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Effect of cinnamon and coriander extracts on oxidative stability and antimicrobial perspectives of cooked beef patties

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Abstract

The current study aimed to improve the shelf life of beef patties prepared with different concentrations of cinnamon and coriander extracts. Purposely, Aqueous-alcoholic extract of cinnamon and coriander was obtained and incorporated in beef patties. Furthermore, the beef patties were subjected to physicochemical and microbial analysis. Addition of cinnamon and coriander extracts significantly increase the nutritional profile of beef patties and reduce the microbial activity. The results showed that the total phenolic content of Cinnamon and Coriander at 1% concentration had the highest value 0.89mg GAE/g and 0.57mg GAE/g, respectively, while patties containing 1% extract contain phenolics for Cinnamon and Coriander as 0.48-0.36 and 0.3-0.21mg GAE/g respectively. Moreover, these treatments also established better scavenging capacity (DPPH) in beef patties. Furthermore, a significant Ferric reducing antioxidant power (FRAP) was observed in beef patties (T_1=6.8-5.8 mmol Trolox eq./kg and T_3=5.5-4.8 mmol Trolox eq./kg). Cinnamon and Coriander at 1% concentration significantly hindered the lipid oxidation during the entire storage interval rather than other treatments whereas total carbonyl (Protein oxidation) was significantly higher in the control sample (0.56-1.79 nmol/mg). Conclusively, among all the treatments T_1 (cinnamon 1%) showed better antioxidant activity and reduced microbial activity.

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Introduction

Meat is the flesh of an animal comprised of protein, minerals, lipids and a lesser amount of carbohydrates. The plenteous nutritional profile of meat and its products make it nonresistant to quality impairment (Devatkal *et al.,* 2014), which often leads to microbial and chemical alterations. Oxidation, the addition of oxygen, is the most common part of the quality decline as it is a composite procedure mainly relies on the processing of meat, light exposure, oxygen and temperature of storage (Karakaya *et al.,* 2011). One of the pivotal causes of the quality decline of meat and its products are associated with lipoprotein oxidation. Oxidative deterioration and microbial spoilage in meat cause the change in colour, generation of off-flavour and foul smell, production of potentially noxious compounds such as peroxy radicals, cholesterol hydroperoxides, and fatty acid peroxides, also drip losses, nutrient and economic losses (Contini *et al.,* 2014).

The application of antioxidants in meat and meat products is an effective way to control and minimize the lipoprotein oxidation as well as microbial growth. Synthetic antioxidants, such as butylated hydroxytoluene (BHT), tert-butyl hydroquinone (TBHQ), butylated hydroxyanisole (BHA) and propyl gallate (PG) may be hazardous for consumers (Biswas *et al.,* 2004; Zhang *et al.,* 2016). The meat industry is increasingly seeking natural solutions to minimize oxidative rancidity and extend the shelf-life of meat products rather than artificial additives. During the last decade, the demand for naturally occurring antioxidants has been increased vastly because of the toxicological effects of synthetic antioxidants and lead to a search for new naturally occurring antioxidants. Natural compounds that act as antioxidants are incurred from the plants such as fruits, vegetables, herbs and spices are investigated to hinder the microbial activity, growth and possess the preservative properties, and lower the lipid oxidation in meat and its products (Akarpat *et al.,* 2008).

Cinnamon is one of the very frequently used spices in many countries since ancient time. It is often added to food for better taste and aroma of food. Its availability along the year makes it further popular. Cinnamon also has shown promising activity in this field. Cinnamon has been reported to be possessing potent antioxidant activity comparable to that of synthetic antioxidants with anticipating potentials to improve the oxidative stability of foods (Singh *et al.,* 2007; Chan *et al.,* 2012).

Antioxidants including extracts obtained from plants, particularly coriander (*Coriandrum sativum* L.) inhibit lipid peroxidation (Delaquis *et al.,* 2002; Wangensteen *et al.,* 2004). Bhattacharyya (2011) reported considerable antioxidant activity in coriander extracts. Hanaa (2009) demonstrated that freeze-dried hydro-distilled extract of coriander have antioxidant capacity.

The present study addressed the utilization of economic plant-based foods such as Cinnamon and coriander as sources of natural antioxidants. The major objective of this study was to evaluate the antioxidant activity of extracts from cinnamon and coriander. Moreover, the effectiveness of plant nutrients presents in extracts in maintaining total phenolic content, radical scavenging activity, reducing power, and preventing or reducing lipid oxidation, protein oxidation, microbial-stability, rancid odour and colour changes of beef patties stored at 4°C was also studied.

Materials and methods

Raw material

The raw material was purchased from the local market of Faisalabad and all chemicals were of analytical grade (Merck Germany) and (Sigma Aldrich).

Preparation of crude extract

The extraction of Cinnamon and Coriander was done by the method adopted by (Fezea *et al.,* 2015). In brief, Methanol, ethanol and water were taken in equal quantity as a solvent. Cinnamon and coriander were added separately in the solvents with 1:10 solid to solvent ratio. Extraction was carried out on

900rpm and kept at 40°C kept in the dark for 24 hours. The extract was filtered with filter paper Whatman no. 4 and residue were again placed for the further extraction. The extract obtained from the extraction kept at freezing temperature until the further studies.

Preparation of beef patties

Beef patties were prepared by the method describe by (Elhadi *et al.,* 2017) with some changing in the formulation. Briefly, the mixture made from the meat and spices was divided into the portions of 50 grams and extracts were added in each portion accordingly.

