1 **TITLE PAGE**

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Abstract

This study was undertaken to evaluate the impact of Chinese cinnamon powder (w/w), at the levels of 0.5%, 1.5% and 2.5% and control (without additive) on ground lamb meat quality. The samples were examined for pH, color, lipid oxidation (thiobarbituric acid reactive substances), and total viable counts (TVC) stored at 4℃. The results demonstrated that pH values were declined with the increase in Chinese cinnamon levels compared to control. The L^* values throughout the storage were significantly higher ($p<0.05$) in the control group than in other treated groups while a^* values were decreased with the increase of Chinese cinnamon levels. The addition of Chinese cinnamon powder strongly inhibited ($p<0.05$) TBARS and TVC in all treated samples. It can be concluded that Chinese cinnamon powder in lower concentration 0.5% has the ability to maintain the quality of ground lamb in comparison with other treatments.

Keywords: Lamb, Chinese cinnamon, Meat quality, Storage

1. Introduction

Seasoning of meat is a possible solution to enhance the color stability, minimize lipid oxidation and improve microbial safety of meat products. The seasoned meat products are more susceptible to spoilage of microorganism (Rysman et al., 2016). These products are usually marketed at refrigerated temperature (2–5°C) in order to increase shelf life (Babuskin et al., 2015). The spoilage due to the lipid oxidation has deleterious consequences on the quality of fresh meat and other meat products resulting in massive economic losses (Shahidi & Zhong, 2010). While microbial activities in the food products may also destroy the quality of meat by the development of undesirable responses involving the worsening of odour, color and textural properties of foods (Del Nobile et al., 2012).

The spoilage factors in meat products sometimes produce toxic materials which are hazardous for human health (Jiang & Xiong, 2016). Therefore a vast majority of antioxidants added to the meat have been chemically synthesized such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). However, the presence of potentially carcinogenic substances and improper attitudes of consumers, these antioxidants are limited in food industries in some countries (Falowo et al., 2014). Therefore, meat industries are largely applying antioxidants from plant sources as safe alternatives and several studies have been carried out on the natural antioxidants as meat preservatives (Devatkal & Naveena, 2010).

A number of plant materials have been used directly or indirectly, as a seasoned material for the antimicrobial purpose, to improve the meat quality (Appendini & Hotchkiss, 2002). The natural preservatives used by the meat producers include cinnamon, clove, rosemary, basil, thyme, oregano, lemon leaf, ginger, basilica, balm, coriander and many of them are generally recognized as safe (GRAS) in food industry (Jiang & Xiong, 2016; Khaleque et al., 2016; Alfonzo et al., 2017). Chinese cinnamon (*Cinnamomum cassia)* usually add to the deserts, drinks or bakery products, moreover in South Asian and Central Asian regions it is considered a vital spice in many meat products. Cinnamon is used for culinary purposes and is commonly used in meat and fast food products and has been described as a powerful antioxidant and antibacterial agent usually used in the seasoning of meat and fish products (Ozogul et al., 2017; Al Sahlany, 2017). It has been confirmed that cinnamon has effective free radical scavenging activity due to the presence of bioactive compounds (Radha at al., 2014). Cinnamaldehyde is the major constituent responsible for it high antioxidant activity (Dudonne et al., 2009). The cinnamon has been observed to check

the quality of beef burger, grass crabs and inactivate *listeria monocytogens* in ground beef and chicken meatballs (Huang et al., 2017; Khaleque et al., 2016; Ghabarie et al., 2017).

The effects of using Chinese cinnamon powder directly into the ground lamb meat is not been reported in the previous literature to check the quality. Therefore the aim of this study was to examine the effectiveness of different concentrations of Chinese cinnamon powder on the ground lamb meat quality. For this purpose, concentrations of 0.5, 1.5 and 2.5 % Chinese cinnamon powder were added to the ground lamb meat and TVC, pH, lipid oxidation and color attributes were evaluated. Furthermore, the antioxidant activity of Chinese cinnamon aqueous extract was also measured. This study may provide potential implications in substituting synthetic antioxidants with natural ones.

