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Research Article

Efficacy of *Allium stracheyi* extract infused edible coating in controlling oxidative stability and microbial degradation in chicken meat patties

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Abstract
There is a gradual shift in consumers' attitudes towards the use of natural food preservatives due to growing awareness for healthy and safe food. The current investigation aimed to develop sodium alginate edible coating (SDG-EC) infused with *Allium stracheyi* (AS) extract to control the oxidative and microbial degradation of chicken meat patties (CP) during 15 days of storage at 4±1^{0}C. The AS extract was made using lyophilization and cold extraction with 50% hydroethanol. FTIR analysis revealed the presence of several functional groups, such as -OH, -COOH, C-H, C=O, etc., in AS extract, suggesting the existence of bioactive components. The final treatments were C (uncoated chicken patties), T_1 (Chicken patties coated with SDG-EC), T_2 (Chicken patties coated with 1% AS SDG-EC), and T_3 (chicken patties coated with 2% AS SDG-EC). The results showed that throughout storage, C_s pH was significantly greater ($p<0.05$). On the 15th day, T_3 had a relatively lower pH than other treatments. T_3 TVB-N (mg/100g) and Thiobarbituric acid reacting substance (mg MDA/1000g) readings were noticeably lower than those of C, T_1, and T_2. In comparison to C, total plate count decreased significantly ($p<0.05$) in T_1, T_2, and T_3. Yeast, mold, and *S. aureus* were not found on the first or fifth day. The yeast, mold, and *S. aureus* (cfu/g) of T_2 and T_3 considerably decreased on the 10th and 15th day. Throughout storage, no coliforms were found in any treatment. It was concluded that *A. stracheyi*-infused edible coating successfully maintained the oxidative and microbial quality of CP for 15 days at 4±1^{0}C.

Keywords: Allium stracheyi extract, Antimicrobial, Antioxidants, Chicken Meat Patties, Edible Coating

INTRODUCTION

Meat-based foods are high in moisture and nutrients, which makes them very vulnerable to oxidation and microbiological degradation. Preservatives such as sorbic acid, sodium benzoate, nitrites, BHT (butylated hydroxytoluene), and BHA (butylated hydroxy anisole) have been employed to increase the longevity of such foods. However, certain preservatives, especially sodium benzoate and nitrites, have been connected to detrimental health outcomes including cancer (Mirza *et al.,* 2017). Simultaneously, there has been a recent shift in consumer preference towards natural alternatives. Bioactive compounds such as phenolic acids, flavonoids, terpenoids, isethionate, etc., which function as antioxidants and antimicrobials, have been found in herbal extracts such as thyme, ashwagandha, ginseng, and rosemary (Alamgir 2018; Cowan 1999; Lahiri *et al*., 2019*). Allium stracheyi* (Baker) is used in medicinal and culinary preparations by the indigenous tribal ethnic group of the Himalayan region (Tiwari *et al.*, 2014). Gusain and Singh (2023) reported that the *Allium stratcheyi* leaf extract in chloroform had significant phenols (0.85±0.03 mg gallic acid equivalent/mg of extract) and flavonoids (0.15±0.006 mg quercetin/mg of extract), content with commendable antioxidant activity as proved by *in vitro* DPPH free radical scavenging activity and Fe^{2+} reducing power. Even so, given their extreme reactivity to light and high temperatures, these herbs quickly deteriorate when added to food products. To skirt around this, edible coatings (EC) consisting of polymers like sodium alginate (SDG) can be infused with herbal extract. Not only does edible coating shield the herbs from deterioration, but it also functions as an oxygen barrier that minimizes lipid oxidation and a water barrier to avoid dehydration in meat products during storage (Song *et al*., 2011; Al-Tayyar *et al*., 2020). The experiment aimed to develop *A. stracheyi* infused edible coating (AS-SDG-EC) for preserving chicken patties (CP) during 15 days storage period at 4±1 ^{0}C.

MATERIALS AND METHODS

The Department of Livestock Products Technology, G.B. Pant University of Agriculture and Technology, Uttarakhand, was the testing site. Chicken meat patties were prepared using the technique outlined by Singh *et al.* (2023). Analytical-grade chemicals and reagents were bought from Himedia Media® Mumbai.

Preparation of *Allium stracheyi* (AS) extract

In a 100 mL glass vessel, powdered AS was mixed with 50% hydroethanolic solvent (1:5 solid: solvent). The mixture was subjected to cold maceration for 48 hours, followed by filtration (Whatman no.1). The filtered herbal extracts were lyophilized for 48 hours for drying.

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR analysis (Bruker alpha FTIR spectroscope) of the herbal extract was conducted to identify the various functional groups present in AS extract. The specifications were: OPUS/Mentor: software, 375–7,500 cm^{-1} - spectral range, 2 cm^{-1} - spectral resolution.