Total phenolic content

Total phenolic content of cinnamon and coriander extracts of different concentrations were measured by the standard method given by Singleton and Rossi (1965). Briefly, in 2.5 ml folin reagent, 0.5 ml sample was added with 1:10 and kept for 4 minutes. 2ml sodium carbonate solution (75g/L) was added and kept for 2 hours at room temperature. The absorbance was measured at 760 nm. In the patties, total phenolic content was measured by the protocol described by (Escarpa and González, 2001). Briefly, 5g patties were mixed with acetone (25 ml, 70%) and extracted overnight at refrigerated temperature. 0.5 ml volume of the obtained extract was made with distilled water. 1N, 0.25 ml folin reagent and 20%, 1.25 ml sodium carbonate were added to above mixture. Absorbance was recorded at 725 nm.

DPPH assay

The free radical scavenging ability of the extracts was evaluated by the procedure described by Yen and Chen (1995). Briefly, 2ml fraction from the test sample taken in methanol and added to 2ml of 0.16 mM DPPH. The mixture was vortexed for 60 seconds and kept in the dark for 30 minutes. Absorbance was recorded at 517 nm.

Ferric reducing antioxidant power (FRAP)

The ferric ions (Fe^{3+}) reducing antioxidant power (FRAP) method (Benzie and Strain, 1996) was used to measure the reducing capacity of extracts with a slight modification, which involves the presence of extracts to reduce the ferricyanide complex to the ferrous form. Briefly, FRAP solution was prepared in 300 mM sodium acetate buffer by adding diluted 10 mM TPTZ and 20 mM ferric chloride in the aforementioned buffer solution with 10:1:1. TPTZ-Fe^{2+} was recorded at 595 nm. Results were expressed in mmol Trolox Eq. / kg meat.

TBARS (Lipid Oxidation)

Lipid oxidation of beef patties was determined by measuring thiobarbituric acid-reactive substances (TBARS) mg MDA/kg by witte *et al.*(1970). With slight changes.

Total carbonyl (Protein Oxidation)

Protein oxidation was measured by the method described by Salminen *et al.* (2006).

Microbial analysis

In the microbial analysis, standard plate count was performed with the standard method adopted by Singh *et al.* (2014).

Colour determination

Using a Hunter colorimeter with measurements standardized the surface colour value of the samples was performed.

The colour CIE L* (lightness), a* (redness) and b* (yellowness) values were obtained using an average value from 5 random readings on each sample surface for statistical analysis.

Sensory analysis

The sensory of the product was done by the semi-trained judges on the basis of colour and odor. The judges were students and staff members including male and female of different age groups (Trindade *et al.,* 2009).

Statistical analysis

Results obtained from the study were analyzed statistically by applying (ANOVA) and LSD using Statistix 8.1 according to Stell *et al.* (1980).

Results and discussion

Total phenolic content in extracts

Results indicated that cinnamon 1% (0.89 mg GAE/g) had significantly ($p<0.05$) increase amount of total phenolic content followed by coriander 1%(0.57 mg GAE/g), cinnamon 0.5% (0.41 mg GAE/g) and coriander 0.5% (0.25 mg GAE/g) (Fig. 1).

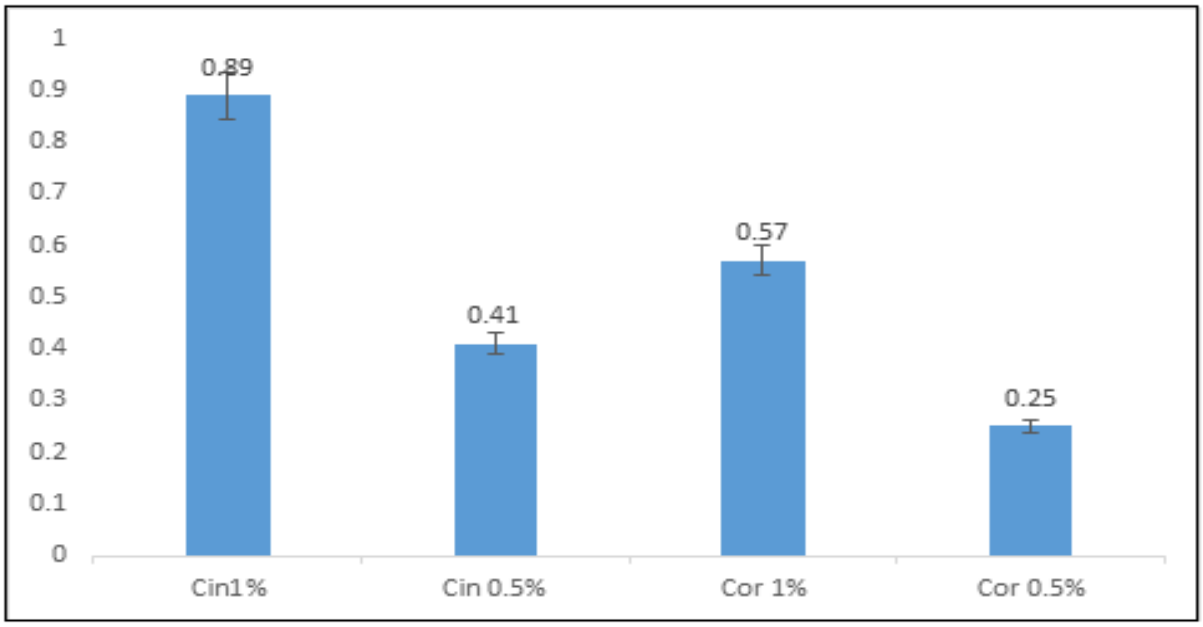

Fig. 1. Total phenolic content in cinnamon and coriander extracts (0.5%, 1%).

