**Journal of Food and Dairy Sciences**

**Journal homepage: www.jfds.mans.edu.eg**
**Available online at: www. jfds.journals.ekb.eg**

# Efficacy Bioactive Components of Lavender (*Lavandula latifolia*) Leaves as a Natural Antioxidant, Antibacterial, and its Uses as a Cake Preserving Agent

**Youssef M. Riyad[1*] and Ebtehal A. Elkholany[2]**

[1]Food Science Department, Faculty of Agriculture, Cairo University, Giza, Egypt,
[2]Department of Special Foods and Nutrition Food Technology Research Institute,Agricultural Research Center, Giza, Egypt.


## ABSTRACT

This search aimed to study the bioactive components of lavender leaves and using it to prolong the shelf life of the cake. Different preparations of the lavender leaves including the extraction of the essential oil, the water extract, and the dried powder were obtained. The chemical composition and total phenols and flavonoids of lavender leaves were determined. The antioxidants, antibacterial, and cytotoxic activities of lavender leaves essential oil were measured. Total phenols content in lavender leaves powder was higher than that of lavender leaves water extract (15.74 vs. 2.36 mg gallic acid equivalent /g). The lavender leaves essential oil exhibited the highest antioxidant activity (85.32%) followed by lavender leaves powder (76.71%) then lavender leaves water extract (27.38 %). Also, lavender leaves essential oil has activity against pathogenic bacteria like *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli* and *Salmonella typhi*, also it has a strong antitumor activity against intestinal carcinoma cells line (Caco-2). The results of sensory evaluation showed that the best characteristics were obtained with using 600 ppm of essential oil, 10% of the water extract, or 7.5% of the leaves powder. In conclusion, it is possible to extend the shelf life of the cake to 28 days by addition of 10% of the lavender leaves water extract or 7.5% of lavender leaves powder to cake ingredients or to 4 months by addition of 600 ppm of lavender leaves essential oil compared to 7 days for control sample at room temperature and also with good sensory properties for the produced cake.

***Keywords:*** lavender, antitumor, antibacterial, shelf life

## INTRODUCTION

Essential oils, also called volatile odoriferous oil, are aromatic oily liquids extracted from different parts of plants, for example, leaves, peels, barks, flowers, buds and seeds. They can be extracted from plant materials by several methods, steam distillation, water distillation, expression, and other methods. Essential oils have been widely used as food flavors (Burt, 2004 and Di Leo *et al*., 2009). Essential oils from plants have been known to act as natural additives, as antimicrobial and antioxidant agents. Their activities vary with the source of plants, chemical composition, and extraction methods. In recent years, essential oils have been qualified as natural antioxidants and proposed as potential substitutes of synthetic antioxidants in food preservation. The safety of synthetic antioxidants has been doubted. (Darughe *et al*., 2012).

The Lavender is a genus of about 25 - 30 species of plants in the Lamiaceae family, the Mediterranean region is the native. The genus includes annuals, subshrubs, small shrubs, and herbaceous plants (Piccaglia *et al*., 1993). Lavender essential oil is popular as complementary medicine, anti-depressive and anti-inflammatory properties, in addition to its recognized antimicrobial effects (Da Silva *et al*., 2015). The pleasant aroma of lavender is mainly due to the occurrence of low molecular weight terpenoids synthesized and accumulated in aerial parts, especially in inflorescences. The distilled volatile oil of this plant has gained great importance in aromatherapy and in perfume, cosmetic and flavoring industries since antiquity. Furthermore, volatile constituents of lavender are of special significance in the pharmaceutical and food industries (Cong *et al*., 2008).

The main active ingredients of lavender leaves essential oil are monoterpenes (linalool, linalyl acetate, lavandulol, and geraniol), these components have different anti-bacterial and anti-fungal effects and antioxidant activity, depending on their chemical composition (Janeczko and Pisulewska, 2008). A high and almost equal content of linalool and linalyl acetate is required for good anti-microbial properties of lavender essential oil. The composition of any essential oil depends on several factors such as local, climatic, seasonal, different stages of plant maturity, and experimental condition (Białoń *et al.*, 2019).

The acute oral toxicity using rats was over 2,000 mg/kg of body weight (bw) for lavender (*Lavandula angustifolia*) essential oils and the acute dermal value was over 4,000 mg/kg bw. Also, lavender has no Irritation for skin and eye (Mekonnen *et al*., 2019).

There are many plants that are essential oil sources, around 300 are of commercial value.

* **Corresponding author.**
**E-mail address: yriyad74@yahoo.com**
**DOI: 10.21608/jfds.2020.95847**

Approximately 30 of these plants are cultivated on a large scale, produce essential oils whose use as drugs since dates back centuries, and are described in international and national Pharmacopoeias. Lavender essential oil is listed in European and Pharmacopoeias (Sharifi-Rad *et al.,* 2017).

Cake is one of the most bakery items consumed in the world due to its nutritional value, different types, and affordable prices (Ibrahium *et al*., 2013). This study aimed to determine the chemical composition of lavender leaves as well as chemical constituents of its essential oil. The antioxidant and antibacterial activities and the bioactive compounds of lavender leaves were evaluated. The activity of lavender leaves essential oil against intestinal carcinoma cells and characteristics and storage ability of cake incorporated with different lavender preparations were also studied.

## MATERIALS AND METHODS

**Materials:**

Lavender (*Lavandula latifolia*) leaves were purchased from the Medicinal and Aromatic Research Department, Horticulture Research, Faculty of Pharmacy, Cairo University in 2019. Soft wheat flour (72% extraction), was obtained from the South Cairo Mills Company, Giza, Egypt. Other ingredients (sugar, butter, eggs, skim milk, vanilla, and baking powder) were purchased from the local market, Giza, Egypt. The cells of human intestinal carcinoma (Caco-2) were purchased from the American Type Culture Collection (Rockville, MD). *Staphylococcus aureus* (ATCC 13565), *Bacillus cereus* (ATCC 11778), *Escherichia coli* (ATCC 35218) *and Salmonella typhi* (ATCC 13076) were provided by National Research Centre, Giza, Egypt. Analytical reagent grade chemicals were obtained from Sigma-Aldrich (St. Louis, MO, USA).

