ESSENTIAL OILS OF CARDAMOM AS A NATURAL PRESERVATIVE OF RETAILED MEAT FILLETS

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ABSTRACT

Meat is commonly marketed at refrigerated temperatures (2–5ºC). The major concern for retailers and public health are microbiological quality and safety of refrigerated beef. Many undesirable changes occur during refrigeration due to microbial growth that lead to meat spoilage, quality reduction, and economic loss. Therefore, improving fresh meat shelf-life and increasing consumer safety by minimizing product contamination and delaying or inhibiting growth of spoilage organisms using safe preservatives is a pre-request. This study examined the effect of cardamom essential oils (CEOs) at concentrations of 0.0, 0.25, 0.5, and 1% on the microbiological, chemical, and sensory qualities of raw beef after storage at 0, 3, 6, 9, 12, and 15 days of treatment at 4°C. The results showed that addition of CEOs significantly delayed the proliferation of aerobic plate counts, Enterobacteriaceae, psychrotrophic bacterial counts and extended the shelf-life of the product up to 12 days compared to the control group that was completely spoiled at the 6th day of storage. Therefore, CEOs could be utilized successfully to reduce the microbial growth, maintain the chemical quality and extend the shelf-life of beef that held under proper refrigeration.

Keywords: Meat Shelf-Life, Cardamom, Essential oils, Natural preservative

1. INTRODUCTION

Meat is one of the important sources of protein. Being rich in valuable proteins containing essential amino acids, minerals such as iron and zinc, as well as different types of vitamins, meat is characterized as a complete nutritive material for human nutrition (Kargiotou et al., 2011). However, it is one of the putrefying food materials and it has a short shelf life. The rapid microbial growth of newly chilled meat shortens its shelf life, reduces storage time, and decreases its quality which result in severe economic losses (Chaleshtori et al., 2014; Loretz et al., 2011). Therefore, the addition of preservatives would increase its shelf-life.

An increasing awareness has been focused on the use of herbs and/or its extracts and essential oils as food preservative agents (Zhang et al., 2016). Cardamom (*Elettaria*

cardamomum, Maton), commonly known as queen of spices, is grown in tropical and warm regions mostly in India, Sri Lanka, Guatemala and Tanzania. The seeds of cardamom dense aromatic flavor and slightly pungent. Therefore, it was used as a spice in meat products such as Bologna and Frankfurter (Baytop 1984). It is rich in a variety of chemical constituents. For example, volatile oils (of about 8%) that contains about 36.3% 1,8-cineole, 31.3% α-terpinyl acetate, 11.6% limonene, 3% linalool, 2.8% sabinene, 2.7% *trans*-nerolidol, 2.6% α-terpineol, 2.5% linalyl acetate, 1.6% myrcene, 1.5% α-pinene, 0.9% terpinene-4-o1, 0.7% γ-terpinene, 0.5% terpinolene, 0.5% geraniol, 0.5% nerd, 0.3% citronellol, 0.2% β-pinene, 0.2% α-phellandrene, and 0.2% methyl eugenol (Korikontimath et al., 1999; Menon et al., 1999; Singh et al., 2008; Savan and Kucukbay 2013). The basic cardamom aroma produced by a combination of two major components; 1,8-cineole and α-terpinyl acetate (Lawrence 1979).

Due to its richness in beneficial chemical components, cardamom essential oil is used in food, pharmaceutical industries, perfumery, and medicine as an antiseptic, stimulant, carminative, stomachic, expectorant, anti-spasmodic and diuretic (Ağaoğlu et al., 1999; Aksu and Kaya 2002; Baytop 1984; Karapınar and Aktuğ 1986; Korikontimath et al., 1999). Also, the essential oil showed carminative and antivirus properties (Akhavan et al., 2008), antibacterial effects (Verma et al., 2009), and antioxidant properties (Aneja and Sharma 2010). Some studies have reported advantageous effects for human nutrition (Akhavan et al., 2008; Busatta et al., 2008), and natural preservative that enhance the quality and taste of food (Chaleshtori et al., 2014; Emiroğlu et al., 2010; Loretz et al., 2011).

Accordingly, the objective of present work was to evaluate the effect of essential oil of *Elettaria cardamomum* as a natural preservative of meat fillets to enhance its microbiological, chemical, and sensory characteristics. Quality parameters changes were assessed to determine the shelf-life of fresh meat fillets during storage under refrigerated conditions at 4±1°C.

Bearing in mind the aforementioned and through the existing data, present study considered the first to inspect the effect of EOs of Cardamom seeds (CEOs) on meat quality and increasing of its shelf-life.