2. Materials and methods

2.1 Materials and preparation of extracts

Dried bark of Chinese cinnamon was obtained from a local supermarket. Chinese cinnamon bark was divided into small pieces and grounded to powder by using a high performance kitchen grinder (High Speed Universal Grinder, Tianjin, China). The powder was sieved with the help of sieve (1.651 mm, ASTM No. 10), into 100 g packs and then stored in high-density polyethylene bags at 25℃ until its further usage. Exactly 50 g powder was refluxed by using 450 ml distilled water for 5 h in enclosed flasks with constant shaking at 100 rpm by following the method of (Sivarajan et al., 2017) to obtain a 10% w/v water extract. Then the extract was cooled and filtered twice using Whatman filter paper and used for performing the DPPH antioxidant assay.

2.2 Antioxidant activity

The DPPH-radical-scavenging activity of aqueous extracts was assessed by following the protocol of Elahi and Mu (2017). Chinese cinnamon and BHT (Butylated hydroxytoluene) at concentrations of (20, 40, 60 mg/mL) were prepared by addition of 2 mL of freshly prepared DPPH solution (0.1 mM in 95% methanol). The solution was vortexes using a mixer and incubated in dark at 27℃ for 40 min. After that, each sample absorbance was checked at 516 nm using a UV vis spectrophotometer (Shimadzu UV-1800 Spectrophotometer, Kyoto Japan) at room temperature. The radical-scavenging activity of samples were calculated in to percentage by following equation.

$$\text{DPPH-radical-scavenging activity \%} = 100 \times (1 - AE/AD)$$

where "AE" shows the absorbance of solution at 516 nm after mixing the 1 mL of all samples with 2 mL of 0.1 mmol·L^{-1} DPPH solutions and 30 min incubation at room temperature, while "AD" shows the absorbance of 2 mL 0.1 mmol·L^{-1} DPPH solutions mixed with 1 mL Milli-Q water.

2.3 Sample preparation, packaging and storage

Fresh lamb meat (*Oyster* muscles) was purchased from a local market at 24 h post-mortem and placed in insulated polystyrene ice boxes and transferred to the laboratory within 1 h. The muscles were trimmed to remove connective tissues under hygienic conditions and minced using mincer machine (8 mm plates). The minced lamb meat samples were assigned to the following four treatments: control (without any additive), 0.5%, 1.5% and 2.5% of Chinese cinnamon powder applied on the 100 g ground lamb meat. Immediately after adding the Chinese cinnamon powder samples were thoroughly hand-mixed using a bowl mixer and 100 g ground lamb meat (round shape and 1.5 cm thick) was prepared for each treatment with three replicates. The lamb meat samples were vacuum packaged (VP), properly labelled and stored at 4℃ for 16 days. After that, the samples were collected at 0 (approximately 24 h post mortem), 4, 8, 12 and 16 days of storage. The vacuum packaged samples were sealed in polyethylene bags (20/70 mm) (Vacioplast, Salamanca, Spain) with an oxygen permeability lower than 40 $cm^3/(m^2$ day atm). At the time of sampling, 10 g sample was collected immediately under aseptic conditions for microbiological analysis. While the meat color was determined after blooming for 30 min at 4℃ and then the remaining samples were frozen at -80℃ priors to TBARS analysis. The above experiment were carried out in triplicates.

2.4 Analysis of meat samples

2.4.1 pH

The pH value of ground lamb was determined by pH meter (Testo 205 pH meter, Lenzkirch, Germany). Before using, pH meter was calibrated by buffers of different pH concentrations i.e. 4.00 and 7.00 at 25℃. The glass rod of pH meter was inserted directly into the ground meat sample. Each time, four readings were recorded from different locations and averaged.

2.4.2 Color

The meat surface color was recorded using Minolta spectrophotometer (CM-600d, Konica Minolta Sensing Inc., Osaka, Japan) with 8 mm diameter measuring aperture size Illuminant D65, 10° standard observer and CIE L^*, a^*, b^* color score. Four measurements were recorded throughout the surface of selected samples (Li et al., 2017). The color of meat samples at 0 days was taken after

collecting the fresh-cut surface from the local market. At each time point the vacuumed packed samples were opened and the surface color of ground lamb meat was measured at 0, 4, 8, 12 and 16 days after 30 min of blooming at 4℃.