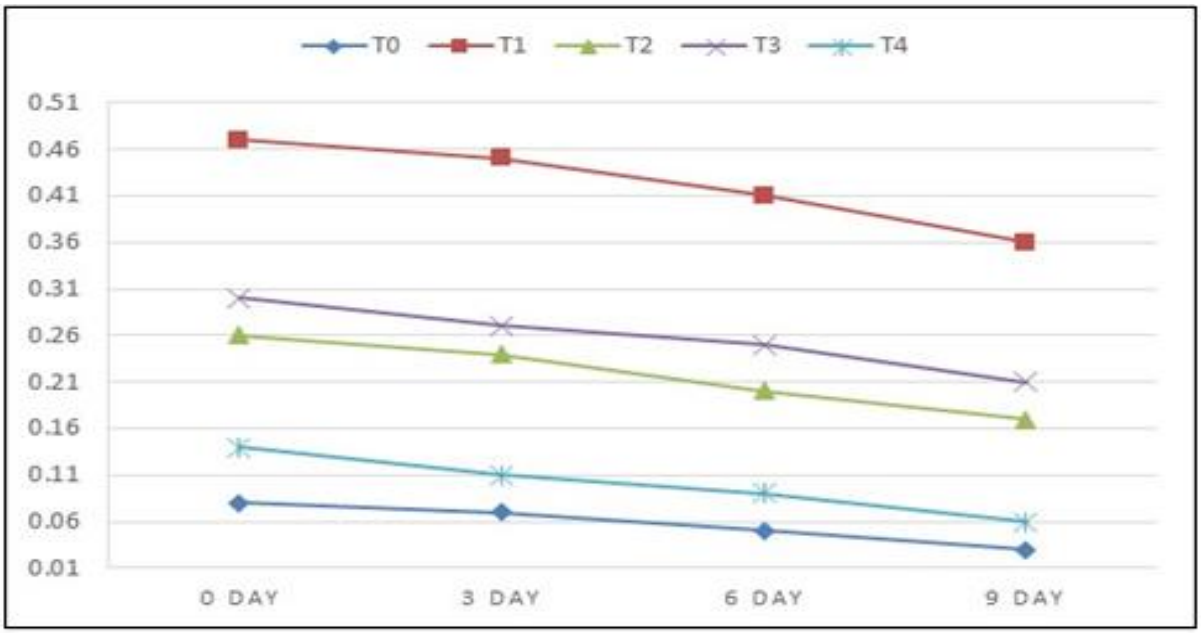

Fig. 2. Effect of different concentrations of Cinnamon and Coriander extracts on Total phenolic content (mg GAE/g) of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

T_1 significantly showed ($p < 0.05$) higher values of TPC throughout storage as compared to T_3, T_2, T_4 and T_0. The values were ranged from 0.48±.02 to .08±.002 on the first day of storage and 0.36±0.018 to 0.03±.001 at the end of storage. Results obtained from the current study indicated that the addition of natural extracts enhanced the phenolic content of end products. Verma *et al.* (2013) revealed that the

addition of guava powder in meat enhanced the total phenolic content of meat products. Similarly, Das *et al.* (2016) claimed that lychee pericarp extracts significantly increase the total phenolic content of nuggets.

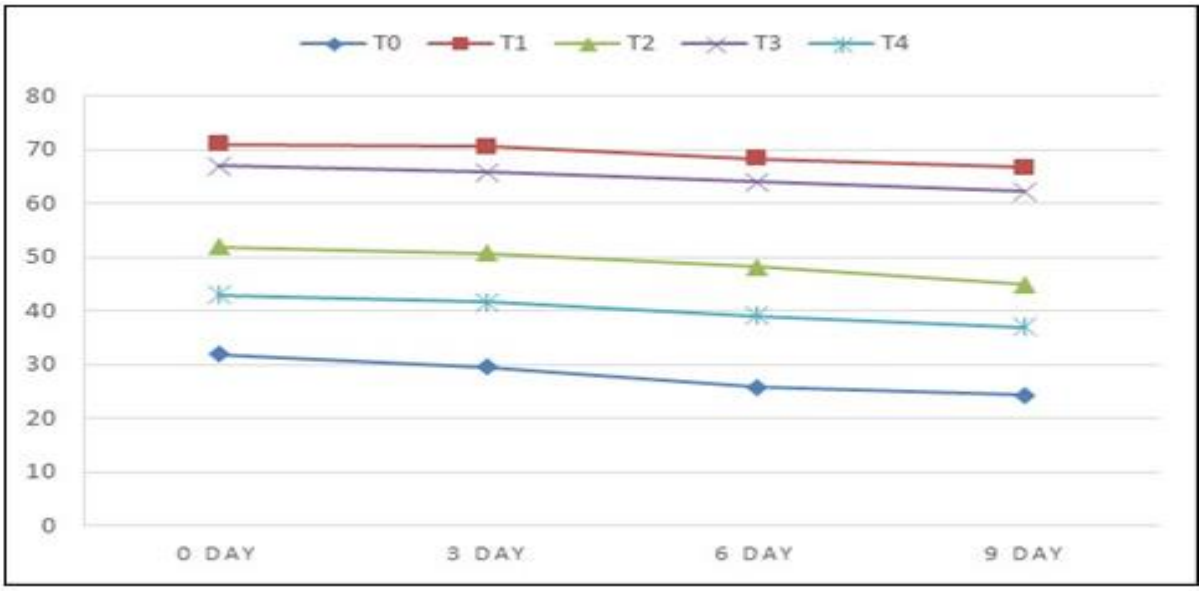

Fig. 3. Effect of different concentrations of Cinnamon and Coriander extracts on radical scavenging activity (DPPH %) of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

DPPH radical scavenging activity

Scavenging capacity of T_1 was relatively higher (71%) at the first day of storage (0 days) followed by T_3 (67%), T_2 (52%), T_4 (43%) and T_0 (32%), and at the end of storage (9th day), T_1 (66.3%), T_3 (62.2%), T_2 (45%), T_4 (37%) and T_0 (24.3%) (Fig. 3). Scavenging activity of T_1 remained the highest throughout the storage period as compared to other treatments ($p<0.05$). However, the scavenging activity of T_0 remained lower throughout the storage.

