Effect of Clove and Lemongrass Essential Oils as Natural Antioxidants on Cake Shelf Life

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Abstract

The objective of this study was to evaluate the effect of clove and lemongrass essential oils (CEO and LEO) as natural antioxidants on cake shelf life at room temperature. The samples contain these natural antioxidants were compared with cake contains synthetic antioxidant (BHT) and control sample which produced without any addition. The variation in peroxide value (PV), Thiobarbutiric acid value (TBA) and fatty acids composition (%) within different storage periods were determined in order to evaluate the lipid oxidation. In additional, the cake organoleptic properties were investigated. The results of PV showed that lipid oxidation of cake delayed ($P<0.05$) when the concentration of essential oils in cake dough was increased. On the other hand, TBA values of cake that contain CEO and LEO were significantly lower ($P>0.05$) at the end of storage compared with control cake. However, it was found that the samples contain CEO were lower in overall acceptability ($P<0.05$) compared with control sample. In the conclusion, the addition of LEO in a level of 600 ppm was highly recommended to increase the shelf life of industrial cakes by delaying the oxidation of oils while the using of CEO was not recommeneded due to it's undesirable sensory effects.

Keywords: *Essential oils, antioxidan, cake, shelf life, clove, lemon grass*

Keklerin Raf Ömrü Üzerine Doğal Antioksidant Olarak Karanfil ve Limonotu Esansiyel Yağlarının Etkisi

Özet

Bu çalışmanın amacı karanfil (CEO) ve limonotu (LEO) esansiyel yağlarının doğal bir antioksitant olarak oda sıcaklığında muhafaza edilen keklerin raf ömrü üzerine etkisini araştırmaktadır. Doğal antioksidan ilave edilerek üretilen kekler sentetik antioksidan (BHA) içeren kekler ve kontrol (antioksidan içermeyen) keklerle karşılaştırılmıştır. Depolamanın farklı günlerinde lipid oksidasyonunu belirlemek için peoksit değeri (PV), TBA değeri ve yağ asidi profilindeki değişimler belirlenmiştir. İlave olarak organoleptik analizler yapılmıştır. PV bulguları kekteki esansiyel yağ miktarının artırılmasıyla lipid oksidasyonunun geciktirildiğini göstermiştir. Diğer taraftan, CEO ve LEO içeren örneklerdeki TBA değerlerinde artış muhafazanın sonunda kontrol keklerden önemli derecede daha yavay gerçekleşmiştir (P<0.05). Bununla birlikte karanfil esansiyel yağı içeren örneklerin genel kabul puanları olumsuz lezzet ve kokudan dolayı diğerlerinden oldukça düşük bulunmuştur. Elde edilen bulgulara göre kek hamuruna 600 ppm düzeyinde limonotu esansiyel yağı ilave edilmesinin yağ oksidasyonunun geciktirerek raf ömrünü artıracağı; karanfil yağının ise arzu edilmeyen duyusal etkisinden dolayı kullanılamayacağı sonucuna varılmıştır.

Anahtar kelimeler: *Esansiyel yağlar, antioksidant, kek, raf ömrü, karanfin, limonotu*

INTRODUCTION

Cake products are one of the important products in the bakery industry. It is very difficult to define cakes due to the large number of cake varieties and formulas, but generally it can be defined as a bakery product obtained by baking dough prepared by using flour, sugar, oil, eggs, baking soda, and water (sometimes milk). The fat content of cake products is varying between 15 % to 60 % and the type and amount of fats significantly affect the texture and structure of these products **(Kadıoğlu, 2009).** The type of used fat (oil, butter, margerin and shortening), the fat storage conditions, the application of heat treatment and the storage of final products are important factors lead to lipid oxidation in cake products. During oxidation, many compounds such as peroxides, aldehydes, ketones, hydrocarbons, alcohols and acids are formed which cause product rancidity at the end of oxidation chain **(Turan et al., 2012)**. Furthermore, the oxidation of lipids has undesirable effects on the human organism and the immune system **(Karpinska et al., 2001).** Because of that it's mandatory to use an antioxidant such as butylated hydroxytoluene (BHT) and butylated hydroxy anisole (BHA) in cakes industry. However, in terms of toxicology and nutrition, synthetic antioxidants used in the food industry are found to have carcinogenic effects on the human organisms **(Ames, 1983)**. For this reason, last few years many studies on the use of plant extracts and essential oils as alternative natural antioxidants in cake industry have been done. In the same way, our study was to investigate the effect of clove and lemongrass essential oils as antioxidant agents in the cake production.