2.4.3 Lipid oxidation

Lipid oxidation analysis was conducted with minor modification by following the method described by Belles et al., (2017). Briefly, 20 ml of 10% tricloracetic acid (VWR) was mixed with 10 g of meat and homogenized at 2000 rpm by using ultraturrax for 90 s (T-10 basic, IKA-WERKE, Staufen, Alemania). Then the samples were centrifuged for 30 min at 10℃ at 4000 rpm (High-Speed Refrigerated Centrifuge, CR 21N, HITACHI, Tokyo, Japan). The supernatant was filtered by using filter paper and 2 ml of the filtrate was added with the equal quantity of TBA 20 mM (Sigma-Aldrich, St. Louis, Missouri, United States). After that, the mixture was vortexed and incubated in a water-bath at 97℃ for 20 min. At the end, samples were cooled under tap water at ambient temperature of 15℃ and absorbance was measured at 532 nm by using spectrophotometer (Shimadzu UV-1800 Spectrophotometer, Kyoto Japan). The TBARS, mainly malondialdehyde (MDA), was calculated from a standard curve of 1, 1, 3, 3 tetraethoxypropane (TEP) (Sigma-Aldrich), the lipid oxidation was expressed as the average of three replicates per sample in mg malondialdehyde/kg meat.

2.4.5 Microbiological analysis

TVC were inspected based on standard plate count method following the protocols of Zhang et al. (2016). In brief, 10 g sample was taken aseptically from vacuumed bags and homogenized in 90 ml of sterile physiological saline in stomacher bags for 1 minute. For microbial enumeration suitable serial dilutions were prepared using the same diluent, by following the protocol of International Organization for Standardization's (ISO, 2003). Then the deriving suspension was serially diluted (1:10) in sterile physiological saline water and 1 ml samples of appropriate dilutions were poured containing 15-20 ml of plates count agar (PCA) in the petridishes. The number of bacterial colonies on the plates were enumerated after incubation for 48 h at 37℃ and expressed as log CFU (colony forming units)/g meat.

2.5 Statistical analysis

The experiment was designed with Chinese cinnamon treatments and storage times as fixed factors and replicates as random factor. General linear model (GLM) was used to express the significance of differences ($p<0.05$) between means. Statistical analysis of data was performed using the IBM

statistical package for social sciences (SPSS) Statistics 22 software (SPSS Inc., Chicago, IL, USA). Duncan multiple range test was applied to determine the significant difference ($p<0.05$). The data were expressed as the mean ± standard deviation. Experiments were replicated three times and all parametric measurements were carried out in duplicate.

3 Results and discussion

3.4 Antioxidant activity

The DPPH radical scavenging activity of Chinese cinnamon aqueous extract at the concentrations of 20, 40 and 60 mg/ml were considerably ($p<0.05$) lower than the pure antioxidant BHT as shown in Fig 1. The Chinese cinnamon aqueous extract showed strong antioxidant activity in all concentrations but the highest antioxidant activity was seen in 60 mg/ml indicating the highest radical scavenging activity ($p<0.05$).

Previously reported studies have confirmed that cinnamon is distinguished by its effective radical scavenging activity due to bioactive substances (Radha et al., 2014). The higher antioxidant activity in cinnamon might be due to the presence of significant amount of phenolic antioxidants and flavonoids compound (Jayaprakasha et al., 2007). Kuspradini et al. (2016) reported that cinnamon aqueous extract as well as cinnamon oil, have shown considerable antioxidant activity. Babuskin et al. (2015) claimed that cinnamaldehyde was responsible compound in the cinnamon for its high antioxidant activity.

3.5 pH

The results of adding Chinese cinnamon powder on the pH of ground lamb meat stored at 4°C were presented in Table 1. The pH of control increased from day 12 to 16 than those of all other treatments samples during storage. The pH for all samples was same at day 0, while at day 4 the pH value of samples stored adding 1.5% Chinese cinnamon powder was significantly lower ($p<0.05$) than those of control and the other treatments samples. The pH values of samples stored under control and 0.5% treated samples were not significantly different on day 8, whereas the stored samples 1.5% and 2.5% showed a significant difference ($p<0.05$) compared with control. With the increase of storage days, the samples stored under 2.5% showed lower pH values at day 12 and 16 than control and other treated samples ($p<0.05$). Overall the pH of samples stored under control was higher ($p<0.05$) at day 12 and 16 than other treatment samples during the storage.

