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Original Research

# Effect of Cranberry Essential Oil on Quality Parameters of Chilled Minced Meat

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## Abstract

Minced meat is a popular meat product found mainly in most types of meat meals as a source of animal-origin food. So, it has high economic worth due to its nutritive value. Owing to the high moisture content and richness in nitrogenous composites, it is an ideal medium for bacterial growth and contamination. Synthetic preservatives are used for extending the shelf life and enhancing quality properties of meat, but consumers are only recently considering them because of worries about potential health risks. Thus, using safe natural preservatives becomes an urgent necessity. The objective of the current study aimed to determine whether cranberry essential oil (CBEO) could improve the sensory, chemical, and bacteriological properties of raw minced beef while also extending its shelf life. 60 minced beef samples were divided into 0.0 (Control), 0. 5, 1, and 1.5% CBEO treated groups. The control and treated samples were kept at 3±1ºC in the refrigerator for 12 days. Minced beef samples' sensory, chemical, and bacteriological properties were evaluated every three days. The results showed that CBEO addition significantly delayed the proliferation of aerobic plate counts, psychotrophic, Staphylococcal and *Enterobacteriaceae* bacterial counts and extended the shelf-life of the minced beef up to 12 days compared to the control group that was completely putrefied at the 6th day of storage. This study suggested that CBEO could be used as a natural preservative for chilled minced meat.

KEYWORDS
Minced meat bacteriological quality, Cranberry, Essential oils, Natural preservative

## INTRODUCTION

Meat is a great source of high-quality protein, fats, vitamins, minerals, and trace elements, so it may be a terrific addition to a healthy diet (Arnarson, 2019). Meat also plays a preventive role against major and minor nutrients deficiency diseases as proteins and amino acids meet the required health benefits needed for growth and building of muscles in human (Ahmad *et al*., 2018). Because it is used as a source of animal origin food in the majority of meat products meals, ground beef has a high economic worth due to its nutritional value (Velzen *et al*., 2008). Meats are susceptible to lipid oxidation and microbial contamination because of their high nutrient content, which is seen as a concern to the general public's health (Aminzare *et al*., 2019). The use of antioxidants is the most efficient and widely used strategy for avoiding, decreasing, or retarding lipid oxidation and the generation of harmful chemicals, enhancing, or maintaining the sensory characteristics, and extending the shelf life of foods containing fat (Amiri *et al*., 2019). Various artificial preservatives with antioxidant function are used in meat products to get rid of undesirable changes in their sensory and nutritional attributes. However, due to the risks of high toxicity, the search for natural alternatives in the food industry is growing (Ribeiro *et al*., 2019). Some plants are incorporated in different beef meat products as "natural antioxidants" which contain active compounds can maintain characteristics of beef meat by retarding chemical oxidation and minimizing microbial spoilage caused by aerobic microorganisms which leading to prolonging the shelf-life (Elhadef *et al*., 2021). Berries show great antibacterial activity against pathogenic bacteria and fungi by producing phytochemicals flavonoids and phenolic contents (Kranz *et al*., 2020). Cranberry belongs to the *Vaccinium* genus and *Ericaceae* family which is commonly known as superfood, due to its high nutrient and antioxidant content. It contains a wide range of chemical components with high biological activity, including volatile oils, significant quantities of tannins, anthocyanins, flavonoids, and phenolic acids, such as coumaric acid, sinapic acid, caffeic acid, ellagic acid, syringic acid, ferulic acid, vanillic acid, gallic acid, and ascorbic acid (Dorris *et al*., 2021). Various biological activities of phenolic acids and anthocyanins have been indicated, including antibacterial (Ranfaing *et al*., 2018), antioxidant (Peixoto *et al*., 2018),antifungal (Ottaviano *et al*., 2021) and antiviral (Zhang *et al*., 2021).CBEO also has been reported for its potential pharmaceutical uses such as, anticancer, neuroprotective (Johnson *et al*., 2010), blood pressure regulation (Flammer *et al*., 2013) and chronic disease prevention as: kidney disease, heart disease, oral disease, type 2 diabetes (Elsayed *et al*., 2023).

Accordingly, the objective of present work was to evaluate the effect of cranberry essential oil at three concentrations (0.5%, 1%, and 1.5%) as a natural preservative of minced meat to enhance its sensory, chemical, and microbial characteristics to determine the shelf-life of fresh minced meat during storage under refrigerated conditions at 3±1°C.


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# MATERIALS AND METHODS

*Preparation of Cranberry Essential Oil*

The ready-made herbal oil of cranberry (*Vaccinium macrocarpon*) used in this study was purchased from Pure Life Company for Herbal & Natural Oils, Giza, Egypt. All the used chemicals were of analytical reagent grade. This oil was stored in amber-colored bottle at 4°C until use.

*Preparation of Minced beef samples*

A grand total of 9 Kg of the fresh minced beef used in this study was purchased from butcher shops in Damanhour City, El-Beheira Governorate, Egypt, packed in an insulated plastic bag in a cool ice box and transferred directly to the Lab. in Food Control Department, Faculty of Veterinary Medicine, Damanhour University, under complete aseptic conditions. Minced beef samples were divided into 4 groups: (Control, 0.5%, 1% and 1.5%), 750g in each group. The first one was control group (without any treatment), and the other three groups were mixed with 0.5%, 1% and 1.5% of cranberry essential oil (5 samples in each group). According to ISO (2013), the minced beef samples were homogenized in a stainless-steel blender. Ground beef was mixed with latex-gloved hands. Treated samples were through-mixed with CBEO (0.5%, 1% and 1.5%). All samples were stored for 12 days in the refrigerator at 3±1ºC. The treated groups were subjected to organoleptic, chemical, and bacteriological assessment at zero day (within 2 h. after treatment) then periodically every three days on the 3rd, 6th, 9th and12th days of chilled storage until decomposition appeared in each group. In each trail 3 kg from the minced beef was divided into two main groups, one group for sensory and bacteriological examination and the other for chemical examination. Each main group weighed 150g and was separated into 2 subgroups (100g each for chemical examination) and (50g for sensory and bacteriological examination) as each subgroup was treated with certain concentration of tested EO.