Clove plant is belong to *Myrtaceae* family, known as *Eugenia caryophyllata* and *syzygium aromaticum* and it was found for the first time in tropical Asia (Indonesia and Zengibar) **(Vural, 2014, Kamkar et al., 2013).** The history of this plant is back to the 1st century B.C. and it was used among lot of people in the past as a teeth pain reliever **(Milind and Deepa, 2011).** This plant can be extend up to 10-20 m, keep green in all seasons and avoid loosing leaves in winter **(Chaieb et al., 2007, Kamkar et al., 2013).** Clove flowers are pink and when their buds are dried, they turn to be brown. The dried buds are called "clove" and the spices obtained from them have a black color, bitter and sour taste **(Çobanı and Patır, 2010)**. According to the study done by **Santos et al. (2009),** the extracted clove oil mainly contain (49-87 %) of eugynol, which is the most responsible component of the oil aroma and antioxidant property, eugenyl acetate (0.5-21 %). In similler way, **Lee and Shibamoto (2001)** have studied the antioxidant properties of CEO isolated by two different methods and found that the main components of oil were eugenol and eugenyl acetate. In another study, the antioxidative effects of CEO were identified to be similler to BHT and BHA **(Lean and Suhaila, 1999).**

Lemongrass is an aromatic plant belongs to the family *Gramineae* **(Akhila, 2010).** Lemongrass (*Cymbopogon citratus)* is long-lived and distributed especially in tropical and subtropical countries **(Tajidin et al., 2012; Karik and Azkan, 2011; Francisco et al., 2011**). The plant can be lengthened to 6 inches. The leaf blade is narrow, linear, about 100 cm long, 2 cm wide and have a strong lemon odor **(Adejuwon and Esther, 2007).** The tea of lemongrass extracts has been extensively used as an antiseptic, antifreeze and antidyspeptic in South America, Asia and West Africa **(Sawyerr, 1982).** The essential oil of the plant is obtained by extraction methods from dry or fresh leaves **(Baytop, 1999)**. The basic structure of lemongrass plant is "citral" **(Schaneberg et al., 2002)** and 1 to 2 % essential oils based on dry matter **(Carlson et al., 2001)**. lemongrass oil is formed by varied and complex volatile mixtures of chemical compounds (such as terpenes, monoterpenes, terpenoids, alcohols, aldehydes, and ketones) **(Pengelly, 2004)**, mainly citral (about 70 %) **(Torres and Ragadio, 1996)**. Citral is a natural combination of two isomeric aldehydes, geranial (α-citral) and neral (β-citral) **(Pengelly, 2004).** In recent days, some researches has been done on antioxidant activity of lemongrass essential oils. **Mirghani et al. (2012)** have shown antioxidant property of lemon grass essential oil with DPPH test, and recorded that both leaves as well as stem extracts have the ability of free radical cleaning.

The objective of our study was to evaluate the effect of CEO and LEO as natural antioxidants on cake shelf life by comparing the oxidation degree of cake produced by adding one or more of these essential oils with the cake produced by adding synthetic antioxidant and control sample which produced without any additions.

MATERIALS and METHODS

Materials

Cake ingredients

Wheat flour, sugar, eggs (10 g fat /100 g egg), milk (3.3 % fat), corn oil, shortening (99.9 % fat), baking powder and vanilla, as well as clove buds were bought from the local market, Istanbul, Turkey. While lemon grass essential oil was purchased ready to use from "Homemade Aromaterapi" company, Istanbul, Turkey.

Chemicals

n-Hexane (Merck 1.04368), n-Hexane for gaz chromatography (Merck 1.04371), Asetik asit (Merck 1.00063), Kloroform (Merck 1.02445), Potasyum iyodür (KI) (Merck 1.05051), Nişasta (Merck 1.01252), sodyum tiyosülfat (Merck 1.09950), TBA (Merck 1.08180), HCL (Merck 1.00317), Propil galat (Merck 8.20599), EDTA (Merck 3.24503), Potassium hydroxide solution methanol (Merck 111787).