The increment in the pH of sample stored under control group during the storage might be the generation of some basic compounds and ammonia caused by proteolysis resulting from the

growth of microorganism (Chaijan et al., 2005; Masniyom et al., 2002). It has been reported in previous literature that addition of antioxidant might decrease the pH of treated samples. Kesavan et al. (2014) and Brilliana et al. (2017) investigated that during refrigerated storage the lower pH was noted in the raw beef meat samples treated with cinnamon oil than control. In the present study the lower pH in the treatment samples might be due to the strong activity of bioactive compounds present in the Chinese cinnamon powder.

3.6 Color

The L^*, a^* and b^* of Chinese cinnamon powder treated and untreated ground lamb meat samples stored at 4°C were presented in Table 2. The obtained data showed that L^* (lightness) value of samples stored under control was significantly ($p<0.05$) higher throughout the storage compared with other treatments. Among all Chinese cinnamon treated samples, the lower L^* values were noted in stored samples 2.5% treatment in all storage days except day 8 ($p<0.05$). By the addition of Chinese cinnamon powder directly into the ground lamb may decrease the lightness of treated samples. The a^* (redness) value of ground lamb was also affected by the addition of Chinese cinnamon powder during storage as shown in Table 2. The a^* value of samples stored under control showed decreasing trend throughout the storage as compared to Chinese cinnamon treated stored samples. The a^* values in all Chinese cinnamon treated samples and control were significantly different from each other on day 0 ($p<0.05$). The a^* values for samples stored under control and 0.5% treatment were significantly higher at day 4 than those of samples stored under 1.5% and 2.5% treatments. At day 8 the a^* value of control samples was considerably higher ($p<0.05$) than treated samples 0.5% and 2.5%, while no significant difference was noted in samples stored under 1.5% treatment. As the days proceeded, at day 12 there were no significant differences between control and all other Chinese cinnamon treated samples. The a^* value for samples stored under control was lower than those of treated samples 1.5% at day 16, while no significant differences were found with samples stored under 0.5% and 2.5% ($p<0.05$).

The b^* (yellowness) value for control was higher at initial day than the samples stored under 1.5% and 2.5% ($p<0.05$), while no significant difference was noted in stored samples for 1.5% treatment. Whereas on day 4 and 8 the only significant difference was noticed between control and 2.5% treatment group than the samples stored under 0.5% and 1.5%. The b^* values for all stored samples included control and other Chinese cinnamon treated samples had no significant difference ($p<0.05$) after day 12 to 16 during storage.

It has been proved that the meat discoloration is directly related with the storage length, and a^* tended to decrease with the increase of storage time (Terns et al., 2011) that might be possibly associated with an increase in TBARS (Grimsrud et al., 2008). Previous results confirmed that the addition of natural antioxidants may slow down the formation of metmyoglobin, ultimately delaying the deterioration of red color (Xia et al., 2009; Belles et al., 2017). Keokamnerd et al. (2008) observed that a^* value was reduced in the minced chicken after 12 days of storage. The lessening in the intensity of redness values during storage was probably due to the relationship between lipid oxidation and color oxidation in the meat (Lynch & Faustman, 2000). In the current study the fluctuations in the a^* values were observed in all samples during the storage. The results are in accordance with the previous findings (Ozunlu et al., 2018; Zhang et al., 2016). The variation in the a^* values might be due the MetMb% formation which can lead to the discoloration of the fresh meat (Krala, 2001).

3.7 Lipid oxidation

The oxidative stability of the samples stored under control and other treatments was evaluated throughout the storage by determining the thiobarbituric acid reactive substances (TBARS) as shown in Figure 2. The TBARS value was continuously increased in the samples stored under control during the storage duration ($p<0.05$). Whereas, the stored samples treated with Chinese cinnamon retarded the TBARS values during the storage intervals. The TBARS for the samples stored under control was notably higher after day 4 to 16 than those of Chinese cinnamon treated samples ($p<0.05$). Whereas, among all treatments, the samples stored under 2.5% exhibited the lower TBARS values after day 8 to 16 ($p<0.05$). The TBARS value for the control was significantly ($p<0.05$) higher at day 16 than those of Chinese cinnamon treated samples. The results suggested that Chinese cinnamon powder was effective against the TBARS formation in the ground lamb during storage.