*Sensory Evaluation of Minced Beef Samples*

During the 12 days of preservation in the refrigerator, sensory evaluation of minced beef meat samples was assessed by twenty panelists (adult, untrained) were asked to evaluate the overall sensory attributes of minced meat samples without being informed of the experimental approach. By using unique codes, the samples were blind-enciphered. They were asked to provide a score for each of color, odor, taste, texture, and overall acceptability while the samples were still fresh (uncooked). 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 to rinse their palate from the previous sample taste. The evaluation was conducted using a nine-point hedonic scale (1: poor; 9: excellent) was used in the evaluation as followed: A score of 9-7 indicated ''Excellent to very good'' quality, 6.9-4.0 indicated ''good'' quality, a score of 3.9-1.0 indicated as spoiled was used for the evaluation of appearance, smell, texture, taste and overall acceptability as noted by Kruse *et al.* (1991).

*Chemical Analysis of Minced Beef Samples*

pH measurement

It is verified according to Pearson (2006). The pH measurement was carried out using an electrical pH meter (Bye model 6020, USA) and it was calibrated using two precisely recognized buffer solutions (pH 7.01 and 4.01). Briefly, 10 g of each minced beef sample was mixed with 10 mL of neutralized distilled water, left at room temperature for 10 min with continuous shaking, and filtered.

Determination of total volatile basic nitrogen (TVB-N) content

TVBN was measured according to the procedure recommended by (ES 63/9., 2006). In brief, in a clean distillation flask 10 g of the minced beef sample was added to 300 mL of distilled water, thoroughly mixed and then antifoaming and 2 g of magnesium oxide was added. To 500 ml receiving flask, 25 ml of 2% boric acid and few drops of indicator were added and heated within 10 min. till boiling, then titration of TVN received in boric acid by $H_2So_4$ n 0.1 was recorded till a faint pink color was obtained. Accordingly, TVBN was calculated from the following formula:

TVN/l00g= (mls $H_2So_4$ n 0.1 for sampl-ml $H_2So_4$ n 0.1 for Blank) x14

Determination of Thiobarbituric acid (TBA)

According to (ES 63/10, 2006), TBA value is calculated as milligrams of malondialdehyde equivalents per Kilogram of samples. Briefly, 10 g of prepared minced beef sample was transferred to a distillation flask and mixed with 50 ml of distilled water, then (2.5ml hydrochloric acid diluted in 47.5 water) were added Then, small pieces of antifoaming agents were added, and the flask was heated for distillation of 50 ml within 10 minutes from the beginning of boiling. Accordingly, 5 ml of a distilled solution was put in a tube with cover, mixed with 5 ml of prepared thiobarbituric acid. The tube was put on water bath and boiled for 35 minutes, then cooled by water for 10 minutes. Then the absorbance of sample was measured using Spectrophotometer (UNICAM969AA Spectronic, USA) under wavelength 538. TBA value was calculated from the following formula:

TBA value (malonaldehyde mg /Kg) = Absorbance of sample x 7.8

Determination of Peroxide Value (PV)

PV was determined using the approach recommended by Asakawa and Matsushita (1978). Accurately, 3 g of the sample were mixed with10 ml chloroform into a 250 ml Erlenmeyer flask. Furthermore, 15 ml acetic acid and 1.0 ml KI solutions were added and mixed. The mixture was kept in a dark place for 5 minutes. Consequently, 30 ml distilled water and 1 ml starch inductor was added. The mixture was titrated with sodium thiosulfate until the blue color disappeared. The peroxide value PV for all samples was calculated from the following formula:

PV = (V1–V0) x T x 1000 /m (mille equivalent available oxygen/kg) where:

V1= Volume of thiosulfate solution required to titrate the sample (ml)

V0= Volume of thiosulfate solution required to titrate the blank

T= Titre of the sodium thiosulfate solution (normality)

m= Weight of sample (g)

*Bacteriological Examination of Minced Beef Samples*

Under complete aseptic conditions, 10 g of each minced meat sample was weighted and transferred into homogenizer flask containing 90 ml sterile peptone water (0.1%) in a homogenizer (Oxide CM0009) at 4000 r.p.m for 2.5 minutes to provide a proper tenfold serial dilution. Total aerobic bacterial Count (TBC) was detected on Plate count agar after incubated for 48±2 h at 37°C (FDA., 2001), Psychrotrophic bacterial count (PBC) was determined using the pour plate method and incubated at 4°C for 5-7 days (APHA., 2001), *Enterobacteriaceae* were counted on violet red bile glucose agar (Oxide CM 485B) medium and incubated at 37ºC for 24 h. (ISO 21528-2004) and Staphylococcal count (STAPH) were counted on Baird Parker agar medium after being incubated at 37ºC for 48 hrs. (ISO 6888-1: 1999 A1:2003).

*Statistical Analysis*

Data was statistically analyzed using One-way analysis of variance (ANOVA) System (SAS Institute, Cary, NC, USA). The chemical, microbiological and organoleptic values were expressed as means±standard deviation (SD). Significant means were compared using Tukey-Kramer HSD difference test (JMP) post-hoc test ($P<0.05$).

## RESULTS

*Sensory Evaluation of Minced Beef Samples*

Table 1 shows the overall acceptability and sensory features of chilled minced beef samples stored at 3±1ºC were significantly increased by addition of different concentrations of CBEO (0.5%, 1%, and 1.5%) up to the 12th day of storage compared to the control samples (untreated) which were completely spoiled at the 6th day of storage. Also, samples containing 1.5% cranberry oil demonstrated the highest enhancement of sensory attributes, while the samples treated with 0.5% of cranberry oil demonstrated the least enhancement.

*Chemical Analysis of Minced Beef Samples*

Hydrogen Ion Concentration (pH) of Minced Beef Samples

The obtained results showed that minced meat samples treated with CBEO had significantly decreasing pH values after treating minced meat sampled with 0.5, 1, and 1.5% of CBEO and stored for 0, 3, 6, 9 and 12 days of chilled storage, respectively compared to control samples. Table 2.