Preparation of Chicken meat patties (CP)

CP was prepared following the method described by Singh *et al.* (2023). Briefly, chicken meat was minced to a size of 6 mm. In a bowl chopper all ingredients *viz*, minced meat (55.2%), rice bran oil (10%), water (10%), ginger garlic onion (5%), spices (2%), refined wheat flour (4%), salt (1.5%), sodium tripolyphosphate (0.3%) and barnyard millet (6%) were mixed and chopped to form a meat batter. Meat batter was shaped in circles of roughly 6 cm diameter and oven-cooked at 160 ^{0}C for 35 minutes.

Preparation of Chicken meat patties with *Allium stracheyi* infused sodium alginate edible coating (AS-SDG-EC)

2.5 g of SG was added to 100 mL of distilled water (80^{0}C) to form the coating solution. AS extract was added to this mixture at the rate of 0, 1, and 2% v/v followed by homogenization. Chicken patties were dipped in the coating solution for 1 min followed by dipping in a 2 % (w/v) calcium carbonate solution to ensure proper bond formation.

Experimental groups and sampling period

The final treatment included $_C$ (uncoated chicken patties), T_1 (Chicken patties coated with sodium alginate edible coating: SDG-EC), T_2 (Chicken patties coated with 1% *Allium stracheyi* infused edible coating: AS SDG-EC) and T_3 (chicken patties coated with 2% *Allium stracheyi* infused edible coating: AS-SDG EC). Storage temperature was 4±1^{0}C and samples were taken at 0th, 5th, 10th and 15th day of storage. Each experiment was done thrice in duplicate.

Physicochemical characteristics

pH

5 g of sample were triturated with 5 mL distilled water. Data was recorded using a digital pH meter.

Thiobarbituric acid reacting substance (TBARS mg malonaldehyde/1000g)

TBARS (mg MDA/1000g) was calculated using the Tarladgis *et al.* (1960) technique. A mixture of 10 g of chicken patties, 49 mL of distilled water, and 1 mL of sulfanilamide reagent was prepared. 2 mL of 50% HCl solution and 48 mL of distilled water were added to the contents of a Kjeldhal flask, and distillate was collected. 5 mL of distillate was mixed with 5 mL of thiobarbituric acid reagent and incubated boiling water bath for 35 minutes. After cooling, absorbance was recorded at 538 nm against blank.

Total volatile base nitrogen (TVB-N mg/100g)

TVB-N (mg/100g) was calculated using AOAC (1995) technique. In short, a 10 g sample of CP was homogenized with a 90 mL solution of 6% perchloric acid for 2 minutes. The filtered contents were sufficiently alkalinized with NaOH using a phenolphthalein indicator and then steamed distilled for ten minutes. About 100 mL of distillate was produced in ten minutes thanks to the regulation of the steam distillation process. A few drops of Tashiro indicator were added to a 100 mL boric acid solution to capture the distillate outflow. Titrating with 0.01 M HCl allowed for the determination of the volatile bases.

Microbiological analysis

The samples were prepared as per the method described in APHA (1992). 10 g of CP was triturated with 45 mL 0.9% normal saline solution to form a homogenous suspension of 10^{-1} under aseptic conditions. Serial dilution was done to a concentration of 10^{-4}. 1 mL of each dilution was inoculated in Petri dishes containing specific growth media. Following tests were conducted total plate count (TPC; Plate Count Agar; incubated at 37 ^{0}C for 24-48 hours), coliform count (Eosin Methylene Blue agar; 37 ^{0}C for 24-48 hours), *S. aureus* count (Baird-Parker agar; 37 ^{0}C for 24-48 hours), yeast and mold count (potato dextrose agar; incubation at 22 ^{0}C for 2-3 days).

Statistical analysis

Using 'SPSS-16.0 software, statistical analysis was performed using the ANOVA technique with completely randomized design (CRD) and the Duncan multiple range test, implementing the guidelines provided by Snedecor and Cochran (1994). Every experiment was carried out thrice in duplicate.

RESULTS AND DISCUSSION

FTIR analysis of *Allium stracheyi*

The FT-IR analysis of a hydroethanolic extract of AS, as shown in Fig.1 shows thirteen major peaks at 3356.21, 2975.94, 2926.35, 2128.81,1753.44,1633.07, 1451.20, 1384.48, 1180.01, 1084.45, 1044.51,878.27 and 657.17 (cm^{-1}) respectively. The FTIR analysis revealed the presence of 8–functional groups in AS extract, as presented in Table 1.