2. Materials and Methods

2.1. Extraction of Essential Oils

The plant seeds of cardamom were purchased from a reputable grocery store in Damanhour City, weighted, dried in an oven at 40°C, and sealed under vacuum until used. The CEO extract was prepared at Pesticide Residue Analysis and Toxicity Laboratory, Faculty of Agriculture, Damanhour University. The ground seeds were submitted to hydro-distillation using

a Clevenger type apparatus for 3 hr. In this method, the seeds were ground and put in a volumetric flask (2L) with distilled water (1:10, w:v), placed over a heating mantle and under the Clevenger type apparatus which is connected to a water condenser. The CEO used in this study at pure state, free from preservatives or antioxidant substance, was collected and stored in brown-colored screw cap bottles at 4°C until use.

2.2. Preparation of Meat fillet Samples

A total 72 of meat slices samples each weighing 100 ±10g were purchased from butchers in Damanhour City, El-Beheira Governorate, Egypt. The samples were rapidly transferred to the Postgraduate Laboratory, Food Control Department, Faculty of Veterinary Medicine, Damanhour University in separate sterile and labeled plastic bags in an ice box under complete aseptic conditions without excessive delay. The meat fillets samples were divided into two groups of treated and untreated (control) ones. The treated groups were divided into 3 groups (18 samples in each group) that dipped in cardamom essential oil at concentrations of 0.25% (T1), 0.5% (T2), and 1% (T3), which stored at 2°C and examined regularly every 3 days for chemically, microbiologically and sensory parameters. The experiment was conducted in quadruplicate for 15 days of storage (Kassem et al., 2011; Rather et al., 2016). Each treated sample was dipped for 15 min in the dipping emulsion solution (0.25, 0.5, and 1 g of pure cardamom essential oil extract to a final volume of 100 ml of sterile distilled water) then drained well for 5 min on a sterile stainless wire mesh screen. Control groups were dipped in sterile distilled water.

2.3. Packaging and Storage

After dipping, meat samples were labeled and each single sample was aerobically packed separately in polyethylene bags and stored at 4±1ºC. Each group was exposed to sensory, chemical and bacteriological assessment at day zero (within 2 hours after treatment) then regularly every three days until decomposition (0, 3rd, 6th, 9th, 12th, and 15th day of storage). The scheme was repeated 4 times.

2.4. Bacteriological Examinations

Preparation of Samples (ISO 6887-6, 2013)

Meat fillets sample (10g) was aseptically moved into homogenizer flask containing 90 ml sterile peptone water 0.1% (Oxide CM0009). The content was homogenized at 4000 rpm for 2.5 min. to provide a dilution of 10^{-1} of the original homogenates and was admissible to stand for 5

min at room temperature then mixed thoroughly by shaking, then ten folds serial dilution were occurred (ISO 6887-6 2013)

a. **Total Aerobic bacterial Count (TBC)** was detected on Plate count agar and was incubated for 48 ± 2 h at 37°C (Swanson et al., 1992).
b. **Psychrophilic bacterial count (PBC)** was identified according to (Swanson et al., 1992) by pour plate technique and incubated at 4 °C for 5-7 days.
c. **Staphylococcal count (STAPH)** were counted on Baird Parker agar medium and incubated at 37º C for 48 hrs (ISO 21528-2 2004).
d. **Enterobacteriaceae** were counted on violet red bile glucose agar (Oxiod CM 485B) medium and incubated at 37º C for 24 hrs (ISO 21528-2 2004).

2.5. Chemical Analysis

a. **pH measurement** was verified using a pH-meter (Digital, Jenco 609) (EOS 63/11 2006).
b. **Determination of total volatile basic nitrogen (TVB-N) content (TVB-N)** (mg/100g) was analyzed according to the method recommended by (EOS 63/10 2006).
c. **Determination of Thiobarbaturic acid (TBA):** TBA number is conveyed as milligrams of malondialdehyde equivalents per Kilogram of samples (EOS 63/9 2006).
d. **Peroxide Value (PV)** was conveyed as milliequivalents of oxygen/kilogram of lipid (AOAC 2000).

2.6. Sensory Evaluation

Twenty panelists (adult, untrained) were asked to assess the sensory qualities of meat samples. The samples were blind–coded with special codes, the panelists were not informed about the experimental approach. They were asked to give a score for each of color, odor, and consistency while the samples were fresh (uncooked). Then the samples without salt and spices were cooked then were attended to the panelists to complete the evaluation of the sensory qualities. The panelists were asked to drink warm water between samples. Nine-point descriptive scale was used. A score of 7–9 indicated ‘‘very good’’ quality, a score of 4.0–6.9 ‘‘good’’ quality, a score of 1.0–3.9 indicated as spoiled was used for the evaluation of appearance, smell texture, taste, and overall acceptability (Amerina et al., 1965).