Total Volatile Basic Nitrogen of Minced Beef Samples

Table 3 shows that treating minced meat samples with CBEO at different concentrations decreased the TVBN values especially after 9 and 12 days of storage at 3±1°C than control samples that exceeded the permissible limit by the 6th day of storage (20.23±1.34 mg/100) which indicated that CBEO could reduce protein decomposition and decrease TVN values.

Thiobarbituric Acid Reactive Substances of Minced Beef Samples (TBARs)

Table 4 shows that CBEO treated samples at different con-

Table 1. Effect of cranberry (*Vaccinium macrocarpon*) EO addition at a concentration of 0.5, 1 and 1.5% on overall acceptability of minced beef after chilling at 3±1ºC (mean±standard deviation “SD”).

| Chilling (days) | Control group | Berry oil treated samples | | |
|---|---|---|---|---|
| | | 0.5% treated group | 1% treated group | 1.5% treated group |
| Zero day | 8.22±1.43 | 8.45±1.39 | 8.63±1.42 | 8.87±1.49 |
| 3rd day | 6.59±1.45$^{a}$ | 6.83±1.39$^{a}$ | 7.23±1.34$^{ab}$ | 8.16±1.32$^{b}$ |
| 6th day | 4.13±1.36$^{a}$ | 5.39±1.36$^{a}$ | 6.11±1.32$^{ab}$ | 7.14±1.32$^{b}$ |
| 9th day | 3.23±1.25$^{a}$ | 5.29±1.32$^{b}$ | 6.44±1.27$^{bc}$ | 6.98±1.34$^{c}$ |
| 12th day | 2.74±1.19$^{a}$ | 4.25±1.29$^{a}$ | 5.16±1.29$^{b}$ | 6.12±1.21$^{c}$ |

Means of the same rows carrying different superscript letters (a.b.c) are significantly different (p<0.05).

Table 2. Changes in pH value of minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1 and 1.5% of CBEO (mean±standard deviation “SD”).

| Chilling (days) | Control group | Berry oil treated samples | | |
|---|---|---|---|---|
| | | 0.5% treated group | 1% treated group | 1.5% treated group |
| Zero day | 5.71±0.22 | 5.69±0.21 | 5.69±0.21 | 5.68±0.21 |
| 3rd day | 6.24±0.23$^{a}$ | 5.87±0.24$^{b}$ | 5.81±0.22$^{bc}$ | 5.76±0.23$^{c}$ |
| 6th day | 6.99±0.27$^{a}$ | 6.12±0.23$^{ab}$ | 5.97±0.23$^{b}$ | 5.89±0.23$^{b}$ |
| 9th day | 7.48±0.27$^{a}$ | 6.61±0.25$^{ab}$ | 6.52±0.24$^{ab}$ | 6.36±0.25$^{b}$ |
| 12th day | 7.92±0.28$^{a}$ | 7.10±0.27$^{ab}$ | 6.81±0.34$^{ab}$ | 6.54±0.29$^{b}$ |

Means of the same rows carrying different superscript letters (a.b.c) are significantly different (p<0.05).

Table 3. Changes in TVB-N content mg% of minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1, and 1.5% of CBEO (mean±standard deviation “SD”).

| Chilling (days) | Control group | Berry oil treated samples | | |
|---|---|---|---|---|
| | | 0.5% treated group | 1% treated group | 1.5% treated group |
| Zero day | 2.27±0.11 | 2.27±0.11 | 2.27±0.11 | 2.27±0.11 |
| 3rd day | 12.64±0.29$^{a}$ | 4.58±0.34$^{ab}$ | 4.12±0.31$^{ab}$ | 3.98±0.23$^{b}$ |
| 6th day | 20.23±1.34$^{a}$ | 9.42±1.13$^{b}$ | 8.26±1.42$^{b}$ | 7.14±1.10$^{c}$ |
| 9th day | 26.36±3.12$^{a}$ | 14.25±2.31$^{ab}$ | 12.56±2.08$^{b}$ | 11.36±2.04$^{c}$ |
| 12th day | 34.88±7.23$^{a}$ | 21.6±3.89$^{b}$ | 18.32±2.54$^{b}$ | 17.95±2.25$^{b}$ |

Means of the same rows carrying different superscript letters (a.b.c) are significantly different (p<0.05).

centrations lessened the TBA values especially at the 6th, 9th and 12th days of storage compared to control samples at the 6th day (0.95±0.12mg MDA/kg). Increasing CBEO level can reduce lipid oxidation and decrease the TBA values in minced meat samples.

Peroxide Values of Minced Beef Samples (PV)

Results presented in Table 5 revealed there are significant differences between the treated samples with different concentrations of CBEO and the control samples. The addition of CBEO in minced beef samples delayed lipid oxidation development and decreased the peroxide values of treated samples compared to the untreated control samples.

*Bacteriological Examination of Minced Beef samples with CBEO*

Total Aerobic Bacterial Count (TABC) of Minced Beef Samples

Table 6 shows that TABC mean values of control samples at day zero were 4.55±1.12 $log_{10}$ cfu/g which had the highest initial TBC followed by 0.5% CBEO treated sample (4.21±1.11 $log_{10}$ cfu/g). In contrast, the lowest initial total bacterial count presented with 1% and 1.5% CBEO treated samples (4.17±1.10, 3.59±1.10 $log_{10}$ cfu/g, respectively). Samples that were treated with 0.5,1 and 1.5% cranberry EO displayed decreasing count of aerobic plate count compared to the control group. Moreover, 1 and 1.5% CBEO effectively improved the microbial characteristics of minced beef samples for 9 and 12 days.

Total Psychrotrophic Count (TPC) of Minced Beef Samples

Results obtained in Table 7 show that cranberry essential oil treated samples indicated significantly lower TPC throughout the storage period compared to untreated control group. CBEO significantly preserved the minced meat samples at zero time in treated groups compared to control where at zero day of storage, TPC of control, 0.5,1 and 1.5% treated groups were 4.14±0.98, 4.02±0.92, 3.98±0.94 and 3.78±0.93 $log_{10}$ cfu/g respectively. Significant variations between control and treated groups ($P<0.05$) were obtained after the 3rd day of storage till the end of the storage period.