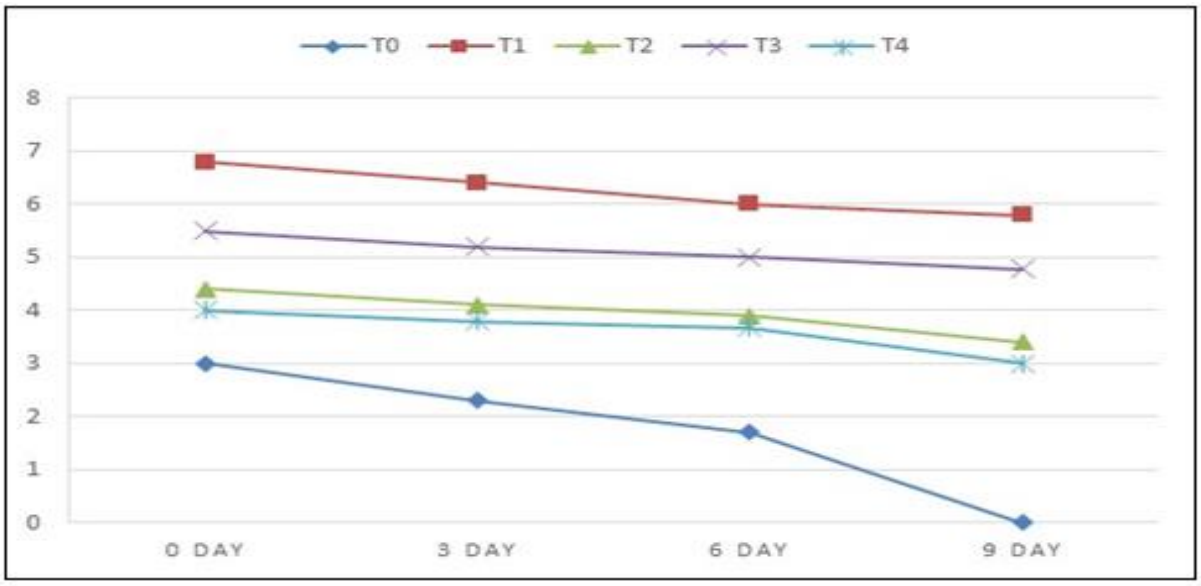

Fig. 4. Effect of different concentrations of Cinnamon and Coriander extracts on reducing power (FRAP mmol Trolox eq./kg) of Beef patties(T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

In the current investigations, scavenging activity was found to be concentration-dependent, by increasing the concentration of extracts in patties scavenging activity was increased. This study clearly indicated that phytonutrients are a major contributor to antioxidant activity. This finding is consistent with previous research reported by Fu *et al.* (2010). Moreover, scavenging activity is positively correlated with the phenolic compounds present in plant sources (Robards *et al.,* 1999; Li *et al.,* 2012).

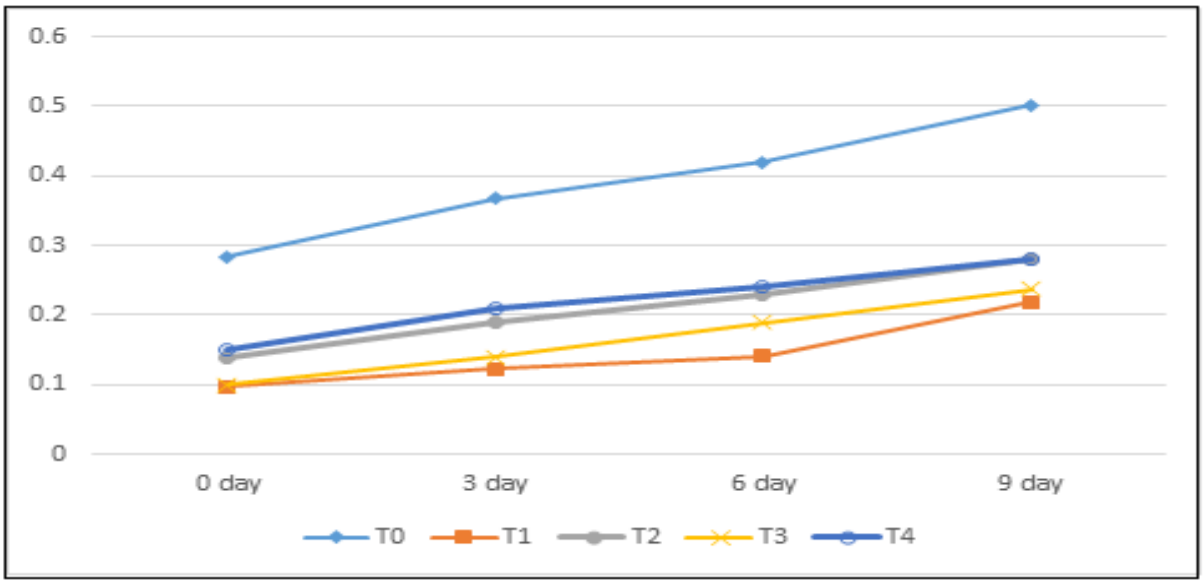

Fig. 5. Effect of different concentrations of Cinnamon and Coriander extracts on TBARS (mg MDA/kg) value Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