2.7. Experimental Design and Analysis of the Data

Data was statistically analyzed using the Statistical Analysis System (SAS, Cary, USA, version 9.3) software (SAS, 2016). The chemical, microbiological, organoleptic parameters were presented as mean ± SD. Significant means were compared using Tukey’s Studentized Range (HSD) post-hoc Test ($P \leq 0.05$).

3. RESULTS AND DISCUSSION

3.1. Microbiological Examination

3.1.1. Total Bacterial Count (TBC)

Data presented in Fig 1-A showed that TBC mean values of control samples were 5.95 ± 0.02, 6.60 ± 0.06, 7.20 ± 0.10, 7.64 ± 0.10, and 8 ± 0.14 log_{10} cfu/g after 0, 3, 6, 9, and 12 days of storage at 4ºC, respectively. At 0.25% of CEO, TBC were 5.92 ± 0.03, 6.43 ± 0.09, 6.80 ± 0.08, 7.28 ± 0.11 and 7.61 ± 0.10 log_{10} cfu/g, while at 0.5% of CEO (T2), the log counts were 5.89 ± 0.03, 6.21 ± 0.15, 6.55 ± 0.16, 6.90 ± 0.07 and 7.32 ± 0.07 cfu/g, and at 1% CEO (T3), TBC scored 5.86 ± 0.04, 5.89 ± 1.16, 6.23 ± 0.20, 6.60 ± 0.15 and 6.91 ± 0.06 log10 cfu/g, after 0, 3, 6, 9, and 12 days of storage, respectively. Samples that were treated with cardamom EO displayed decreasing count of aerobic plate microorganisms than permissible limit (7 log_{10} cfu/g) (ICMSF 1986). CEO effectively enhanced the microbial characteristics of meat samples for 9 and 12 days. Also, the high dose of cardamom was more effective in decreasing the TBC counts than the least concentration (P<0.05). Significant differences were observed between the treated samples with 0.25, 0.5, and 1% of CEO after 6 days of storage. These results were similar to results that were obtained by Chaleshtori and Chaleshtori (2017).

3.1.2. The Psychrotrophic Bacteria (TPS)

Psychrotrophs are those organisms that grow at or below 7ºC and their optimum growth is between 20 to 30ºC. Results in Fig.1-B showed that TPS counts of control meat samples were 5.55 ± 0.05, 6.14 ± 0.11, 6.53 ± 0.08, 6.83 ± 0.06, and 7.23 ± 0.16 log_{10} cfu/g after 0, 3, 6, 9, and 12 days of storage period, respectively. Cardamom essential oil at 0.25% (T1) showed TPS mean values of 5.54 ± 0.06, 5.91 ± 0.09. 6.10 ± 0.08, 6.51 ± 0.09, and 6.93 ± 0.07 log_{10} cfu/g, 0.5% CEO (T2), TPS mean values were 5.46 ± 0.06, 5.72 ± 0.14, 5.89 ± 0.09, 6.26 ± 0.13, and 6.58 ± 0.12 log_{10} cfu/g, and at 1% of CEO (T3) resulted counts of 5.42 ± 0.05, 5.50 ± 0.09, 5.65 ± 0.22, 5.87 ± 0.09, and 6.10 ±0.12 log_{10} cfu/g after 0, 3, 6, 9, and 12 days of storage, respectively. Cardamom essential oils significantly preserved the meat samples at zero time in control and treated groups. A significant difference between control and treated groups (P<0.05) was obtained after the 3rd day of storage to the end of the storage period. The reduction in TPS numbers correlated to active ingredients in cardamom phenolic compounds, flavonoids and aromatic acids and these results were similar to that of Chaleshtori and Chaleshtori (2017).

3.1.3. Staphylococcal organism (STAPH)

Fig.1-C showed that, at control samples the staphylococcal counts (STAPH) were 3.10 ± 0.12, 3.69 ± 0.13, 3.95 ± 0.19, 4.20 ± 0.15, and 4.58 ± 0.14 log_{10} cfu/g after 0, 3, 6, 9, and 12 days of storage, respectively. CEO at 0.25% (T1) resulted in 3.06 ± 0.14, 3.48 ± 0.13, 3.77 ± 0.13, 4.02 ± 0.17, and 4.43 ± 0.17 log_{10} cfu/g, at 0.5% of CEO (T2), STAPH counts were 3 ± 0.14, 3.31 ± 0.19, 3.60 ± 0.08, 3.85 ± 0.07, and 4.27 ± 0.14 log_{10} cfu/g, and at 1% of CEO (T3), the counts were 2.96 ± 0.14, 3.15 ± 0.13, 3.44 ± 0.10, 3.67 ± 0.11, and 4.09 ± 0.09 log_{10} cfu/g after 0, 3, 6, 9, and 12 days of storage, respectively. From the obtained results, samples that were treated by different concentrations of cardamom oil showed decreasing count of STAPH compared with control with specific emphasis after the 9th and 12th day of storage. Also, the CEO at 1% was more effective in decreasing STAPH counts than 0.25%. These results agreed with that obtained by Akrayi et al (2012) and Chaleshtori and Chaleshtori (2017).