Total *Enterobacteriaceae* Count (TEC) of Minced Beef Samples

Table 8 shows that the initial *Enterobacteriaceae* count was the highest in the control sample (2.64±0.35 $log_{10}$ cfu/g) followed by 0.5% CBEO-treated samples (2.40±0.28 $log_{10}$ cfu/g), 1% CBEO -treated samples (2.38±0.26 $log_{10}$ cfu/g), and 1.5% CBEO-treated samples (2.24±0.27 $log_{10}$ cfu/g) at zero day of chilled storage. Different concentrations of CBEO (0.5, 1 and 1.5%) highlight the positive preservative effects of CBEO treatments on minced meat samples, where it decreased the EBC counts compared with control and prolonged the enhancement effect from zero day up to the 9th and 12th day of storage.

Table 4. Changes in TBA mg/kg of minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1, and 1.5% of CBEO (mean±standard deviation "SD").

| Chilling (days) | Control group | Berry oil treated samples | | |
|---|---|---|---|---|
| | | 0.5% treated group | 1% treated group | 1.5% treated group |
| Zero day | 0.07±0.002 | 0.07±0.002 | 0.07±0.002 | 0.07±0.002 |
| 3rd day | $0.42±0.01^{a}$ | $0.27±0.01^{ab}$ | $0.23±0.01^{b}$ | $0.17±0.009^{b}$ |
| 6th day | $0.95±0.12^{a}$ | $0.47±0.11^{b}$ | $0.42±0.10^{b}$ | $0.39±0.10^{c}$ |
| 9th day | $1.63±0.18^{a}$ | $0.74±0.13^{b}$ | $0.71±0.12^{b}$ | $0.65±0.11^{c}$ |
| 12th day | $1.94±0.34^{a}$ | $0.98±0.14^{b}$ | $0.85±0.15^{b}$ | $0.78±0.14^{c}$ |

Means of the same rows carrying different superscript letters (a.b.c) are significantly different ($p<0.05$).

Table 5. Changes in PV content meq $O_2$/kg of minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1, and 1.5% of CBEO (mean±standard deviation "SD").

| Chilling (days) | Control group | Berry oil treated samples | | |
|---|---|---|---|---|
| | | 0.5% treated group | 1% treated group | 1.5% treated group |
| Zero day | $0.19±0.03^{a}$ | $0.19±0.03^{a}$ | $0.19±0.03^{a}$ | $0.19±0.03^{a}$ |
| 3rd day | $0.50±0.21^{a}$ | $0.43±0.12^{a}$ | $0.39±0.11^{ab}$ | $0.37±0.11^{b}$ |
| 6th day | $2.67±0.36^{a}$ | $0.63±0.21^{b}$ | $0.59±0.22^{b}$ | $0.51±0.12^{b}$ |
| 9th day | $3.57±0.49^{a}$ | $1.21±0.31^{b}$ | $0.96±0.22^{b}$ | $0.74±0.23^{b}$ |
| 12th day | 5.44±1.13a | $2.64±0.59^{b}$ | $2.31±0.52^{b}$ | $2.08±0.43^{b}$ |

Means of the same rows carrying different superscript letters (a.b.c) are significantly different ($p<0.05$).

Table 6. Changes in aerobic plate count (log10 cfu/g.) of minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1, and 1.5% of CBEO (mean±standard deviation "SD").

| Chilling (days) | Control group | Berry oil treated samples | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.5% treated group | RC | 1% treated group | RC | 1.5% treated group | RC |
| Zero day | 4.55±1.12 | 4.21±1.11 | 0.34 | 4.17±1.10 | 0.38 | 3.59±1.10 | 0.96 |
| 3rd day | $5.10±1.16^{a}$ | $4.49±1.12^{ab}$ | 0.61 | $4.17±1.11^{b}$ | 0.93 | $4.03±1.10^{c}$ | 1.07 |
| 6th day | $6.55±1.21^{a}$ | $4.59±1.12^{b}$ | 1.96 | $4.52±1.14^{b}$ | 2.03 | $4.35±1.13^{c}$ | 2.2 |
| 9th day | $7.11±1.26^{a}$ | $5.22±1.21^{b}$ | 1.89 | $5.14±1.19^{c}$ | 1.97 | $5.01±1.18^{c}$ | 2.1 |
| 12th day | $8.14±1.54^{a}$ | $6.25±1.37^{b}$ | 1.89 | $5.86±1.32^{b}$ | 2.28 | $5.41±1.33^{c}$ | 2.73 |

Reduction count = Mean of control – Mean of treated

Means of the same rows carrying different superscript letters (a.b.c) are significantly different ($p<0.05$).

Total Staphylococcal Count (TSC) of Minced Beef Samples

The obtained results in Table 9 show that the total staphylococcal count of the control and 0.5%, 1%, and 1.5% CBEO-treated minced meat samples were 3.14±0.21, 2.89±0.17, 2.75±0.16 and 2.67±0.25 $\log_{10}$ cfu/g, respectively at zero day of refrigerated storage at 3±1°C which indicates the positive preservative effects of CBEO treatments on minced meat samples from the beginning of storage. With particular emphasis, samples treated with cranberry oil at various concentrations showed a reduced count of STAPH when compared to the control, which started decomposition on. the 6th day of storage and prolonged the enhancement effect after the 9th and 12th day of storage. Also, the CBEO at 1.5% was more effective in decreasing STAPH counts than 1%.