**Methods:**

**Preparation of lavender leaves powder:**

Lavender leaves were washed and dried at 40 °C in an electric oven overnight (Laboratory Drying Oven-Roshan Enterprises, India), until constant weight. The dried lavender leaves were well ground (Laboratory grinder, FZ102, China), then kept in polyethylene bags at -18 °C until analysis.

**Preparation of lavender leaves water extract:**

The dried lavender leaves were soaked in water for 24 hrs to prepare 5, 10, and 15% extract (weight/volume, (w/v)). The extracts were filtered to remove insoluble parts and then kept in dry, clean and dark bottles at -18 °C until analysis.

**Preparation of lavender leaves essential oil**:

The essential oil of the lavender leaves was obtained using the water-steam distillation method according to the method outlined by Akdag and Qzturk (2019).

**Formulas of cake with lavender:**

Cake was prepared according to the approved methods of the AACC (2010). The formulas are shown in Table (1). After manufacturing cake samples, they were packaged in polyethylene bags and stored at room temperature (27± 3° C) to follow up the microbial load.

**Table 1. Formulas of cake with different lavender preparations.**

| | | Components (g) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Wheat flour (72%)** | **Sucrose** | **Fresh whole egg** | **Milk** | **Oil** | **Baking powder** | **Vanilla** |
| **Control** | | 100 | 80 | 80 | 75 | 80 | 4 | 1 |
| **Treatments*** | **Weight(g)** | | | | | | | |
| Essential oil 400 ppm | 0.17 | 99.83 | 80 | 80 | 75 | 80 | 4 | 1 |
| Essential oil 600 ppm | 0.25 | 99.75 | 80 | 80 | 75 | 80 | 4 | 1 |
| Essential oil 800 ppm | 0.34 | 99.66 | 80 | 80 | 75 | 80 | 4 | 1 |
| Water extract 5 % | 21 | 100 | 80 | 80 | 54 | 80 | 4 | 1 |
| Water extract 10% | 42 | 100 | 80 | 80 | 33 | 80 | 4 | 1 |
| Water extract 15% | 63 | 100 | 80 | 80 | 12 | 80 | 4 | 1 |
| Leaves powder 5% | 5 | 95 | 80 | 80 | 75 | 80 | 4 | 1 |
| Leaves powder 7.5% | 7.5 | 92.5 | 80 | 80 | 75 | 80 | 4 | 1 |
| Leaves powder 10% | 10 | 90 | 80 | 80 | 75 | 80 | 4 | 1 |

*All treatments based on the total weight of the formula (420g)

**Analytical methods:**

**Chemical composition of lavender leaves and cake samples:**

Gross chemical composition of lavender leaves and cake samples incorporated with different lavender preparations including moisture, protein, fat, crude fibers, ash, and the minerals of lavender leaves (potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), manganese (Mn), iron (Fe), zinc (Zn), and phosphorous (P)) were determined according to the methods outlined in AOAC (2005). Carbohydrates were calculated by difference.

**Total phenols and flavonoids of different lavender preparations:**

Total phenolic compounds of lavender leaves powder and their water extract were determined colorimetrically using Folin–Ciocalteu reagent (as gallic acid equivalent) according to the method described by Arabshahi-Delouee and Urooj (2007). Total flavonoid compounds were determined (as Quercetin equivalent) according to the methods of Ordoñez *et al*. (2006).

**Antioxidant activity of different lavender preparations:**

The antioxidant activities of lavender leaves powder, their water extract and their essential oils were determined using the free radical, 2,2-diphenyl-1-picrylhydrazyl (DPPH) as a reagent according to the method described by Poonsri *et al*. (2019).

**Identification of phenols and flavonoids components of lavender leaves:**

Phenolic and flavonoid compounds were fractionated using HPLC according to the method of

Elbadrawy and Sello (2016), and Skerget *et al.* (2005), respectively.

**Chemical components of lavender leave essential oil:**

Gas chromatography analysis was used for the identification of the components of lavender leaves essential oil according to Özcan *et al*. (2006). HP 5890 gas chromatograph (Hewlett Packard, Plus) fitted with a flame ionization detector and a CP WAX 52 fused silica column (30 m 0.32 mm; 0.25 µm film thickness) was used. The oven initial temperature was set at 60°C for 5 minutes and programmed to reach 240°C at a rate of 3°C/minute. Nitrogen was used as carrier gas at a flow rate of 1ml/min and split ratio 1:100 m/z. The temperatures of the injection and the flame ionization detector were 250 and 280 °C, respectively.

**Antibacterial activity of lavender leaves essential oil:**

Antibacterial activity of lavender leaves essential oil was examined against four pathogenic bacteria strains *Bacillus cereus* (ATCC 11778), *Staphylococcus aureus* (ATCC 13565), *Salmonella typhi* (ATCC 13076), and *Escherichia coli* (ATCC 35218) using the agar well diffusion method according to NCCLS (1993).

**The cytotoxic activity of lavender leaves essential oil:**

The cytotoxicity activity was tested according to Alminderej *et al*. (2019) using lavender leaves essential oil concentrations ranged between 0.25 to 500 µg/ml against the human tumor cell line (intestinal carcinoma cells, Caco-2). The mean of the cell viability values was compared to the control to determine the effect of the lavender leaves essential oil on cells and % of cell viability was plotted against the concentration of the lavender leaves essential oil. The minimum concentration of the lavender leaves essential oil that was toxic to intestinal carcinoma cells was recorded as an effective concentration compared to a positive control (A positive control composed of 100µg/ml was used as a known cytotoxic natural agent who gives 100% lethality under the same conditions).

**Percentage of viability = absorbance of the sample/absorbance of control**

**Microbial load of cake samples during storage**:

Packaged cake samples were inspected visually for mold growth every day during storage for 4 months at room temperature (27± 3° C).