Methods

Preparation of clove essential oil

The ground clove bud samples (10 ± 0.5) g were weighed and transferred into filter paper extraction thimble then submitted to start extraxtion by pure ethanol for 6 hours using Soxhlet apparatus. After extraction, the solvent was evaporated under low pressure at (50 °C), by using rotary evaporator **(Quan et al., 2004)**. The obtained CEO was stored in the refrigerator at 2-4 °C until cake production.

Preparation of the cakes

1 Kg of cake was prepared by mixing (75 g) shortening, (80 ml) oil, (266 g) sugar and 3 g vanilla for 3 min. at medium speed then 2 min. at high speed. Then whole eggs (3 eggs around 195 g) were added one after one at medium

speed. After that flour (220 g) which mixed previously with baking powder (5 g) was added in five steps alternately with milk (160 ml) started and ended with flour. CEO and LEO were mixed with milk and added to the cake dough as 4 groups (300 and 600 ppm of LEO, 300 ppm of CEO and 600 ppm of mix of both). BHT was added to the cake at one level (200 ppm), while control cake was prepared without any addition. The cake dough was filled in small cupcakes and baked at (165 °C) for 11 min. The baked cakes leave to be cooled and then covered with nylon films and stored at room temperature for 29 days. Mixing and baking of cakes were carried out 6 times in order to produce 6 groups, and this process was repeated for 3 times. The Samples of all analysis were examined at 1st, 8th, 15th, 22nd and 29th days of storage except the samples of gas chromatography analysis were examined for 4 times starting from the 7th day of storage.

Preparation of lipid extract

The ground cake samples (25 ± 0.5) g were weighed and transferred into 250 ml erlenmeyer then 125 ml of n-Hexane was added. The samples were mixed for 4 hours by using shaker (150 rpm) **(Baiano et al., 2005)**. The mixture of oil and hexane was separated from cake by filter paper and left in petri dishes in the oven overnight at 55 °C for the purpose of evaporating hexane. The extracted oil was sent to the analysis of oxidation activity.

Chemical analysis

The moisture content % and PH value of cake samples were determined according to **(AOAC, 2012; AOAC, 1994).** Peroxide value (PV), thiobarbituric acid value (TBA) were determined according to **(AOAC, 2012; Ke et al., 1984).** The fatty acid composition % was obtained by gas chromatography according to **(AOAC, 2000).**

Sensory evaluation

The sensory analysis of cake samples obtained in a lighted and ventilated environment by a group of 5 people (students and teachers) from İstanbul Aydın University, Faculty of Engineering, Department of Food Engineering. The coded samples were randomly submitted to the panelists as well as a glass of water in order to drink after each tasted sample. In the sensory test, color, odor, taste, texture and overall acceptability of samples using hedonic scale of 7 (1:didn't like at all, 7:liked alot) were evaluated **(Moskowitz ve Sidel, 1971)**.

Statistical evaluation

The data were statistically analyzed using SPSS program (Version 24). The significant differences between experimental results were determined using (Dancun test) and considered significant when $P<0.05$. Data were expressed as means ± standard deviation of three replicates.

RESULTS

Effect of CEO and LEO on chemical quality of cake

The effect of natural antioxidants on moisture content (%) and PH of cake samples during storage period at room temperature was given in Tables 1 and 2. A decreasing trend in the moisture content of all samples was observed (Table 1). The average moisture content of all groups was decreased from 17.64 % to 7.05 % at the end of storage (29th day), but there was no significant effect of adding natural antioxidant on cake's moisture content ($P>0.05$). The PH values of the groups was decreased within storage period in all samples (Table 2). At the end of storage, the highest PH value (7.60) was determined in the control sample and the lowest PH value (7.50) in the CEO

300 and BHT samples. But statistically there was no significant effect of adding oils on the PH value of cake (P>0.05).

The antioxidant activity of CEO and LEO comparing with synthetic antioxidant and control sample was presented as variations of PV, TBA and fatty acid composition (%) in Tables 3 and 4 and Figures 1,2,3,4 and 5.

The PV of cake groups increased continuously within storage periods as showed in (Fig. 1) and the effect of adding antioxidants until the 8th day of storage was not statistically significant (P<0.05). But starting from the 15th day of storage, the difference between PV of the samples was found to be statistically significant (P<0.01). At the end of storage (29^{th} day), samples containing high concentration of essential oils (LEO 600 and CEO+LEO) showed the lowest PV, and the difference between them was not significant (P>0.05). On the other hand, samples contain low concentration of essential oils (CEO 300 and LEO 300) were found to be significantly lower (P<0.05) than control but not different (P>0.05) from BHT sample (Table 3).