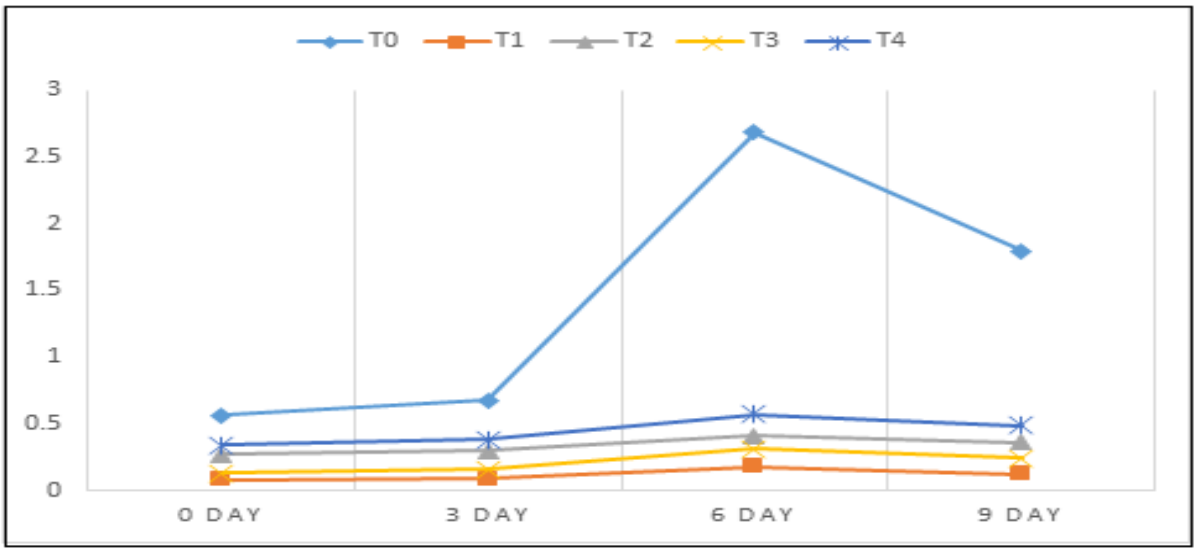

Fig. 6. Effect of different concentrations of Cinnamon and Coriander extracts on formation of protein carbonyl compounds (nmol/mg protein) in Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

FRAP

Reducing power of beef patties ranged from (6.8 mmol Trolox Eq./kg to 3 mmol Trolox Eq./kg) at the 1st day of storage and (3 mmol Trolox Eq./kg to 0 mmol Trolox Eq./kg) at the last day of storage (9th day) (Fig. 4). However, T_1 and T_3 produced a significant ($p<0.05$) reduction throughout the storage. Moreover, T_0 produced significantly lower reduction than treated samples. T_2 and T_4 produced also showed a poor reduction, such behaviour might

be attributed to the poor ability of antioxidants present in these treatments or the number of antioxidants present in T_2 and T_4 was unable to neutralize oxidants. Many studies have demonstrated that phytonutrients present in natural extracts play a pivotal role in the neutralization of free radicals (Sultana *et al.,* 2017).

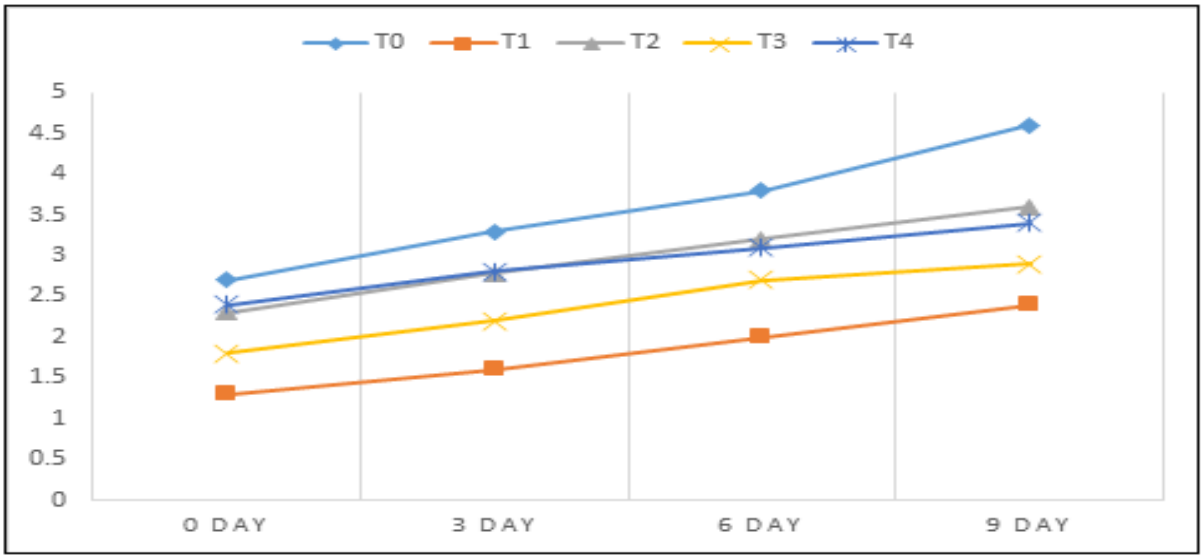

Fig. 7. Effect of different concentrations of Cinnamon and Coriander extracts on Standard plate count values of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

TBARS (Lipid oxidation)

The TBARS value of the beef patties ranged from 0.09±0.004 to 0.28±0.014 mg MDA/kg at day 1 which gradually increases and at the 9th day the values ranged from 0.23±0.01 to 0.502±0.03 mg MDA/kg. An increase in the TBARS values indicated the initiation and progression of the lipid oxidation. Although TBARS values of beef patties with different concentrations of cinnamon and coriander extracts were significantly ($p < 0.05$) lower during the whole span of storage at a refrigerated temperature as compared to the control as depicted in the Fig. 5. However, a significant increase in the T_0 (0.5 mg MDA/KG) was noted on the 9th day of storage.

