is observed that the colour of the β-carotene added oil is suddenly decreased during the first 3 hrs of frying itself. But, from after 6 hrs frying the colour gradually increased after each frying till 60 hrs frying. The lowest initial colour value was found for control oil without adding any antioxidants (0.028).

Fig 2 shows the mean score of sensory evaluation of purées when they were fried in different antioxidant added oils for up to 60 hrs. The mean sensory score decreased as the frying time increased in all the seven oils. Sensory evaluation scores of the products fried in reheated-antioxidant added oils and control oil showed that the products are highly acceptable even after 12 h frying. The mean scores ascribed for all the oils by the panel of judges were between 9 and 8, indicating that the products were rated as “like extremely” and “like moderately” but interestingly, the scores obtained for products fried in fresh oils were in the range if 7.0 to 7.4 for different sensory attributes. After 60 hrs frying, the sensory score range was 3.78 to 5.05 very low sensory evaluation score was observed for control oil after 57 and 60 hours of frying itself. But, from after 6 hrs frying the colour gradually increased after each frying till 60 hrs frying. The lowest initial colour value was found for control oil without adding any antioxidants (0.028).

It was observed that control sample without addition of any antioxidant gave the lowest sensory score of purées up 60 repeated deep fat frying. This was followed in the ascending order by ascorbyl palmitate, β-carotene and BHA added oils. For all the antioxidant added oils, higher levels of antioxidant added resulted in higher sensory scores for purées.

The data 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. The means were separated using least significant difference (LSD) test @ (P = <0.5 and <0.1%) [8].

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dislike is taken as the minimum acceptable level for the quality of the fried product. It was found that the control oil sample recorded least sensory score that was followed by AP, β-carotene, and BHA added oils at lower concentrations (Fig.2). In general, antioxidant added oils and preferably at higher concentrations have recorded higher sensory scores. Analysis of data showed between the antioxidants, their concentrations, and frying time highly significant differences (P<1.0) and concentration x frying time (P<0.5). But the interactions between the antioxidant x concentration, frying time, and antioxidant x concentration x frying time did not show any effect on the sensory score (Table 1).

The overall food quality has been categorized into: quantitative, hidden, and sensory [9]. Based on the sensory score, it has been observed that the control oil sample recorded the least sensory score of purees upon repeated deep fat frying. Based on the sensory score and comparing the effect of other dependable variables on quality characteristics, it can be suggested that the natural antioxidants (β-carotene and ascorbyl palmitate) are effective over BHA, and their higher concentrations resulted in higher scores. These results strongly indicate the antioxidative effect was mostly dependent upon their concentration, and support the earlier findings [10, 11, 12]. These results gain support from Young-Hee Lim [13], who found that the soybean color change to dark brown resulted in decreased acceptability of Yukwa while frying at 180° C from 0 to 16 h. During frozen storage of 16 months at −20 ± 1 °C, the overall acceptability and lightness was found to be decreased from the original value of frozen vegetable snack [14]. The oxidative stability of Palm Olein, Soyabean Oil and Linseed Oil with direct incorporation of antioxidants (tertiary butyl hydroxquinone (TBHQ), butylated hydroxyl toluene (BHT) and mixed (TBHQ and BHT) at room temperature and 70 °C for 168 hours was investigated and peroxide value and the oxidative stability were evaluated and found that TBHQ had significant effect on the oxidative stability of palm olein at 70 °C while (TBHQ and BHT) had synergetic effect on stability of Soya bean oil at room temperature and Linseed oil at 70 °C [15].

![Fig 1: Colour value of different antioxidant added oils during deep fat frying.](image1)

![Fig 2: Sensory score for different antioxidant added oils during deep fat frying](image2)
4. 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 mostly depends on the type of antioxidant and its concentration in the frying medium at the time of each frying operation. On the basis of mean scores obtained for all the seven treatments of oils and the of frying up to which the mean score remained at or above 5, the following conclusions can be arrived at regarding the number of frying (batches of 3 hrs) or frying time in hours up to which the oils with different added antioxidants can be used for deep fat frying acceptable purees. Control oil 13 times (39 hrs), BHA lower level 16 times (48 hrs), BHA higher level 20 times (51 hrs), ascorbyl palmitate higher level 17 times (51 hrs), β-carotene higher level 15 times (45 hrs), β-carotene lower level 15 times (45 hrs), and ascorbyl palmitate lower level 16 times (48 hrs) and ascorbyl palmitate higher level 19 times (57 hrs).

Table 1: Factorial analysis of Sensory score and their interactions of antioxidants coupled with peanut oil in puree preparations.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Mean sum of squares</th>
<th>Sensory score</th>
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<tbody>
<tr>
<td>Antioxidant (A)</td>
<td>2</td>
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</tr>
<tr>
<td>Concentration (C)</td>
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<td>2.46**</td>
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<tr>
<td>Frying time (FT)</td>
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<td>4.37**</td>
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<tr>
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<td>0.01</td>
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<tr>
<td>A x FT</td>
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<td>0.04</td>
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<td>0.04</td>
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<tr>
<td>Error</td>
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*and ** indicates significant at 5% and 1%, respectively.

5. References