Regarding the obtained results from TBA analysis (Fig. 2 and Table 4), an increment trend was observed in all samples within storage periods. But the increment rate was lower in the samples contain antioxidants (P<0.05) when compared with control sample. At the end of storage, the highest TBA value was observed in the control sample (2.3 mg MDA / Kg cake), while the lowest one was determined in the BHT and CEO 300 samples with no significant difference (P>0.05) between both (0.88, 0.98 mg MDA / Kg cake).

The fatty acids composition (%) obtained by gas chromatography indicated that, palmitic acid was the major fatty acid of saturated acids, while the oleic acid was the major fatty acid of unsaturated acisds followed by linoleic acid. The lowest palmitic acid (27.7 %) was obtined from CEO 300 sample and the highest (33.6 %) from control sample. It was observed that the palmitic acid percentafe of all samples were reduced during storage (Fig. 3), but at the end of storage the lowest palmitic acid was observed in (LEO 600 and CEO 300) samples (26, 26.3 %). Oleic acid was increased in all samples, but in the CEO 300 and BHT samples the oleic acid didn't increase so much (Fig. 4). Linoleic acid of al examined samples within storage was indicated in the range of 31.5-33.8 % (Fig. 5). The lowest increment ratio in the linoleic acid was also observed in the CEO 300 sample.

Effect of CEO and LEO on organoleptic properties of cake

The changes occurred in the sensory quality of cakes during storage were given in Figures (6,7,8,9 and 10). The samples contain CEO (CEO 300 and CEO+LEO) was lower (P<0.05) in terms of color and taste quality comparing with control sample. On the other hand, the samples contain LEO (LEO 300 and LEO 600) were higher (P<0.05) in terms of aroma scores, and there was no significant difference (P>0.05) between them and control sample in regard to color and taste. Regarding overall acceptability, the using of LEO in producing of cake showed no significant effect (P>0.05), while using of CEO showed significant effect (P<0.05) comparing with control sample.

DISCUSSION

Generally the addition of nature or synthetic antioxidant is reducing the peroxid products which occurred in the early stages of oxidation chain. And consequently the secondary oxidation products such as alcohols, aldehydes and ketones ending with malondealdehydes which cause the off-flavor taste are also decreased **(Jadhav ve ark., 1996; Decker, 1998).** In the last few years, a lot of studies and researches had evaluated the using of the plant extracts and their essential oils as natural antioxidants due to their content of phenolic components **(Jadhav ve ark., 1996; Decker, 1998).** In our study we are evaluating the effect of CEO and LEO in deferent levels on cake shelf life.

The water in the cake affects the product structure at a significant level. Starch retrogradation occurs due to moisture loss during storage. Therefore it's important in terms of shelf life to determine the moisture content of cakes and the moisture changes that occur during storage. In our study, decrement in moisture content average of all groups from 17.64 % to 7.05 % was observed with no significant effect ($P<0.05$) of anrioxidants addition comparing with control sample. **Sowmya et al. (2009)** used sesame oil in producing cake and the moisture content of control sample was (20.3 %). **Hussien (2016)** used (25 %, 50 %, 75% and 100 %) of pumpkin and melon puree instead of fat in the production of batter cake and indicated the moisture content of the control cake (20.05 %), Similarly, **(Hussein et al., 2011)** studied the low calorie cake with different fat and sugar levels, and found that the moisure of control sample 19.36%. Another study investigated the effect of adding linen flour at different levels on the nutritional value and oxidative stability of cake and found that moisture content of control sample was 18.84 % **(Moraes et al., 2010).** The indicated results from all these studies were close to our obtained result. PH value also one of the important factors to determine the development and activity of microorganisms. In our study, the mean of PH value changed from 7.68 to 7.54 within storage period. This was going in parellel with the study done by **Gunaratne et al. (2015),** who assessed the effect of different packaging methods on the shelf life of sweet rice crackers, and they found a decrease in PH values up to 8 weeks. Other study done by **Sang et al. (2014)** indicated that the rice cake PH value (6.7) which is not so far from ours.