3.1.4. The Enterobacteriaceae (EBC)

Data in Fig.1-D showed that control samples had enterobacteriaceae counts (EBC) of 3.49 ± 0.11, 4.04 ± 0.11, 4.77 ± 0.80, 5.56 ± 0.20, and 5.83 ± 0.13 log_{10} cfu/g after 0, 3, 6, 9, and 12 days of storage, respectively. Application of cardamom essential oil at 0.25% (T1) resulted counts of 3.44 ± 0.10, 3.69 ± 0.09, 4.28 ± 0.09, 4.77 ± 0.06, and 5.35 ± 0.26 log_{10} cfu/g, at 0.5% (T2), the EBC counts were 3.30 ± 0.18, 3.50 ± 0.18, 4.01 ± 0.09, 4.42 ± 0.10, and 4.95 ± 0.24 log_{10} cfu/g, and at 1% (T3), counts were 3.20 ± 0.13, 3.30 ± 0.26, 3.75 ± 0.12, 4.11 ± 0.09, and 4.45 ± 0.13 log_{10} cfu/g after 0, 3, 6, 9, and 12 days of storage, respectively. The obtained results highlight the positive preservative effects of CEO treatments on meat samples, where it decreased the EBC counts compared with control and prolonged the enhancement effect up to the 9th and 12th day of storage. These results were similar to the results of Chaleshtori and Chaleshtori (2017). Cardamom essential oil effectively decreased numbers of enterobacteriaceae as more effective in decreasing this count than when the effect of cardamom oil on decreasing Staphylococcal count.