**Sensory evaluation:**

The sensory characteristics of the cake samples (about 3 × 3 × 1.5 cm) was evaluated using 10 panelists from Food Science Dep., Fac. Agric., Cairo University, according to the method of Meilgaard, *et al*. (2006). Cake samples were given 3 digital codes and served to each panelist in a randomized order. The panelist's mouth was rinsed with water to remove any traces of residual food. Each panelist was asked to rate the quality attributes of the cake sample (appearance, aroma, texture, mouth feel and after taste). The maximum score was five for each parameter.

**Statistical analysis:**

Data were statistically analyzed using one way analysis of variance (ANOVA) according to Rao and Blane (1985). All data were the average of 3 experiments, unless, otherwise stated.

# RESULTS AND DISCUSSION

**Chemical composition of lavender leaves:**

The results presented in Table (2) show the chemical constituents of lavender leaves on a fresh weight basis. It was found that the carbohydrates content was presented in the highest amount (77.57%), while the lowest content was observed for protein (0.92%). Concerning minerals, the highest content was observed for P (101.9 ppm). However, K, Zn, Na, Mg, Mn, Ca, and Fe contents were found in low amounts. These results are mostly in conformity with those reported by Prusinowska and Smigielski (2014). Nevertheless, the composition is influenced by different origins, environmental and seasonal factors as stated by Ganjewala, *et al*. (2009).

**Table 2. Chemical composition of lavender leaves on a fresh weight basis.**

| Constituents (%) | Content |
|---|---|
| Moisture | 11.51 |
| Protein | 0.92 |
| Fat | 2.96 |
| Ash | 7.04 |
| Carbohydrates | 77.57 |
| Mineral contents (ppm) | |
| K | 16.10 |
| Mg | 1.90 |
| Ca | 1.25 |
| Na | 3.08 |
| Mn | 1.30 |
| Fe | 1.16 |
| Zn | 9.20 |
| P | 101.90 |

**- Carbohydrates were calculated by difference.**

**Total phenols and flavonoids and antioxidant activity of different lavender preparations:**

The results presented in Table (3) illustrate the total phenols and flavonoids and antioxidant activity of different lavender preparations. The findings proved that the total phenol compounds in lavender leaves powder was higher content than that of lavender leaves water extract (15.74 *vs*. 2.36 mg gallic acid equivalent /g), with significant differences ($p \geq 0.05$). Similar trend was noticed for flavonoids content, where they recorded 12.62 and 2.08 mg Quercetin equivalent / 100 g, in lavender leaves powder and lavender leaves water extract, respectively. On the contrary, it was found that lavender leaves essential oil exhibited the highest antioxidant potential (85.32%) followed by lavender leaves powder (76.71%), then lavender leaves water extract (27.38 %), with significantly differences among samples ($p \geq 0.05$). The antioxidant activity of lavender essential oil purported by Hamad, *et al*. (2013). They reported that this effectiveness is due to the presence of high content of linalool. Our findings are in the same line with those of Hui, *et al*. (2010), who illustrated that lavender essential oil, displayed the stronger antioxidant activity against lipid peroxidation in a linoleic acid model system. On this connection, Rodrigues, *et al.* (2012) succeeded in utilizing spike lavender (*Lavandula latifolia*) essential oil for the stability of soybean oil during microwave heating. On the other hand, a positive relationship was observed between the content of polyphenols (phenol and flavonoid components) and antioxidant potential (Bandara *et al.*, 2020).

**Table 3. Total phenols, flavonoids and antioxidant activity of different lavender preparations.**

| Samples | Total phenols (mg GAE/g) | Flavonoids (mg QE/100g) | Antioxidant activity (%) |
|---|---|---|---|
| Lavender essential oil | ND | ND | $85.32^{a}\pm3.64$ |
| Lavender leaves water extract | $2.36^{b}\pm0.19$ | $2.08^{b}\pm0.14$ | $27.38^{c}\pm1.09$ |
| Lavender leaves powder | $15.74^{a}\pm0.98$ | $12.62^{a}\pm1.08$ | $76.71^{b}\pm3.59$ |

**E: Gallic acid equivalent – QE: Quercetin equivalents - Antioxidant activity (%): determined as radical Scavenging activity (%) by DPPH method - ND: not determined. Any two means within the same column have different small letters are significantly different at 0.05 % level.**

**Identification of phenols and flavonoids components of lavender leaves:**

The identification of phenols and flavonoids components of lavender leaves was carried out using HPLC and the obtained data are presented in Table (4). The results indicated that the main phenolic components in lavender leaves powder were caffeine (530.48 ppm), followed by benzoic acid (505.70 ppm), catechin (359.51 ppm) then, pyrogallol (342.72 ppm). The lowest values were those of protocatechuic acid (36.38 ppm) and gallic acid (39.67 ppm). Concerning flavonoids, hesperidin (33820.44 ppm) was the major component, followed by naringenin (587.34ppm) while the lowest values were those of apigenin (97.42 ppm) and hesperetin (99.26 ppm). Similar findings were illustrated by Adaszyńska-Skwirzyńska and Dzięcioł (2017), who assessed phenolic acids and flavonoids in two cultivars of *Lavandula angustifolia*: 'Blue River' and 'Ellagance Purple'.

**Table 4. Identification of phenols and flavonoids compounds of lavender leaves.**

| Phenol compounds | | | | Flavonoid compounds | |
|---|---|---|---|---|---|
| **Compound** | **Content (ppm)** | **Compound** | **Content (ppm)** | **Compound** | **Content (ppm)** |
| Pyrogallol | 342.72 | Caffeic acid | 64.78 | Rosmarinic | 278.71 |
| Gallic acid | 39.67 | Caffeine | 530.48 | Hesperidin | 33820.44 |
| Protocatechuic acid | 36.38 | Ferulic acid | 55.78 | Rutin | 705.96 |
| Catechol | 56.54 | Iso- Ferulic acid | 90.54 | Quercetrin | 253.07 |
| Catechin | 359.51 | Coumaric acid | 111.99 | Naringenin | 587.34 |
| Chlorogenic acid | 212.18 | | | Quercetin | 422.39 |
| P-OH-Benzoic acid | 187.91 | 3,4,5-Methoxy cinnamic acid | 188.30 | Hesperetin | 99.26 |
| Benzoic acid | 505.70 | | | kaempferol | 134.84 |
| | | | | Apigenin | 97.42 |

**Identification of bioactive compounds of lavender leaves essential oil:**

The essential oil of lavender leaves was analyzed for its components by GC and the results are presented in Table (5).