The cinnamon contains active compounds leading to antioxidant and antibacterial actions in meat (Madsen & Bertelsen, 1995). Previous studies reported that the rapid increase in oxidation of control samples in the rainbow trout was due to non-availability of anti-oxidants (Shadman et al., 2017). The findings of present study agreed with the results of Shaltout et al. (2017), who also observed that the addition of cinnamon oil on the beef delayed lipid oxidation during storage. Thus the reduction of TBARS in Chinese cinnamon treated samples may be due to the presence of

antioxidant compounds like cinnamaldehyde, eugenol and cinnamic acid (Dudonne et al., 2009). These antioxidants compounds may be useful against free radical damage (Dragland et al., 2003).

3.8 Microbiological analysis

The effect of Chinese cinnamon powder on the TVC of ground lamb meat stored at 4℃ for 16 days were presented in Figure 3. The TVC in the control sample was increased immediately and rapidly than other samples treated by Chinese cinnamon powder. At initial day there was no significant difference between the samples stored in control and other treated samples. The TVC in control was significantly increased ($p<0.05$) with the increment of time points at day 4 and crossed the limit of 7 log CFU/g at 16 days, while the treated samples retarded the growth of TVC. During the whole period of storage, the samples stored under 1.5% showed significantly ($p<0.05$) lower TVC values at days 8 and 16, and lowest enumeration were counted at day 8. From the obtained results, it was revealed that TVC in the ground lamb meat may be inhibited by the addition of Chinese cinnamon powder ($p<0.05$).

It has been reported that, cinnamon inhibited microbes by several ways like rapture of cell wall by the action antioxidant compounds, disorder the cytoplasmic membrane, cellular components disturbance by leakage, changed fatty acid and phospholipid constituents, affect the DNA and RNA formation and destroy protein translocation (Bajpai et al., 2013). Comparable results were obtained by Gutierrez et al. (2008) where it was reported that the addition of cinnamon oil were more effective in decreasing the microbial counts in the food ingridients. In another study cinnamon bark has been proved as a potential source against all pathogenic and spoilage bacteria (Ghabraie et al., 2016). Shaltout et al. (2017) observed that the incorporation of cinnamon oil was more efficient in maintaining meat quality. The reduction in the TVC during storage might be due to the presence of bioactive compounds present in the Chinese cinnamon powder.

4 Conclusions

In conclusion, Chinese cinnamon powder could maintain the quality of ground lamb meat by reducing the TVC and TBARS. The L^* and a^* values in the ground lamb meat can be affected by adding the Chinese cinnamon powder higher than 0.5% during the storage. The results of the present study suggested that Chinese cinnamon powder at a level of 0.5% has the potential to maintain the ground lamb meat quality during storage. So it could be proposed as a natural alternative of synthetic additives to maintain the meat quality.

Conflict interest

The authors declare no potential conflict of interest.

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Figure legends

Fig. 1. The DPPH radical scavenging activity (%) of aqueous extract of Chinese cinnamon powder and BHT. $^{A-B}$ Different letters indicated a significant difference ($p<0.05$) between the same concentrations of Chinese cinnamon aqueous extract and BHT.

Fig. 2. Effect of different concentrations of Chinese cinnamon powder on the TBARS values of vacuumed ground lamb meat stored at 4°C. Different markers shows mean values while the bars indicated standard deviations at each sampling point (n = 3). $^{A-D}$ Mean with different letters indicated changes between treatments differ significantly ($p<0.05$); $^{a-d}$ Mean with different letters showed changes during storage differ significantly ($p<0.05$).

Fig. 3. Effect of different concentrations of Chinese cinnamon powder on the TVC values of vacuumed ground lamb meat stored at 4°C. Different markers shows mean values while the bars indicated standard deviations at each sampling point (n = 3). $^{A-D}$ Mean with different letters indicated changes between treatments differ significantly ($p<0.05$); $^{a-d}$ Mean with different letters showed changes during storage differ significantly ($p<0.05$).

Table 1. Effect of different concentrations of Chinese cinnamon powder on the pH of vacuumed ground lamb meat at 4℃.