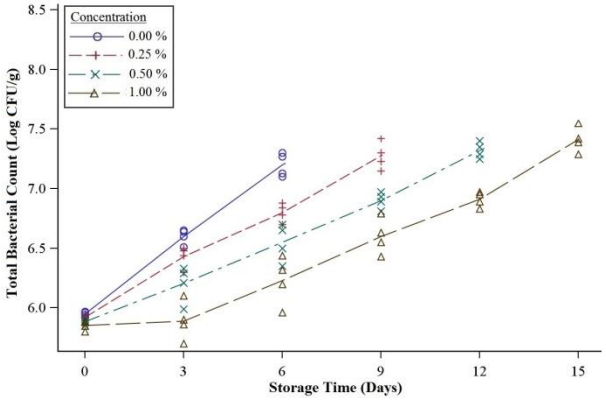

Fig. 1-A

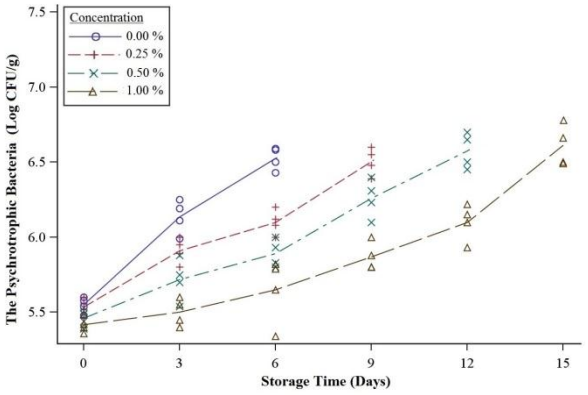

Fig. 1-B

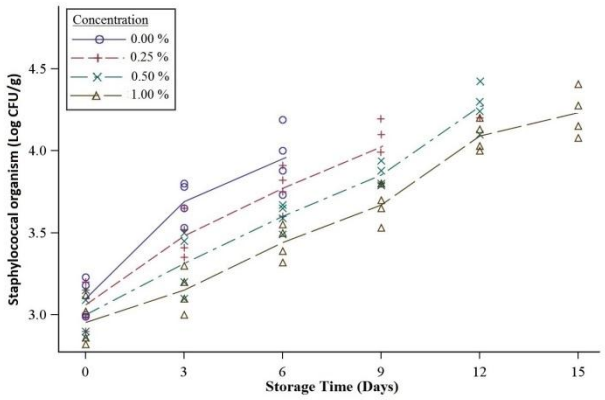

Fig. 1-C

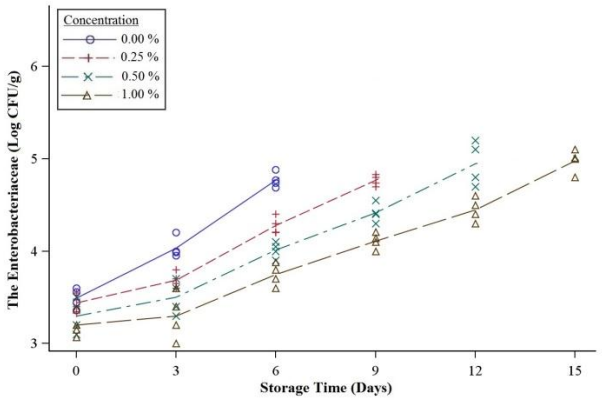

Fig. 1-D

Fig.1 Microbiological Evaluation: Changes in (A) total bacterial counts (Log CFU/g), (B) psychrotrophic bacterial counts (Log CFU/g), (C) Enterobacteriaceae counts (Log CFU/g), and (D) Staphylococcal counts (Log CFU/g) of meat fillets after storage (for 0, 3, 6, 9, 12 and 15 days) at 4 ±1°C of treated samples with 0, 0.25, 0.5, and 1% (w/v) of cardamom essential oil

3.2. Chemical Analysis

3.2.1. Hydrogen ion concentration (pH)

Fig.2-A showed that the pH values of untreated and treated meat fillets samples were 5.67 ± 0.06, 6.35 ± 0.14, 6.84 ± 0.27, 7.45 ± 0.23, and 8.12 ±0.43 for the control group after 0, 3, 6, 9, and 12 days of storage, respectively. CEO different concentrations affected the pH value of treated samples. pH mean values were 5.66 ± 0.06, 5.93 ± 0.15, 6.20 ± 0.08, 6.76 ± 0.07, and 7.21 ± 0.08, 5.65 ± 0.06, 5.85 ± 0.13, 6.06 ± 0.08, 6.28 ± 0.05, and 6.88 ± 0.06, and 5.62 ± 0.06, 5.74 ± 0.12, 5.93 ± 0.08, 6.11 ± 0.06 and 6.34 ± 0.05 after treating meat fillets with 0.25, 0.5, and 1% of CEO and stored for 0, 3, 6, 9, and 12 days of storage, respectively. The obtained results showed that samples treated with cardamom essential oil had low pH values than pH values of control samples during different periods of analysis these may be due to activation effect of cardamom oil as antimicrobial agent causing protein hydrolysis with appearance of alkyl groups Salem et al.,(2010). Also, by increasing concentration of cardamom to 1%, the pH values scored the highest effect in lowering pH values for 15 days in chilled storage. The increase in pH values reflects the degree of meat spoilage which might result from protein breakdown and the production of free amino acids, leading to the formation of NH_3 and amines, and compounds of alkaline reactions (Chaleshtori et al., 2014; Emiroğlu at al., 2010; Loretz et al., 2011). There was a statistically significant difference between the control and treatment groups (Skandamis and Nychas, 2001). A significant positive preservative effect of CEO was observed compared with the control in terms of pH levels (P<0.05). The initial decrease in pH level could be due to rigor

mortis, but with increased storage time at a temperature of 4 ± 1°C, the pH level of the meat increased. This may be ascribed to microorganism growth and protein breakdown (Wu et al., 2014).

3.2.2. Total Volatile Nitrogen (TVN)

Total volatile basic nitrogen (TVBN mg/100g) is used as an index of raw meat for example when TVBN reach 20 mg/100 mg in raw meat it's spoiled EOS (2013). Fig.2-B showed that at control sample had TVN values of 3.16 ± 1.05, 15.91 ± 4.08, 24.90 ± 2.22, 31.12 ± 4.94, and 40.20 ± 5.92 mg/100g after 0, 3, 6, 9, and 12 days of storage, respectively. By using cardamom oil at concentration 0.25% (T1), TVN values were 3.08 ± 1.08, 10.41 ±0.74, 15.32 ± 0.95, 22.69 ± 1.20, and 28.86 ± 2.12 mg/100g, at 0.5% of CEO, TVN were 3.04 ± 1.11, 8.90 ± 1.25, 13.06 ± 1.37, 18.32 ± 1.24, and 23.83 ± 1.41 mg/100g, and at 1% of CEO, TVN values were 2.80 ± 1.11, 7.45 ± 0.84, 11.53 ± 1.73, 15.08 ± 1.71, and 19 ±0.81 mg/100g after 0, 3, 6, 9, and 12 days of storage at 4ºC, respectively. Obtained result showed that treating meat samples with cardamom essential oil at different concentrations decreased the TVN values than control samples especially after 9 and 12 days in storage. Also, increasing concentration of cardamom to 1% gave more effective effects in decreasing TVN values than the low concentration of cardamom (0.25%). There were significant differences between the negative control group and the other treatment groups ($P<0.05$) and our results agree with the results El-Harrery (1997) and Skandamis and Nychas (2001).