**Table 5. Identification of bioactive compounds of lavender leaves essential oil.**

| Components | RA (%) |
|---|---|
| α-Pinene | 0.466 |
| Myrcene | 0.945 |
| Limonene | 4.678 |
| 1,8 Cineol | 2.969 |
| Camphor | 2.630 |
| Linalool | 47.980 |
| Linalyl acetate | 20.772 |
| Terpine-4- ol | 10.702 |
| Terpineol | 1.899 |
| Betenol | 0.346 |
| Geraniol acetate | 1.103 |
| Nerol | 2.635 |
| Geraniol | 1.808 |
| Total identified components | 98.933 |
| Total unknown components | 1.067 |
| Total oxygenated components | 92.844 |
| Total non oxygenated components | 6.089 |

**RA (%) = Peak area relative to the total peak area.**

Thirteen components were fractionated and identified which constituted 98.860 % of the total oil. These components belong to three groups; terpenes (6.089%), esters (21.875%) and alcohols (70.969%). Our findings ascertained that the main components were linalool; an acyclic monoterpene alcohol (47.980%), followed by linalyl acetate (20.772%), then terpine-4-ol (10.702%). Also, the terpene fraction comprised 6.089% and contained 3 components namely; α-pinene, myrcene, and limonene, however, the two esters were identified as geraniol acetate, and linalyl acetate. On the other hand, eight alcoholic components were identified as 1,8 cineol, camphor, linalool, terpineol, betenol, nerol and geraniol in amounts of less than1 to 47.98%. These results are highly similar to those found by Nurzyńska-Wierdak and Zawiślak (2016) who ascertained that oil obtained from lavender leaves was characterized by high share of linalool and linalyl acetate. Also, our findings are in harmony with those of Cong, *et al.* (2008). Although the results of Hamad, *et al.* (2013) agreed with our results, the amounts of the main components (linalool and linalyl acetate) are lower. This difference could be due to the variation in cultivars, climatic conditions as well as post-harvest treatments.

**Antibacterial activity of lavender leaves essential oil:**

The lavender leaves essential oil was evaluated for its antibacterial activity against pathogenic strains. It was found to be active against all tested bacterial strains. The activity of the oil varied according to type of bacterial strains as illustrated in Table (6). The obtained results indicated that as the concentration of the oil increased, the inhibition zone (mm) was also increased. The results indicated that *St. aureus* exhibited maximum inhibition zone (>90 mm) at 40 µl of oil/well, however, the inhibition zones recorded 45, 57 and 63 mm at 40 µl of oil/well for *B. cereus*, *E. coli* and *S. typhi*, respectively. Meanwhile at a concentration of 60µl/well, no growth was observed for the previous strains. These results clearly indicated the antibacterial effect of the essential oil of lavender

leaves. The ability of essential oil to disrupt the permeability barrier of cell membrane structures and the accompanying loss of chemiosmotic control are the mostly likely reasons for its lethal action as reported by Hui, *et al.* (2010). They also illustrated that lavender essential oil displayed good antibacterial activity against four rhinitis-related bacteria including *Staphylococcus aureus, Micrococcus ascoformans, Proteus vulgaris* and *Escherichia coli.* In this regard, Kalemba and Kunicka (2003) showed that essential oils had an affinity for lipid cell structures; therefore, they could destroy the cell wall and bacterial membranes mainly of Gram-positive ones (less often Gram-negative) and fungi, as a consequence, there is leakage and coagulation of the cytoplasm. In respect to lavender oil, it inhibits the synthesis of RNA, DNA, proteins, and polysaccharides in bacteria, while, in fungi, they act as anti-mycotics and inhibit the production of enzymes. The obtained results are mostly in conformity with those reported by Jianu, *et al.* (2013). Furthermore, Herman *et al.* (2016) stated that addition of linalool to essential oil significantly enhanced its antimicrobial effectiveness and reduced its concentrations in products. Also, Duman, *et al.* (2010) found that linalool, the main constituent of thymus and lavender oils, and it showed strong inhibitory effects against 17 bacteria and 10 fungi. Similar findings were observed by Białoń, *et al.* (2019), who added that The Gram-positive bacteria were more sensitive to lavender oil than Gram-negative bacteria.

**Table 6. Antibacterial activity of lavender leaves essential oil.**

| Concentration of essential oil (µL/well) | Inhibition zone (mm) | | | |
|---|---|---|---|---|
| | Gram-positive bacteria | | Gram-negative bacteria | |
| | *St. aureus* | *B. cereus* | *E. coli* | *S. typhi* |
| 5 | 1.5 | 2.5 | 1.5 | 1.0 |
| 10 | 12 | 4 | 8 | 6 |
| 15 | 47 | 18 | 12 | 10 |
| 20 | 80 | 20 | 35 | 43 |
| 40 | NG | 45 | 57 | 63 |
| 60 | NG | NG | NG | NG |
| 80 | NG | NG | NG | NG |
| 100 | NG | NG | NG | NG |