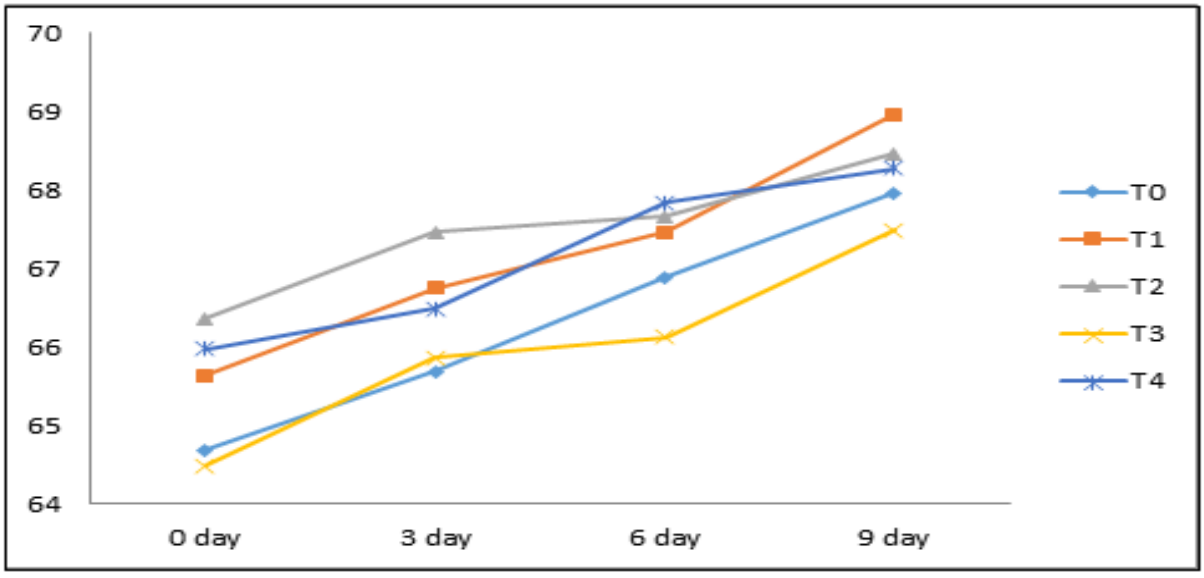

Fig. 8. Effect of different concentrations of Cinnamon and Coriander extracts on Degree of lightness (L*) of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

The results of the present study were parallel to Chan *et al.* (2014), in which they observed a significant increase in the control sample as compared to the treated samples. Another study was conducted by Marangoni and Moura (2011) in which coriander possessed strong antioxidant activity in order to inhibit TBARS value in complex meat products.

Protein Oxidation (Total Carbonyl)

The initial level of protein oxidation was 0.57 nmol/mg observed in the T_0 while in all treated samples, carbonyl content ranged from 0.08 to 0.34 nmol/mg (Fig. 6). In the first 6 days of storage, protein carbonyls content was upsurge and reached to the maximum level which was approximately 5.7 folds compared to the initial level in the control sample. Among other treatments, the basal level of carbonyl groups (3 nmol/mg protein) has been reported in fresh beef meat (Martinaud *et al.,* 1997; Mercier *et al.,* 2004). Also, in different oxidation systems, a slight decline of the carbonyl groups was already observed after a long incubation (Batifoulier *et al.,* 2002; Mercier *et al.,* 2004) which is in line with our results. The present results are in accordance with Vuorela *et al.* (2005) who applied pine bark and rapeseed extracts on pork beef patties and found a direct relationship of lipid and protein oxidation. Moreover, they claimed that rapeseed and pine bark extract retard the lipid and protein oxidation found that lipid oxidation has a direct relationship with the production of protein carbonyls. They also expounded that the use of rapeseed and pine bark phenols inhibited the lipid and protein oxidation in pork meat patties.

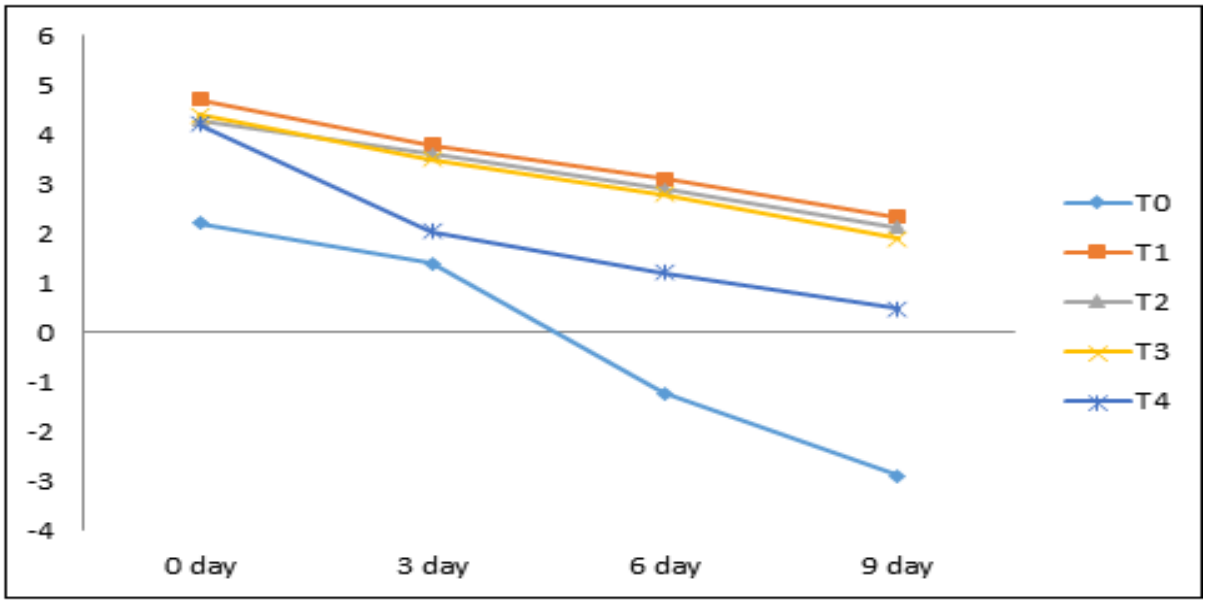

Fig. 9. Effect of different concentrations of Cinnamon and Coriander extracts on Degree of Redness (a*) of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