3.2.3. Thiobarbituric Acid Reactive Substances (TBARs)

TBA values as mg malonaldehyde equ/kg routinely used as an index of lipid oxidation in meat products in retailer Gray et al.,(1996). The rancid flavor is initially detected in meat products when TBA values reach to 0.9 EOS (2013). Fig.2-C showed that at control samples had TBA values of 0.17 ± 0.09, 0.72 ± 0.18, 1.14 ± 0.11, 1.55 ± 0.21, and 1.99 ± 0.34 mg MDA/kg after 0, 3, 6, 9, and 12 days of storage, respectively. Control samples had rancid flavor after 6, 9, and 12 days of storage. After the addition of samples in cardamom oil at 0.25%, TBA values were 0.16 ± 0.10, 0.42 ± 0.05, 0.72 ± 0.07, 1.04 ± 0.05, and 1.48 ± 0.07 mg MDA/kg, 0.5% of CEO showed TBA values of 0.13 ± 0.08, 0.35 ± 0.05, 0.56 ± 0.12, 0.85 ± 0.05, and 1.12 ± 0.09 mg MDA/kg, and the 1% of CEO, TBA values were 0.11 ± 0.07, 0.24 ± 0.07, 0.43 ± 0.16, 0.66 ± 0.07, and 0.80 ± 0.07 mg MDA/kg after 0, 3, 6, 9, and 12 days of storage, respectively. Treated samples with cardamom oil at different concentrations lessened the TBA values especially at 6, 9, and 12 days of storage compared to control samples. Increasing cardamom essential oil level decreased the TBA values. Such findings may be attributed to the high antioxidant effect of cardamom essential oil, which is related to the scavenger nature of its flavonoids and phenolic content Kassem et al.,(2011).