Peroxides occur due to lipid oxidation in the early stages and considered as one of quaity indicators affecting product shelf life **(Yanishlieva and Marinova, 2001).** Some studies indicated that, when PV of the product in the range of 10 to 20 mEq/kg oil, this product is rancid but still acceptable while more than 20 mEq/kg oil is considered rancid and unacceptable to consume (**Pearson, 1970).** In this study, all samples except control were found less to 10 mEq/kg oil, therefore considered as non-rancid while the control sample (15.6 mEq/kg oil) considered as rancid but still acceptable. Our obtained results of control cake were inagreement with the study of **Hafez, (2012),** who determined the changes in cake PV when adding marjoram as natural antioxidant and indicated that PV was 16.27 in control sample after 28 days of storage at room temeprature. Similarly, **Izzreen and Noriham (2011)** studied antioxidation activity of malesian herbal extracts in cake production and reported that all samples were not been ranceed till 15th day of room temperature storage but the PV of control was the highest (8.5 mEq/kg oil). In present study, it has been reported that CEO and LEO significantly ($P>0.01$) inhibiting the increament ratio of peroxides. The antioxidant activity of CEO and LEO can be explained due to their high content of phenolic compounds, specially egunol in CEO and citral in LEO (**Santos et al. 2009; Lee ve Shibamoto, 2001; Villalobos, 2015).** Phenolic compounds delay lipid oxidation by inhibiting the free radical reaction chain and preventing oxygen atom to give hydroxil free radicals and many secondary products such as alcohols, aldehydes, ketones and malonaldehydes which cause off-flavour **(Lean et al., 1999; Rossel, 2005).** TBA value measures malondialdehyde, which occurs at the end of lipid oxidation **(Özen et al., 2011).** In our study, the highest TBA value at the end of storage (2.4 mg MDA/ Kg cake) was recorded in control sample while the lowest in BHT and CEO 300 samples (0.79, 0.88 mg MDA/ Kg cake). **Saatchi et al. (2014)** used three Iranian plant essential oils in the production of cakes and found at the end of four weeks, the TBA value of the control sample reached (3.5 mg MDA/ Kg cake), while the other samples varied in the range of values (0.5-2.2 mg MDA/ Kg cake). **Oskoueian et al. (2013)** reported a significant reduction in TBA values when applying CEO on a Tilapia fish and cook it by two different methods (grill and microwave). **Ojo *et al*. (2006)** suggested that lemongrass extracts inhibit lipid peroxidation by preventing free radical attacks on biomembranes.

In addition to using TBA value to evaluate the formation and extension of secondary oxidation, it is widely used to detrmine the fatty acid composition% by gas chromatography **(Wqsowicz et al., 2004).** In our study, the determination of fatty acids by gas chromatography indicated that, the majority of saturated fatty acids of cake oils was palmitic acid and it was detected in the lowest level in CEO 300 and LEO 600 at the end of storage. Oleic and linoleic acids were determined respectively as the basic composition of unsaturated fatty acids and it was observed that oleic acid had a little small increament in BHT and CEO 300 compring to other samples. Similarly, the lowest linoleic acid increament was observed in the CEO 300 sample. In the study of **Kadıoglu (2009),** fatty acids were determined by gas chromatography of oils obtained by hexane extraction from the same kinds of biscuits and cake products of different brands collected from the market. As a result of this study, it was observed that palmitic acid was the basic saturated fatty acids and the unsaturated fatty acids were oleic and linoleic respectively. In another study, when fatty acid profiles were determined by gas chromatography in various flour products (oil<10 %) purchased from the market (biscuits, crackers, fruit cake and wafer), palmitic acid was the main saturated fatty acids, linoleic and oleic acids wrer the majority of unsaturated fatty acids **(Daglioglu et al., 2004).** The reported results in the above studies were in agreement with our obtained results. In additional it was reported that CEO has an ability to keep the fatty acids quite stabile within 28 days of storage. However, there was one replicate of gas chromatographic analysis, and due to that results were not studied statistically.