Standard plate count

The standard plate count values of all treatments ranged between 1.3 to 2.7 log cfu g^{-1}on 0^{th} day of storage which increased significantly to 4.6 log cfu g^{-1} in control samples (T_0), 2.4 cfu g^{-1}in T_1, 3.6 log cfu g^{-1} in T_2, 2.9 log cfu g^{-1} in T_3 and 3.4 log cfu g^{-1} on the 9^{th} day of storage respectively as depicted in the Fig. 7. Among all treatments, the standard plate count value of the T_1 was found to be the lowest followed by T_3, T_4, T_2 and control which could be attributed to the high antimicrobial activity of the extracts at this concentration level. In a previously conducted study, Bhattacharyya (2011) noted a considerable decrease in total plate count in meat products by adding coriander extract. Todd *et al.* (2013), Mith *et al.* (2014), and Brnawi *et al.* (2019) reported in their studies that Cinnamon has a strong antibacterial effect against these pathogens at different concentration levels. Grohs and Kunz (2000) concluded that coriander inhibited the growth of

many meat spoiling pathogens when applied along with spice mixture. Thus, Cinnamon and Coriander have strong bactericidal activity against *E. coli* and *Salmonella*.

Color determination

Inductive work with the interpretation of instrumental color in all samples showed the non-significant difference during the entire storage as illustrated in Fig. 8. However, a slight reduction was observed in T_2 and T_3. Possibly, it was due to the incorporation of cinnamon and coriander extracts which caused a decline in the lightness of beef patties because of brown and green color of extracts. Yogesh and Ali (2014) also detected the decrease in the degree of lightness after addition of thuja cone and peach seed extracts in meat products which are in agreement with current results.

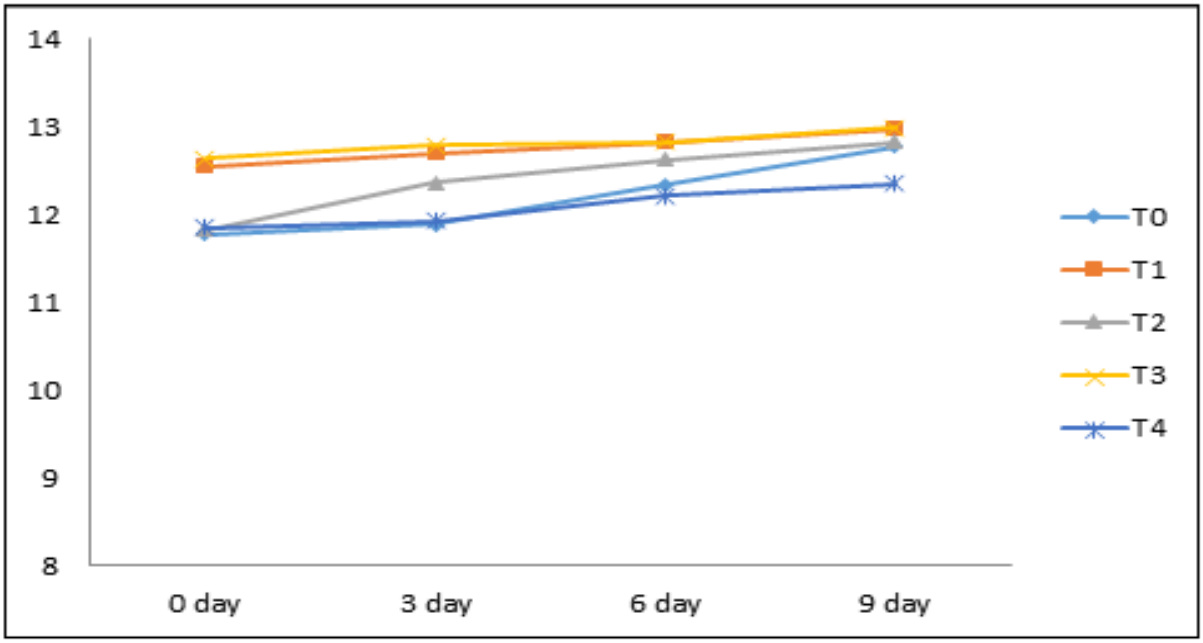

Fig. 10. Effect of different concentrations of Cinnamon and Coriander extracts on Degree of Yellowness (b*) of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