**NG: no growth or the inhibition zone is higher than 90 mm.**

**The cytotoxic activity of lavender leaves essential oil:**

The cytotoxicity activity was carried out to verify if lavender leaves essential oil is able to produce lethal effect on the human tumor cell line (intestinal carcinoma cell line Caco-2). The cytotoxicity of lavender leaves essential oil against the human tumor cell line was studied using different preparations with concentrations varied between 0.00 to 500µg/ml. The results of cell viability and toxicity assay of lavender leaves essential oil are shown in Table (7). These results indicated that as the concentration of lavender leaves essential oil increased the viability percentages were decreased, while inhibitory activity percentages were increased. Decreasing of the lavender leaves essential oil concentration from 500µg/ml to 0.25 µg/ml led to increase the viability percentage from 2.76% to 69.47% and to decrease the inhibitory activity percentages from 97.24% to 30.53%. As indicated in Table (7) it was found that the maximum percentage of inhibitory (97.24 %) was observed with the maximum concentration (500µg/ml). Moreover, the $IC_{50}$ value [the concentration causing death of 50% of tumor cell] was found to equal 0.97µg/ml. Such findings are highly matching with those reported by Sharifi-Rad, *et al.* (2017), who explained that linalool could be used in the synthesis of several type of compound with ability to act as antioxidant and might be used as a medicine drug. It can be used in the treating several types of disease and cancer due to its antioxidant activity (Jabir *et al.*, 2019 and Tenuta *et al*., 2020).

**Table 7. The cytotoxic activity of lavender leaves essential oil.**

| lavender leaves essential oil concentration (µg/ml) | Viability (%) | Inhibitory (%) | S.D. (±) |
|---|---|---|---|
| 500 | 2.76 | 97.24 | 0.38 |
| 250 | 4.83 | 95.17 | 0.71 |
| 125 | 6.75 | 93.25 | 0.63 |
| 62.5 | 12.39 | 87.61 | 0.67 |
| 31.25 | 18.68 | 81.32 | 0.54 |
| 15.6 | 25.34 | 74.66 | 0.62 |
| 7.8 | 30.96 | 69.04 | 0.38 |
| 3.9 | 37.68 | 62.32 | 0.19 |
| 2 | 43.12 | 56.88 | 0.67 |
| 1 | 49.58 | 50.42 | 0.96 |
| 0.5 | 57.64 | 42.36 | 1.32 |
| 0.25 | 69.47 | 30.53 | 0.84 |
| 0 | 100 | 0 | 0 |
| $IC_{50}$ | 0.97 µg/ml | | |

**$IC_{50}$: Lethal concentration of the sample which causes the death of 50% of cells in 48 hrs**

**Sensory evaluation of cake incorporated with different lavender preparations:**

The essential oil of lavender leaves and or leaves water extract in addition to leaves powder were used at different concentrations in manufacturing of the cake. The organoleptic tests are always a necessary guide of the quality from the consumer's point of view (David and Stuart, 2002). Therefore, sensorial characteristics (appearance, aroma, texture, mouth feel and after taste) of the produced cake samples were evaluated and the obtained results are shown in Table (8). It could be noticed that addition of 400ppm of lavender essential oil resulted in production of cake not significantly different ($p \geq 0.05$) from control for all the evaluated characteristics with exception of aroma. The results also indicated that addition of 600 ppm of the oil led to produce cake with no significant differences ($p \geq 0.05$) from control for all the evaluated characteristics except texture. However, addition of 800 ppm of the oil led to produce cake significantly different ($p \leq 0.05$) from control for all the evaluated characteristics except appearance.

**Table 8. Sensory evaluation of cake samples incorporated with different lavender preparations.**

| Cake samples* | | Appearance (5) | Aroma (5) | Texture (5) | Mouth feel (5) | After taste (5) |
|---|---|---|---|---|---|---|
| **Control** | | $4.90^{ab} \pm 0.32$ | $4.80^{a} \pm 0.42$ | $4.90^{a} \pm 0.32$ | $4.60^{ab} \pm 0.52$ | $4.60^{ab} \pm 0.52$ |
| Essential oil (ppm) | 400 | $4.80^{abc} \pm 0.42$ | $4.05^{cd} \pm 0.55$ | $4.35^{ab} \pm 0.41$ | $4.15^{b} \pm 0.24$ | $4.60^{ab} \pm 0.50$ |
| | 600 | $4.95^{a} \pm 0.16$ | $4.60^{ab} \pm 0.21$ | $4.20^{b} \pm 1.31$ | $4.60^{ab} \pm 0.21$ | $4.60^{a} \pm 0.21$ |
| | 800 | $4.60^{abcd} \pm 0.52$ | $3.55^{d} \pm 0.44$ | $4.00^{b} \pm 0.41$ | $3.70^{c} \pm 0.48$ | $3.40^{e} \pm 0.52$ |
| Water extract (%) | 5 | $4.20^{d} \pm 0.42$ | $3.60^{d} \pm 0.84$ | $4.15^{b} \pm 0.47$ | $4.2^{b} \pm 0.42$ | $3.60^{de} \pm 0.84$ |
| | 10 | $4.50^{bcd} \pm 0.53$ | $4.75^{b} \pm 0.42$ | $4.60^{ab} \pm 0.45$ | $4.85^{a} \pm 0.33$ | $4.85^{a} \pm 0.34$ |
| | 15 | $4.50^{bcd} \pm 0.52$ | $4.00^{cd} \pm 0.82$ | $4.15^{b} \pm 0.33$ | $4.50^{ab} \pm 0.52$ | $4.45^{abc} \pm 0.64$ |
| Leaves Powder (g) | 5 | $3.60^{e} \pm 0.13$ | $3.85^{cd} \pm 0.33$ | $4.15^{b} \pm 0.94$ | $4.80^{a} \pm 0.63$ | $4.70^{ab} \pm 0.67$ |
| | 7.5 | $4.40^{cd} \pm 0.52$ | $4.25^{bc} \pm 0.26$ | $4.55^{a} \pm 0.28$ | $4.20^{b} \pm 0.42$ | $4.25^{bc} \pm 0.42$ |
| | 10 | $4.50^{bcd} \pm 0.52$ | $3.85^{e} \pm 0.75$ | $4.10^{b} \pm 0.39$ | $4.25^{b} \pm 0.68$ | $4.05^{cd} \pm 0.68$ |
| LSD | | 0.38 | 0.49 | 0.55 | 0.42 | 0.48 |

***All cake samples based on the total weight of the formula of cake (420 g). - Any two means within the same column have different small letters are significantly different at 0.05 % level.**

**Any two means within the same column have different small letters are significantly different at 0.05 % level.**

Concerning using the lavender leaves water extract, the results indicated that addition of 5% led to produce cake samples with non significant differences ($p \geq 0.05$) from control for all the evaluated characteristics except mouth feel. Similar trend was observed with addition of 10% with exception of aroma and with addition of 15% with exception of aroma and texture. Moreover, the same findings also indicated that incorporation of 7.5 g of lavender leaves powder to the cake formula gave the best acceptability comparing to the other two levels (5 or 10 gm), since, it led to cake with no significant different ($p \geq 0.05$) from control except appearance and aroma. So, such treatment was chose beside addition of 600 ppm of essential oil or 10% of water extract to produce the cake for further experiments.