Sensory analysis is an important factor in assessing food quality. The color and taste scores were siginficantly lower ($P<0.05$) in CLO 300 and CLO+LEO samples than control and these low scores mainly could be due to the bitter taste and dark color of the clove oil. On other hand the LEO 600 sample was significantly ($P<0.05$) prefered by the panelists in terms of aroma which can be explained due to the desirable lemon odor of LEO. Regarding texture, there was no significat difference between all samples. In terms of overall acceptability, CEO 300 and CEO+LEO samples had received lower scores ($P>0.05$) than the other samples in the whole storage period. However, CEO+LEO sample was higher when compared to the CEO 300 at the begining, with no difference between them at the end ($P<0.05$). In a similar study**, Ibrahim et al.**

(2013) examined the effect of CEO on sponge cake shelf life by adding it at different levels (400, 600 and 800 ppm) and keeping the cake for 28 days at room temperature, there was no significant difference detected among all samples in terms of color and texture, while the cake contains (600 and 800) ppm showed significant decreament in both taste and odur. In additional, they had reported that increasing the concentration of CEO has negative effect on overall acceptability. This obtained result was different a little bit from the one we had achieved, because in our study adding of CEO even at low level (300 ppm) showed significant negative effect on sensory quality of cake.

CONCLUSION

As a conclusion, It was observed in this study that CEO and LEO were stable during baking and can be considered as effecient natural antioxidants in cake production during one month of storage. However, due to the negative effect of CEO on sensory quality of cake, it was not recommended to use it in this kind of products when LEO was assumed to be a natural alternative for the synthetic antioxidants and recommended for using in cake and other foodstuffs.

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APPENDIX

Table 1: Variations in moisture content (%) of cakes stored at room temperature

Group	Storage Period (Day)				
	1	8	15	22	29
Control	18.07±0.67 [a]	13.27±1.63 [a]	10.50±1.56 [a]	8.00±1.56 [a]	7.03±0.83 [a]
BHT	18.33±0.74 [a]	13.07±1.45 [a]	10.20±0.70 [a]	8.97±0.91 [a]	6.77±1.31 [a]
Lemon grass 300	17.17±0.50 [a]	12.37±1.72 [a]	8.85±1.43 [a]	8.62±0.77 [a]	7.57±0.64 [a]
Lemon grass 600	17.03±0.40 [a]	12.17±0.55 [a]	8.75±0.90 [a]	7.37±0.57 [a]	6.93±0.55 [a]
Clove 300	17.97±1.70 [a]	11.73±1.58 [a]	9.15±1.46 [a]	8.30±0.85 [a]	7.10±0.35 [a]
Clove + Lemon grass	17.28±0.93 [a]	12.50±1.21 [a]	9.63±1.85 [a]	7.73±1.29 [a]	6.90±1.04 [a]

Table 2: Variations in PH value of cakes stored at room temperature

Group	Storage Period (Day)				
	1	8	15	22	29
Control	7.67±0.03 [a]	7.66±0.03 [a]	7.62±0.03 [a]	7.62±0.01 [a]	7.60±0.02 [a]
BHT	7.68±0.05 [a]	7.64±0.06 [a]	7.59±0.05 [a]	7.59±0.09 [ab]	7.50±0.07 [b]
Lemon grass 300	7.65±0.0.04 [a]	7.60±0.01 [a]	7.56±0.02 [a]	7.50±0.02 [b]	7.53±0.02 [b]
Lemon grass 600	7.67±0.07 [a]	7.58±0.03 [a]	7.55±0.02 [a]	7.53±0.05 [ab]	7.56±0.04 [ab]
Clove 300	7.67±0.04 [a]	7.65±0.06 [a]	7.59±0.03 [a]	7.58±0.07 [ab]	7.50±0.04 [b]
Clove + Lemon grass	7.66±0.05 [a]	7.60±0.07 [a]	7.60±0.11 [a]	7.58±0.07 [ab]	7.56±0.09 [ab]

Table 3: Variations in PV of cakes stored at room temperature

Group	Storage Period (Day)				
	1	8	15	22	29
Control	1.36±0.55 [ab]	4.53±0.81 [a]	7.91±0.85 [a]	11.39±0.77 [a]	15.16±0.93 [a]
BHT	1.48±0.36 [a]	4.42±0.51 [a]	6.96±0.42 [ab]	8.18±1.12 [bc]	8.95±0.87 [bc]
Lemon grass 300	1.02±0.32 [ab]	3.65±0.56 [a]	6.16±0.69 [bcd]	8.13±0.99 [bc]	8.76±0.92 [cd]
Lemon grass 600	1.25±0.06 [ab]	3.78±0.46 [a]	5.29±0.84 [d]	6.38±0.88 [c]	6.80±0.64 [d]
Clove 300	1.29±0.34 [ab]	4.46±0.55 [a]	6.78±0.37 [abc]	8.64±1.11 [b]	9.85±0.75 [b]
Clove + Lemon grass	0.74±0.18 [b]	3.46±0.43 [a]	5.62±0.51 [cd]	6.76±0.79 [c]	7.18±0.52 [cd]