Treatments	Storage time (days)				
	0	**4**	**8**	**12**	**16**
Control	5.62 ± 0.03^{Ab}	5.57 ± 0.01^{ABbc}	5.46 ± 0.01^{Ac}	5.67 ± 0.03^{Ab}	5.80 ± 0.03^{Aa}
0.5 %	5.64 ± 0.02^{Aa}	5.54 ± 0.02^{Bb}	5.40 ± 0.03^{ABd}	5.45 ± 0.04^{Bc}	5.48 ± 0.03^{Bc}
1.5 %	5.62 ± 0.03^{Aa}	5.49 ± 0.03^{Cb}	5.42 ± 0.04^{Bb}	5.42 ± 0.03^{Bb}	5.48 ± 0.03^{Bb}
2.5 %	5.60 ± 0.04^{Aa}	5.60 ± 0.04^{Aa}	5.36 ± 0.03^{Bb}	5.38 ± 0.01^{Cb}	5.35 ± 0.04^{Cb}

Results are presented as means ± standard deviation (n = 3). $^{A–D}$ Mean values in different capital letters within the same column differ significantly; $^{a–d}$ Mean values in different small letters within the same row differ significantly ($p<0.05$).

Table 2. Effect of different concentrations of Chinese cinnamon powder on instrumental color parameters (CIE L^*, a^*, b^*) of vacuumed ground lamb meat at 4℃.

Parameters	Treatments	Storage time (days)				
		0	4	8	12	16
L^* (Lightness)	**Control**	53.06 ± 0.79^{Aa}	52.76 ± 0.73^{Aab}	51.80 ± 0.87^{Aab}	51.24 ± 0.70^{Aab}	50.98 ± 1.88^{Ab}
	0.5 %	47.02 ± 0.40^{Bb}	48.37 ± 1.67^{Bab}	49.25 ± 1.61^{Ba}	49.25 ± 0.62^{Ba}	48.20 ± 0.56^{Bab}
	1.5 %	45.77 ± 0.72^{Cb}	45.11 ± 0.94^{Cb}	44.44 ± 0.77^{Cb}	47.39 ± 0.99^{Ca}	46.20 ± 1.80^{Bab}
	2.5 %	41.67 ± 0.49^{Db}	42.03 ± 0.79^{Dab}	43.55 ± 0.88^{Ca}	42.31 ± 0.90^{Dab}	41.76 ± 1.68^{Cb}
a^* (Redness)	**Control**	16.87 ± 0.35^{Aa}	15.42 ± 0.73^{Aab}	14.06 ± 1.05^{Ab}	13.86 ± 1.12^{ABb}	12.20 ± 0.66^{Bc}
	0.5 %	15.63 ± 0.48^{Ba}	14.81 ± 0.47^{Aab}	13.42 ± 0.81^{BCb}	13.08 ± 0.75^{Bb}	13.21 ± 0.70^{ABb}
	1.5 %	12.14 ± 0.52^{Db}	12.21 ± 0.89^{Bb}	13.37 ± 0.38^{ABab}	14.16 ± 0.57^{Aa}	13.64 ± 1.09^{Aa}
	2.5 %	13.26 ± 0.18^{Cab}	12.55 ± 0.16^{Bab}	11.91 ± 0.28^{Cb}	13.45 ± 1.10^{ABa}	12.46 ± 1.18^{ABab}
b^* (Yellowness)	**Control**	19.31 ± 1.20^{Aa}	15.34 ± 1.34^{Ac}	17.33 ± 1.48^{Ab}	16.61 ± 1.07^{Ab}	16.11 ± 0.62^{Ab}
	0.5 %	17.87 ± 0.54^{ABa}	15.11 ± 1.15^{Ab}	17.27 ± 0.67^{Aa}	16.27 ± 0.67^{Aa}	16.50 ± 0.95^{Aab}
	1.5 %	17.31 ± 1.02^{Ba}	14.66 ± 0.73^{Ab}	16.29 ± 0.59^{ABa}	16.36 ± 0.78^{Aa}	16.50 ± 0.31^{Aa}
	2.5 %	15.31 ± 0.78^{Cb}	13.81 ± 0.45^{Bc}	15.48 ± 0.68^{Bb}	16.07 ± 0.61^{Aa}	16.20 ± 0.76^{Aab}

Results are presented as means ± standard deviation (n = 3). $^{A-D}$ Mean values in different letters within the same column differ significantly; $^{a-d}$ Mean values in different letters within the same row are differ significantly ($p<0.05$).