**Chemical composition of cake sample incorporated with different lavender preparations:**

The chemical constituents of cake samples produced with addition of 600 ppm of lavender leaves essential oil, lavender leaves water extract at level of 10% or 7.5% of lavender leaves powders as well as control were determined and the obtained results are presented in Table (9) on dry weight basis. The results indicated that protein, fat and carbohydrates contents of all samples were approximately the same, since it ranged between 10.98% - 11.36%, 19.87% - 20.09% and 65.85% - 68.07%, respectively. The results also indicated that samples contained leaves powder showed the highest content of crude fiber (1.71%) and of ash (1.35%).

**Table 9. Chemical composition of cake samples incorporated with different lavender preparations on dry weight basis**

| Constituents (%) | Control cake | Cake samples incorporated with different lavender preparations | | |
|---|---|---|---|---|
| | | Essential oil (600 ppm) | Water extract (10%) | Leaves powder (7.5%) |
| Moisture | $19.85^{c} \pm 0.03$ | $19.85^{c} \pm 0.03$ | $21.34^{a} \pm 0.01$ | $20.44^{b} \pm 0.04$ |
| Protein | $11.36^{a} \pm 0.01$ | $11.36^{a} \pm 0.01$ | $10.98^{c} \pm 0.02$ | $11.07^{b} \pm 0.05$ |
| Fat | $20.09^{a} \pm 0.01$ | $20.09^{a} \pm 0.01$ | $19.87^{b} \pm 0.05$ | $20.02^{a} \pm 0.01$ |
| Crude fibers | $0.65^{b} \pm 0.00$ | $0.65^{b} \pm 0.00$ | $0.57^{c} \pm 0.03$ | $1.71^{a} \pm 0.11$ |
| Ash | $0.64^{b} \pm 0.04$ | $0.64^{b} \pm 0.04$ | $0.51^{c} \pm 0.01$ | $1.35^{a} \pm 0.07$ |
| Carbohydrates | $67.26^{b} \pm 0.05$ | $67.26^{b} \pm 0.05$ | $68.07^{a} \pm 0.06$ | $65.85^{c} \pm 0.09$ |

**- Carbohydrates were calculated by difference. Any two means within the same row have different small letters are significantly different at 0.05 % level.**

**Microbial examination of cake samples during storage:**

From the results presented in Table (9) it could be noticed that the moisture content of the tested cake samples ranged between 19.85 to 21.34%, which permit the growth of mold or bacteria. The results ascertained that the control sample (with no additives) showed mold growth after 7 days of storage at room temperature, meanwhile, cake samples incorporated with lavender leaves powder (7.5%) as well as lavender leaves water extract (10%) could retard mold growth up to 28 days. On the other hand, cake samples incorporated with lavender leaves essential oil (600 ppm) showed the maximum shelf life (more than 4 months) at room temperature (27± 3° C).These findings supported the previous results of antimicrobial potency of lavender leaves essential oil (Table 6).

## CONCLUSION

From the obtained results, it could be concluded that lavender leaves essential oil showed good antioxidant activities and broad activity against bacteria. The study also revealed lavender cake as a source of natural bioactive compounds and antioxidant activity which could be attractive to the food or pharmaceutical industry. The major lavender leaves essential oil component was linalool, which contributed greatly to the high antioxidant and antibacterial activities as well as anticancer activity. Lavender cake with leaves powder as well as leaves water extract contained high amounts of phenols and flavonoids, subsequently, high antioxidant potential for producing specific health-promoting antioxidants in the food industry. Also, utilizing lavender leaves preparations in cakes offer a

good alternative to traditional applications by utilizing natural preserving agents instead of synthetic ones, besides, making it even more favorable, especially sensorial characteristics of cakes were comparable with control samples.

## ACKNOWLEDGMENT

Thanks are extended to Dr. Ghada Mohamed Youssef, Professor of Food Technology, Department of Special Food and Nutrition, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt, for her appreciated advice and her kind help.

## REFERENCES

AACC (2010). Approved Method of the American Association of Cereal Chemists. Approved Methods the A.A.C.C. Published by the American Association of Cereal Chemists. 13thEd. Inc. St. Paul, Minnesota, USA.

Adaszyńska-Skwirzyńska, M. and Dzięcioł, M. (2017). Comparison of phenolic acids and flavonoids contents in various cultivars and parts of common lavender (*Lavandula angustifolia*) derived from Poland. Journal Natural Product Research, 31(21): 2575-2580.

Akdag A. and Qzturk, E. (2019). Distillation methods of essential oils. Nisan, 45(1), 22-31.

Alminderej, F.M.; Elganzory, H.H.; El-Bayaa, M.N.; Awad, H.M. and El-Sayed, W.A. (2019) Synthesis and Cytotoxic Activity of New 1,3,4-Thiadiazole Thioglycosides and 1,2,3-Triazolyl-1,3,4-Thiadiazole N-glycosides. Molecules, 24: 3738; doi:10.3390/molecules24203738

AOAC (2005). Official Methods of Analysis. Association of Official Analytical, Chemists 18th ed., Washington, DC, USA.