Table 4: Variations in TBA value of cakes stored at room temperature

Group	Storage Period (Day)				
	1	8	15	22	29
Control	ND	0.28±0.04[abc]	0.83±0.06[a]	1.69±0.10[a]	2.30±0.09 [a]
BHT	ND	0.18±0.05[c]	0.46±0.06 [b]	0.47±0.05[e]	0.79±0.07 [d]
Lemon grass 300	ND	0.32±0.11[b]	0.62±0.20 [b]	1.40±0.10 [b]	1.79±0.11[b]
Lemon grass 600	ND	0.38±0.06[a]	0.60±0.08 [b]	0.86±0.14[c]	1.06±0.07 [c]
Clove 300	ND	0.24±0.08[abc]	0.46±0.08 [b]	0.68±0.05[d]	0.88±0.15 [cd]
Clove + Lemon grass	ND	0.22±0.03[bc]	0.47±0.02 [b]	0.57±0.03 [de]	0.98±0.08 [c]

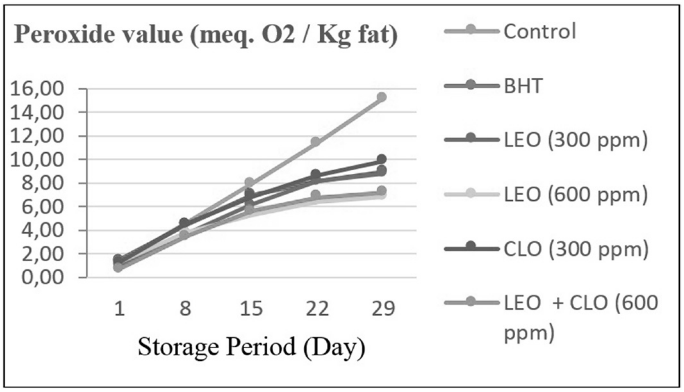

Figure 1: Variations in PV in cakes during storage

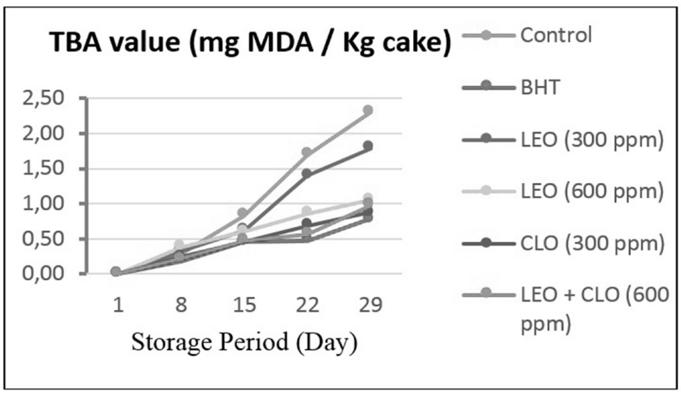

Figure 2: Variations in TBA values in cakes during storage

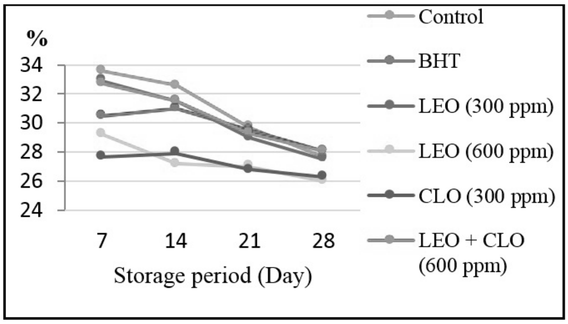