## DISCUSSION

The organoleptic evaluation of minced meat samples stored at 3±1°C were significantly increased by cranberry EO different concentrations at 0.5, 1 and 1.5% which significantly improved the color, odor, taste, texture, and overall acceptability for 6, 9 and 12 days after storage, respectively. This observation agreed with Gniewosz and Stobnicka (2018) and Lau (2019) who indicated that application of cranberry concentrates could provide food safety without affecting acceptance and other sensory features of meat products. Furthermore, Yang *et al*. (2022) reported that cranberry powder could enhance sensory and microbial characters of fermented sausages as a natural substitute to nitrite and this investigation supported by Liangli *et al*. (2005) who revealed that CB seed oil is edible, having a pleasant flavor and have good oxidative stability. Minced beef samples treated with an increasing concentration of CBEO had lower pH values than control samples during different periods of analysis. These findings agreed with Salem *et al*. (2010) who concluded that the activation effect of used essential oil as antimicrobial agent may cause protein hydrolysis with appearance of alkyl groups leading to decrease pH value. Also, by increasing CBEO to 1.5%, the pH values scored the highest effect in lowering pH values for 12 days in chilled storage and these results coincide with Gniewosz and Stobnicka (2018) who reported increasing in acidity of minced pork meat samples treated with different cranberry pomace extract stored at 4°C for 6 days compared to control along the storage time and Daoutidou *et al*. (2021) who indicate that the CB aqueous extract incorporation into the pork meatballs slowed the increase of pH values during refrigerator storage compared to the control. Total volatile basic nitrogen (TVBN mg/100g) is the traditional chemical mean most usually employed for evaluation of raw minced meat as more than 20 mg TVN/ 100 gm in raw samples indicates the spoilage of minced meat according to ES:63-9/2006 (EOS, 2006). The obtained result showed that treating minced meat samples with cranberry EO at different concentrations decreased the TVBN values especially after 9 and 12 days of storage. Similar results for initial TVBN values reported by Karre *et al*. (2013) who suggested that berries owing to their high content of phenolic compounds might be used as antioxidants in meat and poultry products through reducing the TBARS value

Table 7. Changes in total Psychrotrophic count log10 cfu/g. of chilled minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1, and 1.5% of CBEO (mean±standard deviation "SD").

| Chilling (days) | Control group | Berry oil treated samples | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.5% treated group | RC | 1% treated group | RC | 1.5% treated group | RC |
| Zero day | 4.14±0.98 | 4.02±0.92 | 0.12 | 3.98±0.94 | 0.16 | 3.78±0.93 | 0.36 |
| 3rd day | 4.95±0.93$^{a}$ | 4.35±0.89$^{a}$ | 0.6 | 4.31±0.86$^{a}$ | 0.64 | 4.12±0.87$^{b}$ | 0.83 |
| 6th day | 6.40±1.02$^{a}$ | 5.12±0.96$^{a}$ | 1.28 | 5.08±0.97$^{a}$ | 1.32 | 4.96±0.94$^{b}$ | 1.44 |
| 9th day | 7.05±1.16$^{a}$ | 5.61±1.02$^{a}$ | 1.44 | 5.58±0.98$^{a}$ | 1.47 | 5.44±0.98$^{b}$ | 1.61 |
| 12th day | 7.93±1.21$^{a}$ | 6.12±1.08$^{b}$ | 1.81$^{b}$ | 6.01±1.02$^{cb}$ | 1.92 | 5.97±1.01$^{c}$ | 1.96 |

Reduction count = Mean of control – Mean of treated
Means of the same rows carrying different superscript letters (a.b.c) are significantly different (p<0.05).

Table 8. Changes in total *Enterobacteriaceae* count log10 cfu/g. of minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1, and 1.5% of CBEO (mean±standard deviation "SD").

| Chilling (days) | Control group | Berry oil treated samples | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.5% treated group | RC | 1% treated group | RC | 1.5% treated group | RC |
| Zero day | 2.64±0.35 | 2.40±0.28 | 0.24 | 2.38±0.26 | 0.26 | 2.24±0.27 | 0.4 |
| 3rd day | 3.12±0.36$^{a}$ | 2.67±0.29$^{a}$ | 0.45 | 2.62±0.26$^{a}$ | 0.5 | 2.51±0.23$^{b}$ | 0.61 |
| 6th day | 3.95±0.37$^{a}$ | 3.13±0.31$^{b}$ | 0.82 | 3.08±0.29$^{b}$ | 0.87 | 3.04±0.27$^{b}$ | 0.91 |
| 9th day | 4.55±0.42$^{a}$ | 3.98±0.33$^{a}$ | 0.57 | 3.74±0.31$^{ab}$ | 0.81 | 3.62±031$^{b}$ | 0.93 |
| 12th day | 5.13±0.84$^{a}$ | 4.47±0.75$^{a}$ | 0.66 | 4.06±0.71$^{b}$ | 1.07 | 3.82±0.68$^{b}$ | 1.31 |

Reduction count = Mean of control – Mean of treated
Means of the same rows carrying different superscript letters (a.b.c) are significantly different (p<0.05).

Table 9. Changes in total Staphylococcal count log10CFU/g of minced beef at 3±1ºC after 3, 6, 9 and 12 days of storage with 0.5, 1, and 1.5% of CBEO (mean±standard deviation "SD").

| Chilling (days) | Control group | Berry oil treated samples | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.5% treated group | RC | 1% treated group | RC | 1.5% treated group | RC |
| Zero day | 3.14±0.21 | 2.89±0.17 | 0.25 | 2.75±0.16 | 0.39 | 2.67±0.25 | 0.47 |
| 3rd day | 3.75±0.23$^{a}$ | 3.11±0.21$^{ab}$ | 0.64 | 3.08±0.22$^{ab}$ | 0.67 | 2.85±0.11$^{b}$ | 0.9 |
| 6th day | 4.27±0.27$^{a}$ | 3.65±0.24$^{ab}$ | 0.62 | 3.45±0.26$^{b}$ | 0.82 | 3.17±0.22$^{c}$ | 1.1 |
| 9th day | 4.85±0.32$^{a}$ | 3.87±0.27$^{b}$ | 0.98 | 3.65±0.25$^{bc}$ | 1.2 | 3.42±0.24$^{c}$ | 1.43 |
| 12th day | 5.44±0.36$^{a}$ | 4.91±0.32$^{ab}$ | 0.53 | 4.22±0.29$^{b}$ | 1.22 | 3.95±0.27$^{b}$ | 1.49 |

Reduction count = Mean of control – Mean of treated
Means of the same rows carrying different superscript letters (a.b.c) are significantly different (p<0.05).