Physicochemical characteristics

pH

pH values of C, T_1, T_2 and T_3 are presented in Fig.2a; Table 2. Due to microbial enzymatic activity, meat proteins broke down into simple nitrogenous molecules, including ammonia and trimethylamine (TMA) during the storage period, which elevated the pH of all the treatments from 0 to 15 days (Li *et al.,* 2023). However, T_3 had significantly (p<0.05) lower pH when compared to C, T_1, and T_2, indicating that 2% AS-infused edible coating was more efficient in reducing bacteria growth and protein degradation. Similar results were demonstrated by Panahi *et al.* (2022) where chicken meat coated with 2% sodium alginate (SDG) coating containing 2% citrus and lemon extract had significantly (p<0.05) lower pH as compared to the control sample during 16 days at 4 ^{0}C.

Thiobarbituric acid reacting substance (TBARS mg malonaldehyde/1000g)

Thiobarbituric acid-reacting substances are formed due to lipid oxidation in the food system. TBARS (mg MDA/1000g, Fig. 2b; Table 2) value of each treatment decreased significantly (p<0.05) with an increase in storage days from 0 to 15 days. This is because, with passing days, bioactive compounds responsible for

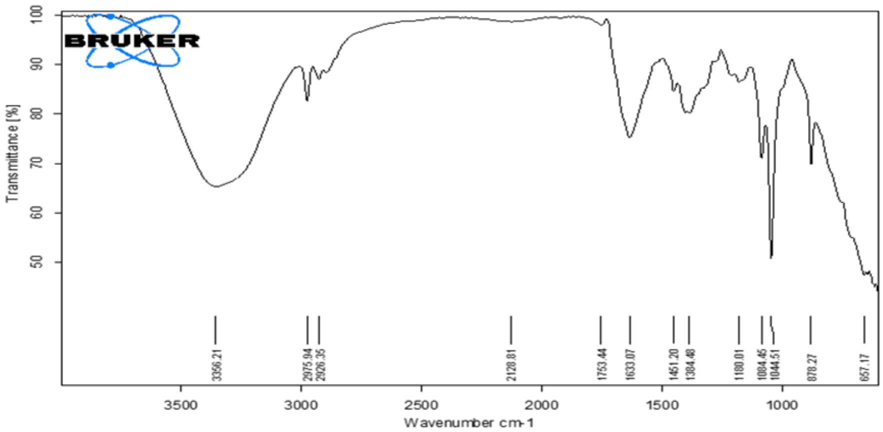

Fig 1. *FTIR spectrum of A. stracheyi* (AS)

Table 1. Functional groups detected in AS extract by FTIR analysis

Serial no.	Wavelength	Functional group	Remarks
1.	3356.21cm^{-1}	O-H (alcohol group)	Intermolecular bonds in compounds
2.	2975.94cm^{-1}	Carboxylic acid	It is a broader band that corresponds to the –OH group in phenolic compounds
3.	2926.35 cm^{-1}	C-H	Alkene group
4.	2128.81cm^{-1}	S-CΞN	Thiocyanate group
5.	1753.44 cm^{-1}	C=O	6-membered lactone
6.	1633.07 cm^{-1}	C=O	Conjugated ketone
7.	1451.20 cm^{-1}	Medium strength O-H bending	Carboxylic acid groups
8.	1384.48 cm^{-1}	C-O	Ester group