Arabshahi-Delouee, S and A. Urooj (2007) Antioxidant properties of various solvent extracts of mulberry (*Mocus indica* L.) leaves. Food Chem., 102, 1233-1244.

Bandara, U.Y.; Witharana, C. and Soysa, P. (2020). Extraction, total phenol content, flavonoid content, free radical scavenging capacity and phytochemical screening of the parts of Sri Lankan pomegranate (*punica granatum* l.) fruit. Current Trends in Biotechnology and Pharmacy, 14(1), 70-80.

Białoń, M.; Krzyśko-Łupicka, T.; Nowakowska-Bogdan, E. and Wieczorek, P. P. (2019). Chemical composition of two different lavender essential oils and their effect on facial skin microbiota. Molecules, 24(18): 3270 - 3275.

Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods: A review. Intern. J. Food Microbiol., 94: 223–253.

Cong, Y.; Abulizi, P.; Zhi, L.; Wang, X. and Mirensha, Y. (2008). Chemical composition of the essential oil of *Lavandula angustifolia* from Xinjiang, China. Chem. Nat. Compd., 44(6): 108. https://link. springer.com/article/10.1007/s 10600 -009-9210-8

Da Silva, G.; Luft, C.; Lunardelli, A.; Amaral, R.H.; Melo, D.A.D.; Donadio, M.V.F.; Nunes, F. B.; De Azambuja, M.S.; Santana, J.C.; Moraes, C.M.B.; Mello, R.O.; Cassel, E.; Pereira, M.A.D. and De Oliveira, J.R. (2015). Antioxidant, analgesic and anti-inflammatory effects of lavender essential oil. Annals of the Brazilian Academy of Sciences, 87(2): 1397–1408.

Darughe, F.; Barzegar, M. and Sahari, M. A. (2012). Antioxidant and antifungal activity of coriander (*Coriandrum sativum* L.) essential oil in cake. International Food Research Journal, 19(3): 1253-1260.

David, K. and Stuart, C. (2002). Sensory perception of creaminess and its relationship with food structure. Food Quality and Preference, 13:609-623.

Di Leo, L. P.; Retta, D.; Tkacik, E.; Ringuelet, J.; Coussio, J. D.; van Baren, C. and Bandoni, A. L. (2009). Essential oil and by-products of distillation of bay leaves (*Laurus nobilis* L.) from Argentina. Ind. Crops Prod., 30: 259–264.

Duman, A. D.; Telcib, I.; Dayisoylua, K. S.; Metin, D.; İbrahim, D. and Mehmet, H. A. (2010). Evaluation of bioactivity of linalool-rich essential oils from *Ocimum basilucum* and *Coriandrum sativum* varieties. Natural Product Communications, 5 (6): 969 – 974.

Elbadrawy, E. and Sello, A. (2016). Evaluation of nutritional value and antioxidant activity of tomato peel extracts. Arab. J. Chem., 9,1010-1018.

Ganjewala, D.; Sam, S. and Khan, K. (2009). Biochemical compositions and antibacterial activities of *Lantana camara* plants with yellow, lavender, red and white flowers. Eur. Asian J. BioSci., 3: 69 – 77.

Hamad, K. J.; Al-Shaheen, S. J. A.; Kaskoos, R. A.; Ahamad, J.; Jameel, M. and Mir, S. R. (2013). Essential oil composition and antioxidant activity of *Lavandula angustifolia* from Iraq.Inter. Res. J. of Pharm., 4(4): 117 – 120.

Herman, A.; Tambor, K. and Herman, A. (2016). Linalool affects the antimicrobial efficacy of essential oils. Curr Microbiol., 72: 165-172.

Hui, L.; He, L.; Lu, H.; Lan, L.X. and AiGuo, Z. (2010). Chemical composition of lavender essential oil and its antioxidant activity and inhibition against rhinitis- related bacteria. African Journal of Microbiology Research, 4(4): 309-313.

Ibrahim, M.; Abd El-Ghany, M. and Ammar, M. (2013). Effect of clove essential oil as antioxidant and antimicrobial agent on cake shelf life. World J. of Dairy and Food Sci., 8(2): 140–146.

Jabir, M. S.; Taha, A. A. and Sahib, U. I. (2019). Antioxidant activity of Linalool. Engineering and Technology Journal, 36(B1):64 – 67.

Janeczko, Z. and Pisulewska, E. (2008). Domestic Oil Plants. Occurrence, Cultivation, Chemical Composition, Application. pp. 7–11, 43–47"Know-How" Publishing, Kraków, Poland.

Jianu, C.; Georgeta, P.; Alexandra, T. G. and Horhat, F. G. (2013). Chemical Composition and Antimicrobial Activity of Essential Oils of Lavender (*Lavandula angustifolia*) and Lavandin (*Lavandula x intermedia*) Grown in Western Romania. Int. J. Agric. Biol., 15(4): 772 – 776.

Kalemba, D. and Kunicka, A. (2003). Antibacterial and antifungal properties of essential oils. Curr. Med. Chem., 10(10):813-829.

Meilgaard, M.; Civille, G. V. and Carr, B. T. (2006). Sensory evaluation techniques. 4th Edition, CRC Press, Boca Raton.

Mekonnen, A.; Tesfaye, S.; Christos, S.G.; Dires, K.; Zenebe, T.; Zegeye, N.; Shiferaw, Y. and Lulekal, E. (2019) Evaluation of Skin Irritation and Acute and Subacute Oral Toxicity of Lavandula angustifolia Essential Oils in Rabbit and Mice. J. Toxicol., Published online 2019 Jan 27. doi: 10.1155/2019/5979546

NCCLS (1993). National Committee for Clinical Laboratory Standards. Performance Standards for Antimicrobial Disc Susceptibility Tests. Approved Standard, Villanova.

Nurzyńska-Wierdak, R. and Zawiślak, G. (2016). Chemical composition and antioxidant activity of lavender (*Lavandula angustifolia* Mill.) aboveground parts. Acta Sci. Pol. Hortorum Cultus, 15(5): 225 – 241.