during storage and Brink *et al*. (2019) who evaluated the antibacterial effect of edible films containing CB extracts on fresh cut turkey pieces that decreased TVBN counts for at least 6 days .This could be caused by the high total antioxidant capacity of CBE which have the ability to successfully inhibit foodborne pathogens as mentioned by Lau (2019) and Ahmad *et al*. (2019) who demonstrated that CB seeds regarded as a source of edible oil with high antioxidants contain appreciable amounts of tannins, anthocyanins, flavonoids and phenolic acids related to both organoleptic properties and antioxidant activities. The most widely used biomarker for assessing lipid oxidation in meat and its products is TBARS value expressed as mg malonaldehyde equi/kg (Salami *et al*., 2015). Table 4 shows significant decrease in TBARS content value in treated minced meat samples with CBEO compared to the control group, which exceeded the permissible limit of TBARS value, according to data from ES: 63-10/2006 (EOS, 2006).This could be linked to CBEO's high antioxidant effect, which is related to the fact that its flavonoids and phenolic content act as scavengers, as was previously indicated by Peixoto *et al*. (2018) and Dorris *et al*. (2021). Likewise, previous studies by Semenova *et al*. (2019) have shown that essential oils usage as antioxidants in minced meat can prevent lipid oxidation displayed lower TBARs values. Ganhão *et al*. (2013) provided support for these findings when found that the addition of berry extracts had a significant effect on TBA-RS numbers in raw, cooked, and chilled burger patties where burger patties treated with berry extracts showed significantly lower TBA-RS numbers than the control patties which indicate effectively retarded lipid oxidation by berry extracts. The PV is used as a pointer for lipid oxidation in raw meat and its products. The low peroxide values might be associated to CBEO content of phenols and flavonoids that have antioxidant activity. This is consistent with numerous research that shown the impact of 200 mg/kg tannic acid found in some plants as cranberry in lowering PV content values in refrigerated ground beef, as mentioned by Maqsood and Benjakul (2010) and supported by Zhang *et al*. (2016) who reported that utilizing berries extract high in flavonoids as an antioxidant reduced PV and TBARS values and Khodaei *et al*. (2023) who indicated that that the usage of cranberry extracts / apple Polyphenol as a multi-antioxidant system protected the ground pork product against oxidation. As a result, it contributes significantly to increasing the shelf life and improving quality of minced beef. According to EOS (2006), samples treated with CBEO showed a decrease in aerobic plate count below the acceptable limit (6 log10 cfu/g) as the 1.5% CBEO significantly improved the microbial properties of minced beef samples for 12 days. Results of present study are in agreement with the findings of Daoutidou *et al*. (2021) who indicated that APC of the control samples exceeded the limit of 6 log CFU/g for total viable counts in fresh ground meat set by European law (EC 2073/2005) at the 5$^{th}$ day while meat samples containing CBAE was extended to the 8$^{th}$ day of chilled storage and supported by Gniewosz and Stobnicka (2018) who noted a decrease in total cell number of minced pork inoculated with pathogens stored at 4°C after CBE addition for 6 days. Our findings revealed that CBEO significantly preserved the minced meat samples by reduction in total psychrotrophic numbers correlated to active ingredients in cranberry phenolic compounds, flavonoids and aromatic acids and these results were similar to that of Lorenzo *et al*. (2018) who told that inhibitory effects of berry extracts on meat oxidation is mainly related to the numerous phenolic compounds with recognized antioxidant activity. Additionally, Aminzare *et al*. (2019) indicated that phenolic antioxidant components have the ability to delay food spoilage, enhance organoleptic quality and prevent pathogens growth in products, so they are widely used in the food industry and Yang *et al*. (2014) who proved that there is an evidence of berry juice ability of pathogenic bacteria inhibition while stimulating the probiotics growth. These results could be attributed to the bacteriostatic or bactericidal activity of flavonols and other organic acids of cranberries where the largest inhibitory impact against *S. aureus* was produced by an ethanol extract of cranberries, mostly through inhibiting peptidoglycans in bacterial cells according to Tamkutė *et al*. (2019). These current results indicated that minced beef samples that were treated by CBEO (0.5, 1 and 1.5%) showed decreasing count of STAPH and prolonged the shelf life from 6 to 9 and 12 days of chilled storage, respectively compared to control. Nearly similar results were obtained by Daoutidou *et al*. (2021) who recorded displayed decreasing count of *S. aureus* values of treated pork meatballs with CBAE than control samples stored for eight days in chilling at 4°C, Liepiņa *et al*. (2013) who concluded that CB aqueous and ethanol extracts showed antibacterial activity against *S. aureus*, *B. cereus* and *P. aeruginosa* strains especially. Our results also highlight the positive preservative effects of CBEO treatments on minced meat samples by decreased EBC counts compared with control and prolonged the enhancement effect up to the 9$^{th}$ and 12$^{th}$ day of chilled storage. These results coincided with those of Gniewosz and Stobnicka (2018) who discovered that the *E. coli* count was inhibited in the examined minced pork meat samples stored at 4°C treated with various CB pomace extract for 6 days where *E. coli* count decreased by 3.23 log cfu/g after 30 minutes and decreased by 4 log cfu/g after 2 days of storage and Daoutidou *et al*. (2021) who reported the effect of CB aqueous extract on decreasing *Enterobacteriaceae* for raw pork meatballs against control samples on the 3$^{rd}$ day of refrigerated storage. Furthermore, our results are supported by Wu *et al*. (2009) who discovered antibacterial impact of CB different concentrates (2.5%, 5.0%, and 7.5%) in commercial ground beef patties by decreasing 6 log CFU/g *E. coli* O157:H7 by 0.4 to 2.4 log CFU/g after 5 days.

## CONCLUSION

This study provides, for the first time, evidence for the addition of cranberry essential oil as a natural preservative for retailed minced beef. Cranberry EO at concentrations of 0.5%, 1% and 1.5% enhanced the sensory, chemical, and microbial attributes. Specifically, as it is a potent source of polyphenols having antioxidant and antimicrobial properties, it inhibits the microbial growth of TABC, TPC, TEC, TSC and increases shelf-life. The 0.5%-treated samples has a shorter shelf-life compared with 1 and 1.5%-treated samples. Applying CBEO to extend shelf life while maintaining the safety of minced beef could satisfy the expectation of consumers for naturally safe minced meat ingredients without health adverse effects.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## REFERENCES


Ahmad, N., Anwar, F., Abbas, A., 2019. Cranberry Seed Oil. In: Fruit Oils: Chemistry and Functionality. Springer Nature Switzerland AG 2019, pp. 663-674.