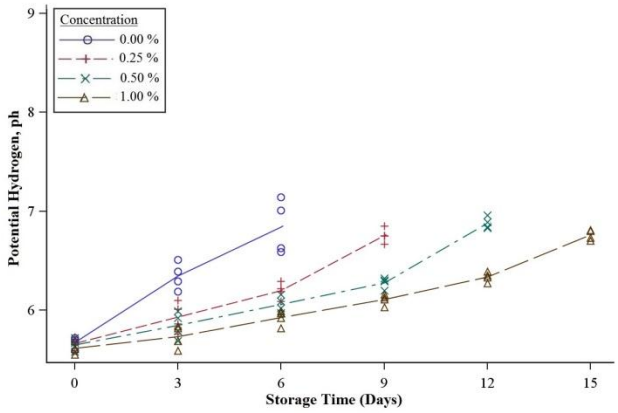

Fig. 2-A

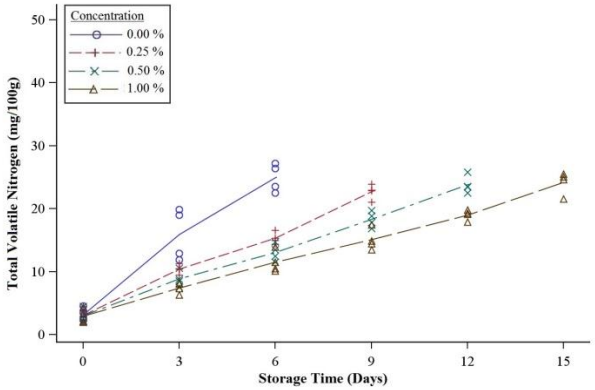

Fig. 2-B

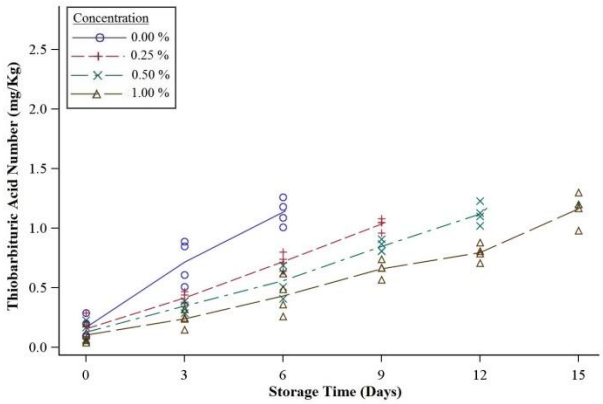

Fig. 2-C

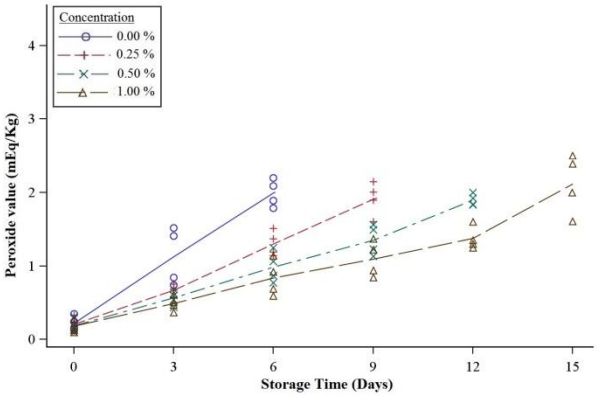

Fig. 2-D

Fig.2 Chemical Evaluation: Changes in (A) pH, (B) TVBN (mg/100g), (C) TBA (mg malonaldehyde equ/Kg), and (D) PV (milli Equ O_2/kg lipid) index values of meat fillets during storage time (0, 3, 6, 9, 12, and 15 days) at 4 ±1ºC for 0, 0.25, 0.5, and 1% (w/v) cardamom essential oil extract treated samples.

TBA values of meat fillets were within the permissible limits after 9 days in storage at 4°C while the control samples were spoiled after 6 days. Moreover, treating meat samples with CEO had significant effect in reducing the TBA values than control, which were in agreement with Fernandez-Lopez et al. (2005).

3.2.4. Peroxide Value (PV)

Peroxide value (milli Equ O_2/kg lipid) indicates the overall picture of rancidity of fat present in meat. It is used as an index for lipid oxidation in raw meat and its products especially

when PV each 1.8 milliequivalent peroxide/kg. Results presented in Fig.2-D showed that control samples had PV values of 0.22 ± 0.10, 1.13 ± 0.39, 1.99 ± 0.19, 2.51 ± 0.44, and 3.22 ± 0.48 milliEqu O_2/kg lipid after 0, 3, 6, 9, and 12 days of storage, respectively. Using cardamom oil at 0.25%, TVN values scored 0.21 ± 0.10, 0.67 ± 0.07, 1.30 ± 0.17, 1.91 ± 0.23, and 2.34 ± 0.05 milliEqu O_2/kg lipid, the 0.5% CEO showed TVN values of 0.19 ± 0.09, 0.57 ± 0.10, 0.99 ± 0.21, 1.35 ± 0.21, and 1.90 ± 0.08 milliEqu O_2/kg lipid, and at 1%, TVN values were 0.18 ± 0.08, 0.49 ± 0.10, 0.84 ± 0.25, 1.09 ± 0.25, and 1.38 ± 0.16 milliEqu O_2/kg lipid after 0, 3, 6, 9, and 12 days of storage, respectively. The obtained result revealed significant differences ($P<$ 0.05) between the control and treated samples. These results agreed with that reported by Chaleshtori et al. (2014), Emiroğlu et al. (2010), and Loretz et al. (2011).

3.3. Sensory Evaluation

The results of organoleptic examination of meat fillets samples stored at 4°C revealed that the control sample (untreated) was completely spoiled at the 6th day of storage (Fig 3). The addition of CEOs at 0.25, 0.5, and 1% (treated samples) drastically improved the appearance (Fig 3-A), taste (Fig 3-B), smell (Fig 3-C), texture (Fig 3-D), and overall acceptability (Fig 3-E) sensory properties for 6, 9, and 12 days after storage, respectively. There were significant differences between the control and treated groups after zero days, as control samples were started to spoilage and had rancid odor at the 6th day of storage, while cardamom oil improved the sensory properties up to the 12th day of storage. Also, samples containing 1% cardamom oil demonstrated the highest enhancement of sensory attributes, while the samples treated with 0.25% of cardamom oils demonstrated the least enhancement. This result agrees with that obtained by Sasse et al.,(2009)who reported that many herbs and spices have antioxidant components and improved both color and flavor stability in meat. The sensory evaluation results appeared to be associated with microbial and chemical value analysis.