Figure 3: Variations in palmitic acid ratios in cakes during storage

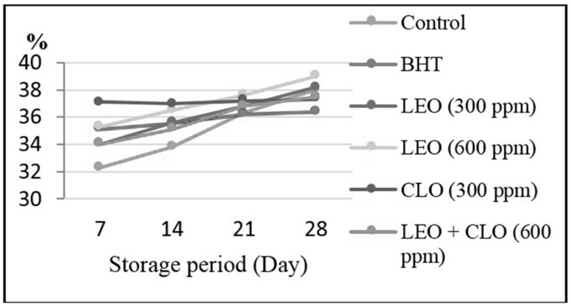

Figure 4: Variations in oleic acid ratios in cakes during storage

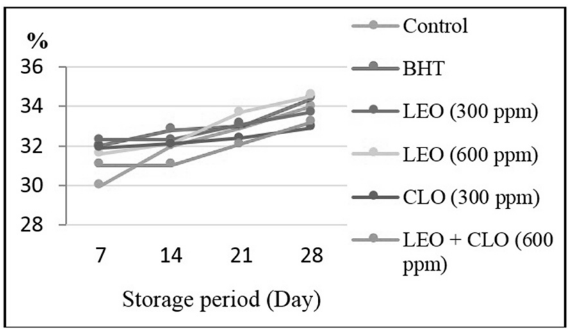

Figure 5: Variations in linoleic acid ratios in cakes during storage

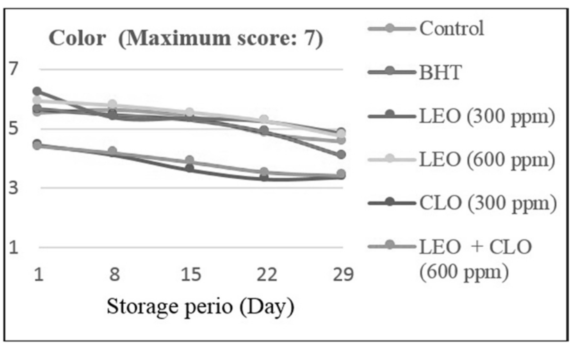

Figure 6: Variations in color scores in cakes during storage

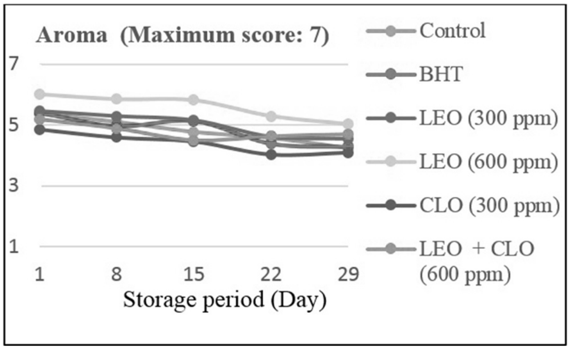

Figure 7: Variations in aroma scores in cakes during storage

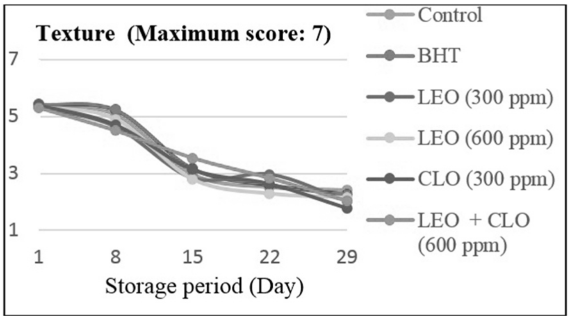

Figure 8: Variations in texture scores in cakes during storage

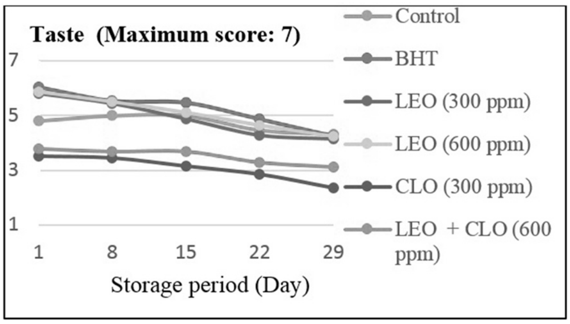

Figure 9: Variations in taste scores in cakes during storage

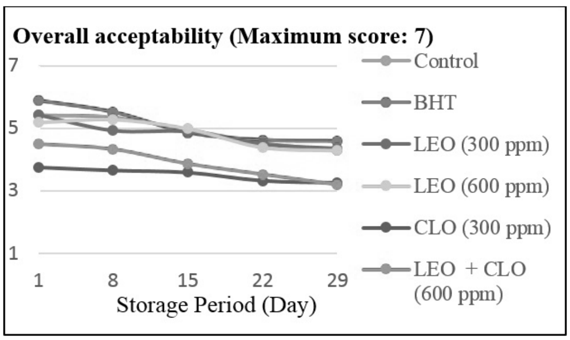

Figure 10: Variations in overall acceptability scores in cakes during storage