Ahmad, R.S., Imran, A., Hussain, M.B., 2018. Nutritional composition of meat. Meat Science and Nutrition, Intechopen, DOI:10.5772/intechopen.77045.

Aminzare, M., Hashemi, M., Ansarian, E., Bimakr, M., Hassanzad Azar, H., Mehrasbi, M. R., Afshari, A., 2019. Using natural antioxidants in meat and meat products as preservatives: A review. Advances in Animal and Veterinary Sciences 7, 417-426.

Amiri, E., Aminzare, M., Azar, H.H., Mehrasbi, M.R., 2019. Combined antioxidant and sensory effects of corn starch films with nanoemulsion of Zataria multiflora essential oil fortified with cinnamaldehyde on fresh ground beef patties. Meat Science 153, 66-74.

APHA (American Public Health Association), 2001. Compendium of methods for microbiological examination of foods. 4th Edition 365-366- 800. 1st, NW Washington DC2000 1-3710.

Arnarson, A., 2019. Beef 101: Nutrition facts and health effects. Retrieved from https://www.healthline.com/nutrition/foods/beef.

Asakawa, S., Matsushita, T., 1978. Colorimetric determination of peroxide value with potassium iodide-silica gel reagent. J. American Oil Chemists Society 55, 619- 620.

Brink, I., Šipailienė, A., Leskauskaitė, D., 2019. Antimicrobial properties of chitosan and whey protein films applied on fresh cut turkey pieces. International Journal of Biological Macromolecules 130,810-817.

Daoutidou, M., Plessas, S., Alexopoulos, A., Mantzourani, I., 2021. Assessment of antimicrobial activity of pomegranate, cranberry, and black chokeberry extracts against foodborne pathogens. Foods 10, 486.

Dorris, M. R., Bolling, B.W., 2021. Cranberry (*Vaccinium macrocarpon*) Juice Precipitate Pigmentation Is Mainly Polymeric Colors and Has Limited Impact on Soluble Anthocyanin Loss. Antioxidants 10, 1788.

EOS (Egyptian Organization for Standardization), 2006. Methods of analysis and testing for meat. Part 10: determination of thiobarbituric acid (TBA). ES:63-10/2006.

EOS (Egyptian Organization for Standardization), 2006. Methods of analysis and testing for meat. Part 9: determination of total volatile nitrogen (TVN). ES:63-9/2006.

Elhadef, K., Ennouri, K., Fourati, M., Ben Hlima, H., Akermi, S., Mellouli, L., Smaoui, S., 2021. Pistachio Hull Extract as a Practical Strategy to Extend the Shelf Life of Raw Minced Beef: Chemometrics in Quality Evaluation. Evidence-Based Complementary and Alternative Medicine 2021, 2429766.

Elsayed, M., Ahmed, A., Ahmed, E., Hassan, D., Sliem, M., Zewail, D., Sameh, S., Ibrahim, Y., Ibrahim, A., Ahmed, Y., Elsayed, N., Yasser, M., Deghedy, M., Abdellatief, M., Tarek, H., Awad, A.I., Mohamed, T., Mekky, R.H., Elgindi, O., 2023. A review on bioactive metabolites and great biological effects of Cranberry. ERU Research Journal. 2, 177-209.

ES, (2005).1694/2005. Egyptian standards specification for minced meat. Egyptian Organization for Standardization and Quality Control.

European Commission, 2005. Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. Off. J. Eur. Union, 50, 1-26.

Maturin, L., Peeler J.T., 2001. Aerobic plate count. In: Bacteriological analytical manual. Chapter 3. US Food and Drug Administration. https://www.fda.gov/food/laboratory-methods-food/bam.

Flammer, A.J., Martin, E.A., Gössl, M., Widmer, R.J., Lennon, R.J., Sexton, J.A., Loeffler, D., Khosla, S., Lerman, L.O., Lerman, A., 2013. Polyphenol-rich cranberry juice has a neutral effect on endothelial function but decreases the fraction of osteocalcin-expressing endothelial progenitor cells. European Journal of Nutrition 52, 289-296.

Ganhão, R., Estévez, M., Armenteros, M., Morcuende, D., 2013. Mediterranean berries as inhibitors of lipid oxidation in porcine burger patties subjected to cooking and chilled storage. Journal of Integrative Agriculture 12,1982-1992.

Gniewosz, M., Stobnicka, A., 2018. Bioactive components content, antimicrobial activity, and foodborne pathogen control in minced pork by cranberry pomace extracts. Journal of Food Safety 38, e12398.

ISO, 2004. International Organization for Standardization, No. 21528-2: Microbiology of food and animal feeding stuffs-Horizontal methods for detection and enumeration of *Enterobacteriaceae* part (2): colony count method.

ISO, 2013. 6887-2. Microbiology of food and animal feeding stuffs -Preparation of test samples, initial suspension and decimal dilutions for microbiological examination-Part 2: Specific rules for the preparation of meat and meat products.

ISO, 2003. 6888-1: 1999 AMD 1., 2003. International Organization for Standardization, No.6888-1 Microbiology of food and animal feeding stuffs –Protocol for the validation of alternative methods. Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) — Part 1.

Johnson, J.B., Lin, B., Bongard, J., 2010. Genus vaccinium: medicine, cosmetics, and coatings. Recent Patents on Biotechnology 4,112-124.

Karre, L., Lopez, K., Getty, K.J.K., 2013. Natural antioxidants in meat and poultry products. Meat Sci. 94, 220–227.

Khodaei, N., Houde, M., Bayen, S., Karboune, S., 2023. Exploring the synergistic effects of essential oil and plant extract combinations to extend the shelf life and the sensory acceptance of meat products: multi antioxidant systems. Journal of Food Science and Technology 60, 679-691.