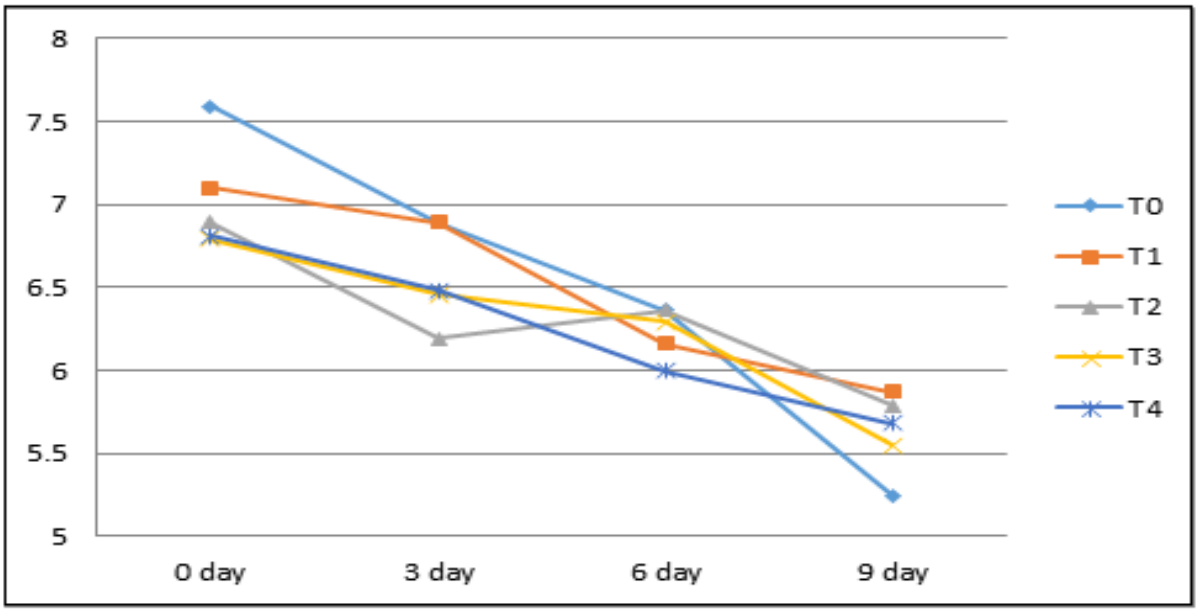

Fig. 11. Effect of different concentrations of Cinnamon and Coriander extracts on Appearance of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

The degree of redness (a*) is an indicator of the meat freshness. All the treated samples showed a non-significant difference on the 1st day of storage illustrated in Fig. 9. A momentous difference was observed in control, T_2 and T_4. The values were ranged from 2.2 to -2.9, 4.4 to 1.9 and 4.2 to 0.48 respectively during the whole storage span. Intensive oxidation of myoglobin leads to the production of metmyoglobin initiated by high temperature (Chan *et al.,* 2014). Therefore, a negative value in control (Green color) was detected while a non-significant difference was observed in T_1 and T_2. The degree of yellowness (b*) of all the samples that were stored at 4°C were not significantly different during the storage period. Generally, the degree of yellowness for all samples was ranged from 8.78 to 12.4 on the first day of storage and 10.77 to 12.99 on the last day of the storage as represented in Fig. 10.

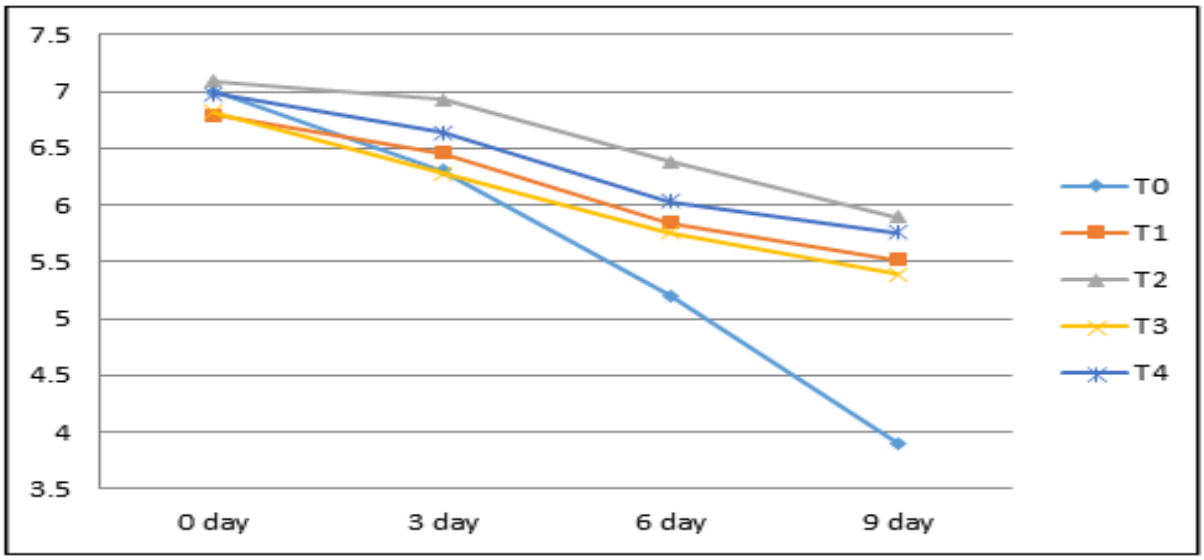

Fig. 12. Effect of different concentrations of Cinnamon and Coriander extracts on Odor of Beef patties (T_0; Control: T_1; Cinnamon 1%: T_2; Cinnamon 0.5%: T_3; Coriander 1%: T_4; Coriander 0.5%).

Sensory evaluation

In comparison to instrumental colour values, sensory evaluation scores did not exhibit any significant difference in appearance as well as the odor of all samples on the first day of storage. However, a gradual decline in both odor and appearance of the cooked beef patties of the control sample was noted at the end of the storage interval (Fig. 11., 12).

It was possibly due to a high TBARS value of control sample on the last day of storage, the sensory acceptance of the control sample was affected. Probably it is due to the detectable limit of TBARS i.e (0.5 to 2.0 mg MDA/kg) (Boles, 1990) and rancidity (color/off-flavour) of T_0 was exceeded from the limit and detected by the panellists. Furthermore, the slight change in L* values and a* values of the treated beef patties did not affect the acceptance of the panellists.

Conclusion

Cinnamon and Coriander extracts are natural preservatives and possess antioxidant and antimicrobial activity in complex food systems to stabilize the nutritional value. This comparative study demonstrated that the addition of 1% Cinnamon and Coriander extracts in cooked beef patties developed much better results in terms of physicochemical characteristics, oxidative stability and microbiological parameters than other treatments during refrigerated storage. Therefore, the meat industry should use cinnamon and coriander extracts as they have immense nutraceutical properties. Conclusively, the aqueous-alcoholic extract of Cinnamon and Coriander at 1% concentration can be used to minimize microbial and oxidation-induced deteriorative changes and to improve the sensorial properties of cooked beef patties.

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