Ordoñez, A.A.L.; Gomez, J.D.; Vattuone, M.A. and lsla, M.I. (2006). Antioxidant activities of *Sechium edule* (Jacq.) Swartz extracts. Food Chem., 97(3): 452- 458.

Özcan, M.M.; Chalchat, J.; Arslan, D.; Ates, A.E. and Ünver, A. (2006) Comparative essential oil composition and antifungal effect of bitter fennel (*Foeniculum vulgare* ssp. Piperitum) fruit oils obtained during different vegetation. J Med Food, 9(4), 552–561.

Piccaglia, R.; Marotti, M.; Giovanelli, E.; Deans, S. G. and Eaglesham, E. (1993) Antibacterial and antioxidant properties of Mediterranean aromatic plants. Ind. Crop Prod., 2: 47-50.

Poonsri, T.; Jafarzadeh, S.; Ariffin, F.; Abidin, S. Z.; Barati, Z.; Latif, S. and Müller, J. (2019) Improving nutrition, physicochemical and antioxidant properties of rice noodles with fiber and protein-rich fractions derived from cassava leaves. Journal of Food and Nutrition Research, 7(4), 325-332. DOI: 10.12691/jfnr-7-4-10

Prusinowska, R. and Smigielski, K. B. (2014). Composition, biological properties and therapeutic effects of lavender (*Lavandula angustifolia* L.): A review. Herba Polonica, 60(2), 200 – 205.

Rao, M. and Blane, K. (1985). PC-STAT, Statistical Programs for Microcomputers. Version 1A. Department of Food Sci. and Technol. The University of Georgia, Athens, GA.

Rodrigues, N.; Malheiro, R.; Casa, S.; Asensio, S.; Manzanera, M.C.; Bento, A. and Pereira, J.A. (2012). Influence of spike lavender (*Lavandula latifolia* Med.) essential oil in the quality, stability and composition of soybean oil during microwave heating. Food Chem. Toxicol., 50(8), 2894-2901.

Sharifi-Rad, J. ; Sureda, A.; Tenore, G.C.; Daglia, M. ; Sharifi-Rad, M.; Valussi, M.; Tundis, R.; Sharifi-Rad, M.; Loizzo, M.R.; Ademiluyi, A.O.; Sharifi-Rad, R.; Ayatollahi, S.A. and Iriti, M. (2017). Biological activities of essential oils: from plant chemoecology to traditional healing systems. Molecules, 22: 70- 125.

Skerget, M.; Kotnik, P.; Hadolin, M.; Hras, A.R.; Simonic, M. and Knez, Z. (2005). Phenols, proanthocyanidins, flavones and flavonols in some plant materials and their antioxidant activities. Food Chem., 89: 191-198.

Tenuta, M.C.; Deguin, B.; Loizzo, M.R.; Dugay, A.; Acquaviva, R.; Malfa, G.A.; Bonesi, M.; Bouzidi, C. and Tundis, R. (2020) Contribution of flavonoids and iridoids to the hypoglycaemic, antioxidant, and nitric oxide (no) inhibitory activities of *Arbutus unedo* L. *Antioxidants*, *9*(2), 184-208 . https://doi.org/10.3390/antiox9020184

## فعالية المكونات النشطة حيوياً لاوراق اللافندر كمضاد للأكسدة ومضاد للبكتيريا واستخدامها كعامل لحفظ الكيك

**يوسف مصطفي رياض[١] و ابتهال الخولاني[٢]**

**[١] قسم علوم الأغذية، كلية الزراعة، جامعة القاهرة، الجيزة، مصر**

**[٢] قسم بحوث الأغذية الخاصة والتغذية، معهد بحوث تكنولوجيا الأغذية، مركز البحوث الزراعية، الجيزة، مصر.**

يهدف هذا البحث إلى دراسة المكونات النشطة بيولوجيا لأوراق اللافندر واستخدامها في إطالة مدة صلاحية الكيك. تم تحضيرتجهيزات مختلفة من أوراق اللافندروتشمل الزيت العطري والمستخلص المائي والمسحوق المجفف. تم تقدير التركيب الكيميائي والفينولات الكلية والفلافونويد لأوراق اللافندر. كما تم تعريف مكونات الفينولات الكلية والفلافونويد والزيت العطري بواسطة HPLC . تم قياس نشاط الزيت العطري لاوراق اللافندر كنشاط مضاد للأكسدة ونشاط مضاد للبكتيريا ونشاط مثبط وسام للخلايا السرطانية. أوضحت النتائج أن إجمالي محتوى الفينولات في مسحوق أوراق اللافندر كان أعلى من المستخلص المائي لأوراق اللافندر (١٥,٧٤ مقابل ٢,٣٦ مجم مكافئ من حمض الجاليك / جم). أوضحت النتائج ايضا أن الزيت العطري لأوراق اللافندر أظهر أعلى قيمة كمضاد للأكسدة (٨٥,٣٢٪) يليه مسحوق أوراق اللافندر (٧٦,٧١٪) ثم المستخلص المائي لأوراق اللافندر (٢٧,٣٨٪). أشارت النتائج إلى أن الزيت العطري لاوراق اللافندر له نشاط ضد البكتيريا المرضية مثل *Staphylococcus aureus , Escherichia coli, Bacillus cereus ,Salmonella typhi* ، كما أن له نشاطًا قويًا ضد خلايا سرطان الأمعاء. هذا وقد أوضحت نتائج هذه الدراسة انه يمكن اطالة فترة صلاحية الكيك الي ٢٨ يوما وذلك بخلط ١٠٪ من المستخلص المائي لأوراق اللافندر أو ٧,٥٪ من مسحوق أوراق اللافندر مع مكونات الكيك أو الي ٤ أشهر عند استخدام ٦٠٠ جزء في المليون من الزيت العطري لاوراق اللافندر مقارنة بـ ٧ أيام لعينة الكنترول علي درجة حرارة الغرفة وأيضا خصائص حسية جيدة للكيك الناتج.