Kranz, S., Guellmar, A., Olschowsky, P., Tonndorf-Martini, S., Heyder, M., Pfister,W., Sigusch, B., 2020. Antimicrobial effect of natural berry juices on common oral pathogenic bacteria. Antibiotics 9, 533.

Kruse, R.H., Puckett, W.H., Richardson, J.H., 1991. Biological safety cabinetry. Clinical Microbiology Reviews 4, 207-241.

Lau, A., 2019. The Effect of Cranberry Pomace Extracts on the Growth of Meat Starter Cultures and the Subsequent Effect on Dry Fermented Sausage Safety and Quality Characteristics. Doctoral dissertation, University of Guelph. United States.

Liangli, L.Y., Zhou, K.K. and Parry, J., 2005. Antioxidant properties of cold-pressed black caraway, carrot, cranberry and hemp seed oils. Food Chemistry 91, 723-729.

Liepiņa, I., Nikolajeva, V., Jākobsone, I., 2013. Antimicrobial activity of extracts from fruits of *Aronia melanocarpa* and *Sorbus aucuparia*. Environmental and Experimental Biology 11, 195-199.

Lorenzo, J.M., Pateiro, M., Domínguez, R., Barba, F.J., Putnik, P., Kovačević, D.B., Shpigelman, A., Granato, D., Franco, D., 2018. Berries extracts as natural antioxidants in meat products: A review. Food Research International 106, 1095-1104.

Maqsood S., Benjakul S., 2010. Preventive effect of tannic acid in combination with modified atmospheric packaging on the quality losses of the refrigerated ground beef. Food Control 21, 1282–1290.

Ottaviano, E., Baron, G., Fumagalli, L., Leite, J., Colombo, E.A., Artasensi, A., Aldini, G., Borghi, E., 2021. Candida albicans Biofilm Inhibition by Two *Vaccinium macrocarpon* (Cranberry) Urinary Metabolites: 5-(3′, 4′-DihydroxyPhenyl)-γ-Valerolactone and 4-HydroxybenzoicAcid. Microorganisms 9, 1492.

Pearson, D., 2006. Chemical Analysis of Foods. 11th Ed, Publishing Co., Churchill Livingstone, Edinburgh, London, United Kingdom.

Peixoto, T.C., Moura, E. G., de Oliveira, E., Soares, P.N., Guarda, D.S., Bernardino, D.N., Xue Ai, X., da S T Rodrigues, V., de Souza, G.R., da Silva, A.J.R., Figueiredo, M.S., Manhães, A.C., Lisboa, P.C., 2018. Cranberry (*Vaccinium macrocarpon*) extract treatment improves triglyceridemia, liver cholesterol, liver steatosis, oxidative damage and corticosteronemia in rats rendered obese by high fat diet. European Journal of Nutrition 57, 1829-1844.

Ranfaing, J., Dunyach-Remy, C., Lavigne, J.P., Sotto, A., 2018. Propolis potentiates the effect of cranberry (*Vaccinium macrocarpon*) in reducing the motility and the biofilm formation of uropathogenic Escherichia coli. PLoS One,13, e0202609.

Ribeiro, J.S., Santos, M.J.M.C., Silva, L.K.R., Pereira, L.C.L., Santos, I. A., da Silva Lannes, S. C., da Silva, M.V., 2019. Natural antioxidants used in meat products: A brief review. Meat science, 148, 181-188.

Salami, S.A., Majoka, M.A., Saha, S., Garber, A., Gabarrou, J.F., 2015. Efficacy of dietary antioxidants on broiler oxidative stress, performance and meat quality: science and market. Avian Biology Research 8,65-78.

Salem, A.M., Amin, R.A., Afifi, G.S., 2010. Studies on antimicrobial and antioxidant efficiency of some essential oils in minced beef. J. Am. Sci. 6, 691-700.

Semenova, A.A., Nasonova, V. V., Tunieva, E.K., 2019. The effect of essential oils on the color stability of minced meat. In IOP Conference Series: Earth and Environmental Science. IOP Publishing, Volume 333, 012098.

Tamkutė, L., Gil, B.M., Carballido, J.R., Pukalskienė, M., Venskutonis, P.R., 2019. Effect of cranberry pomace extracts isolated by pressurized ethanol and water on the inhibition of food pathogenic/spoilage bacteria and the quality of pork products. Food Research International 120, 38-51.

Velzen, E.U.T., Linnemann, A.R., 2008. Modified Atmosphere Packaging of Fresh Meats – Sudden Partial Adaptation Caused an Increase in Sustainability of Dutch Supply Chains of Fresh Meats. Packaging and Technological Science 21, 37–46.

Wu, V.C., Qiu, X., Benildo, G., Lin, C. S., Pan, Y., 2009. Application of cranberry concentrate (*Vaccinium macrocarpon*) to control Escherichia coli O157: H7 in ground beef and its antimicrobial mechanism related to the downregulated slp, hdeA and cfa. Food Microbiology 26, 32-38.

Yang, H., Hewes, D., Salaheen, S., Federman, C., Biswas, D., 2014. Effects of blackberry juice on growth inhibition of foodborne pathogens and growth promotion of Lactobacillus. Food Control 37, 15-20.

Yang, L., Yan, X., Liu, T., Kang, L., Gao, X., Sun, Y., Duan, Y., 2022. Effects of cranberry powder on the diversity of microbial communities and quality characteristics of fermented sausage. Front. Nutr. 10, 1123627.

Zhang, G., Jiang, Y., Liu, X., Deng, Y., Wei, B., Shi, L., 2021. Lingonberry Anthocyanins Inhibit Hepatic Stellate Cell Activation and Liver Fibrosis via TGFβ/Smad/ERK Signaling Pathway. Journal of Agricultural and Food Chemistry 69, 13546-13556.

Zhang, X., Li, D., Meng, Q., He, C., Ren, L., 2016. Effect of mulberry leaf extracts on color, lipid oxidation, antioxidant enzyme activities and oxidative breakdown products of raw ground beef during refrigerated storage. Journal of Food Quality 39, 159-170.