Fig. 1

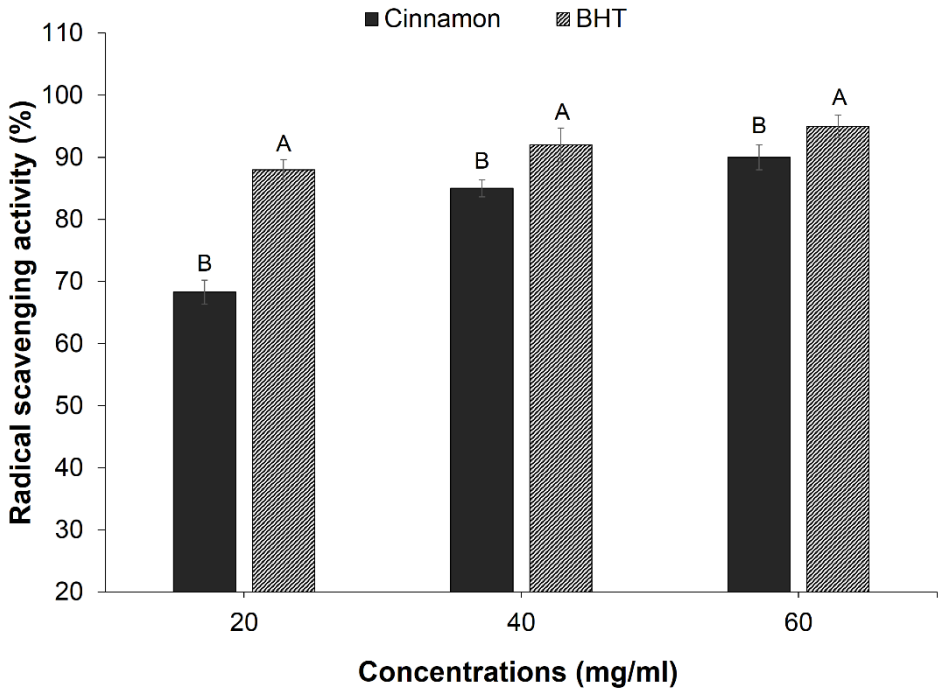

Fig. 2

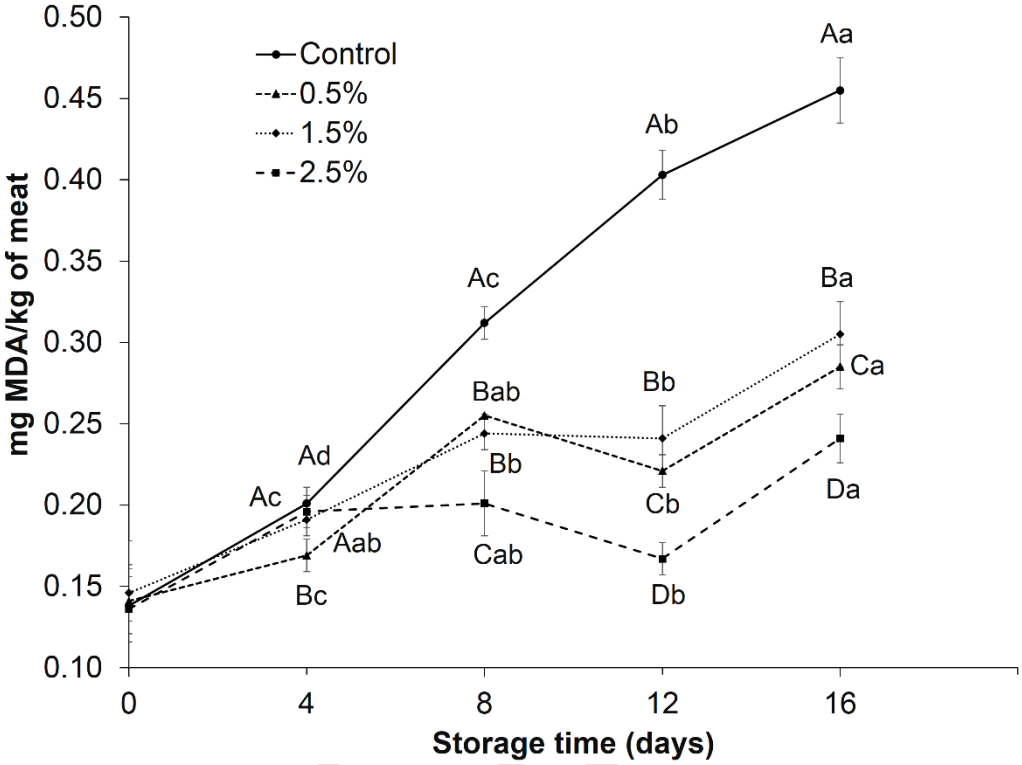

Fig. 3