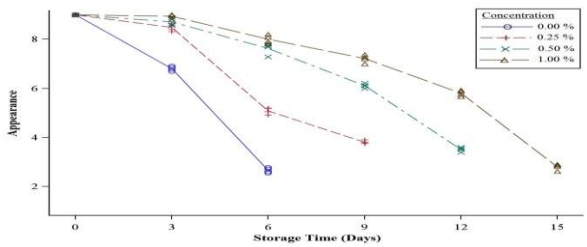

Fig. 3-A

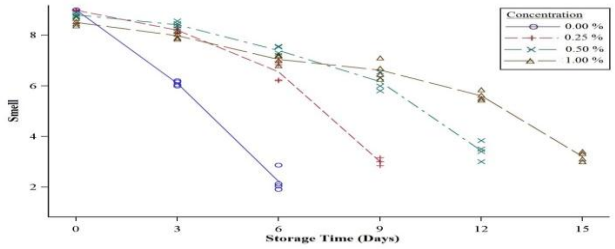

Fig. 3-B

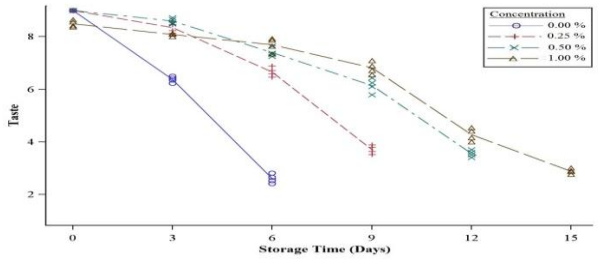

Fig. 3-C

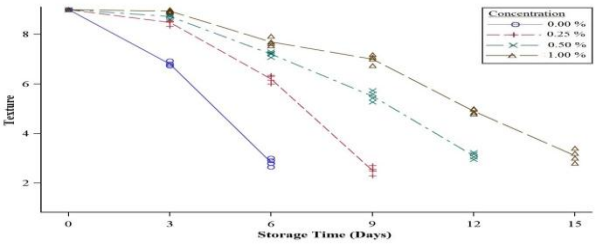

Fig. 3-D

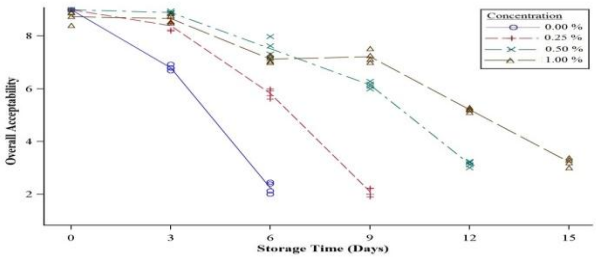

Fig. 3-E

Fig 3. Sensory Evaluation: Changes in (A) appearance, (B) taste, (C) smell, (D) texture, and
(E) Overall acceptability of meat fillets after storage for 0, 3, 6, 9, 12, and 15days at 4 $\pm 1^0$C with 0, 0.25, 0.5, and 1% (w/v) of cardamom essential oils.

4. CONCLUSIONS

Briefly, the addition of cardamom essential oil to chilled meat enhanced the chemical, microbiological, and sensory attributes. Specifically, it inhibited the microbial growth and increased shelf-life. The results were concentration-dependent, with increasing CEO concentration, an enhancement of the safety and quality of putrefying food that reduces the economic losses caused by the decomposition. The 0.25%-treated samples had a shorter shelf-life compared with 0.5 and 1%-treated samples. CEO is rich in antioxidant and antibacterial components that efficiently highlight its role as a natural preservative material in the retailed meat storage and preservation in food industry.

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إستخدام الزيوت الطيارة لنبات الحبهان كمادة حافظة طبيعية لشرائح اللحم

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تعتبر سلامه وجوده اللحوم خاصه المبرده منها من اهم الموضوعات التي تهدد الصحه العامه للمستهلك. حيث تتعرض اللحوم خلال فتره حفظها (على 2-5 °م) لنمو وزيادة عدد العديد من الميكروبات التي تسبب فسادها تجعلها خطرا علي الصحه العامه. وايضا تعتبر سبب اساسي للكثير من الخسائر الاقتصاديه ، لذا زاد الاهتمام بمحاولات تحسين جوده اللحوم واطاله فتره حفظها باستخدام مواد حافظه امنه وطبيعيه. من هنا أجريت هذه الدراسة على شرائح اللحوم الطازجه لاختبار تاثير إضافة الزيوت الطياره لنبات الحبهان (الهيل) علي تحسين فترة حفظها وتحسين جودتها. وقد تم معالجه المجموعات بتركيزات (0.0 ، 0.25. ، 0.5 ،و 1%) من زيت الحبهان واختبار تاثيرها علي الصفات الكيميائيه وبعض الميكروبات االمسببه للمرض بعد أزمنة 0 ، 3 ، 6 ، 9 ، 12 و15 يوم من التخزين علي 4±1°م. أوضحت النتائج زياده فتره الحفظ للمجموعات المعالجه بتركيزات 0.25 ، 0.5 ،و 1% من زيت الحبهان الي 12 يوم بالمقارنه بالمعاملة الكنترول التي فسدت بعد 6 ايام. وقد اظهرت المجموعات المعالجه من شرائح اللحوم تحسنا معنويا في الصفات الكيميائيه والحسيه وتقليل معنوي لأعداد الميكروبات المختبره لذا ينصح باستخدام زيت الحبهان لزياده فتره الحفظ وتحسين جوده اللحوم .