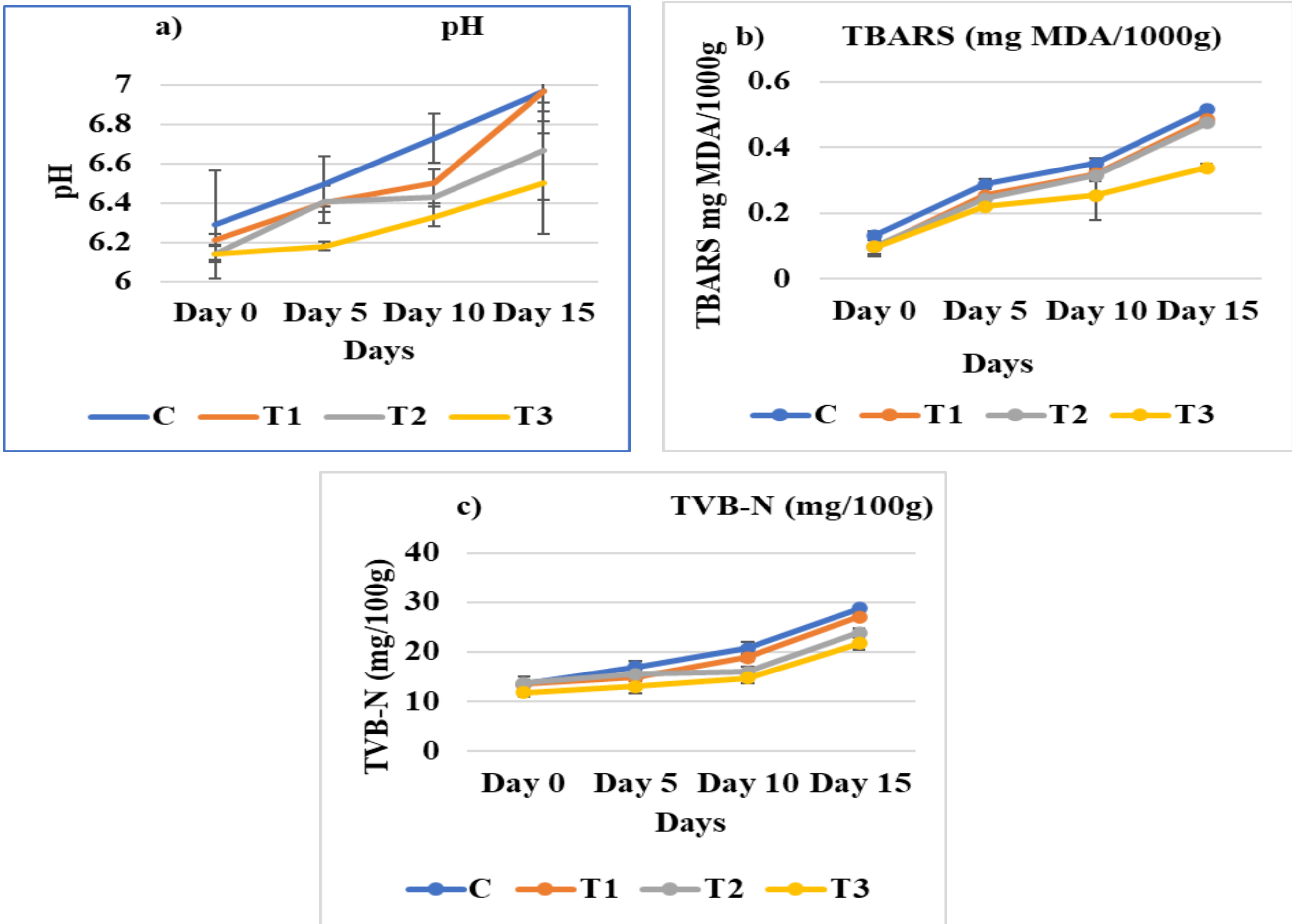

Fig. 2. *Graphical representation of change in physicochemical characteristics of chicken meat patties during 15 days of storage at 4±1 ^{0}C. (a) pH (b) TBARS (mg MDA/1000g) and (c) TVB-N (mg/100g) of C, T_1, T_2, and T_3 during 15-day storage at 4±1 ^{0}C*

Table 2. *Physicochemical characteristics pH, TBARS (mg MDA/1000g) and TVB-N (mg/100g); each value (Mean ± S.E.) bearing different superscripts in each row by small alphabet (a, b, c, d) and in each column by capital alphabet (A, B, C, D) differ significantly (p<0.05)*

	Storage days			
Treatment	**0th day**	**5th day**	**10th day**	**15th day**
pH				
C	6.29±0.02^{dA}	6.49±0.01^{cA}	6.73±0.00^{bA}	6.97±0.04^{aA}
T_1	6.21±0.01^{dB}	6.40±0.03^{cB}	6.50±0.02^{bB}	6.97±0.01^{aA}
T_2	6.14±0.05^{cC}	6.40±0.00^{bB}	6.43±0.03^{bC}	6.67±0.00^{aB}
T_3	6.14±0.02^{cC}	6.18±0.03^{cC}	6.33±0.06^{bD}	6.49±0.02^{aC}
TBARS (mg MDA/1000g)				
C	0.13±0.05^{dA}	0.29±0.03^{cA}	0.35±0.02^{bA}	0.51±0.01^{aA}
T_1	0.09±0.01^{dB}	0.25±0.03^{cB}	0.32±0.03^{bB}	0.48±0.04^{aB}
T_2	0.09±0.01^{dB}	0.24±0.06^{cB}	0.31±0.01^{bBC}	0.47±0.03^{aBC}
T_3	0.09±0.00^{dB}	0.22±0.04^{cB}	0.25±0.04^{bD}	0.34±0.05^{aD}
TVB-N(mg/100g)				
C	13.49±0.11^{dA}	16.99±0.03^{cA}	20.77±0.07^{bA}	28.75±0.12^{aA}
T_1	13.44±0.12^{dA}	14.79±0.22^{cBC}	18.85±0.11^{bB}	27.07±0.14^{aB}
T_2	13.72±0.09^{dA}	15.49±0.06^{cB}	15.96±0.16^{bC}	23.85±0.09^{aC}
T_3	11.76±0.14^{dB}	12.98±0.05^{cD}	14.75±0.13^{bD}	21.70±0.1^{aD}

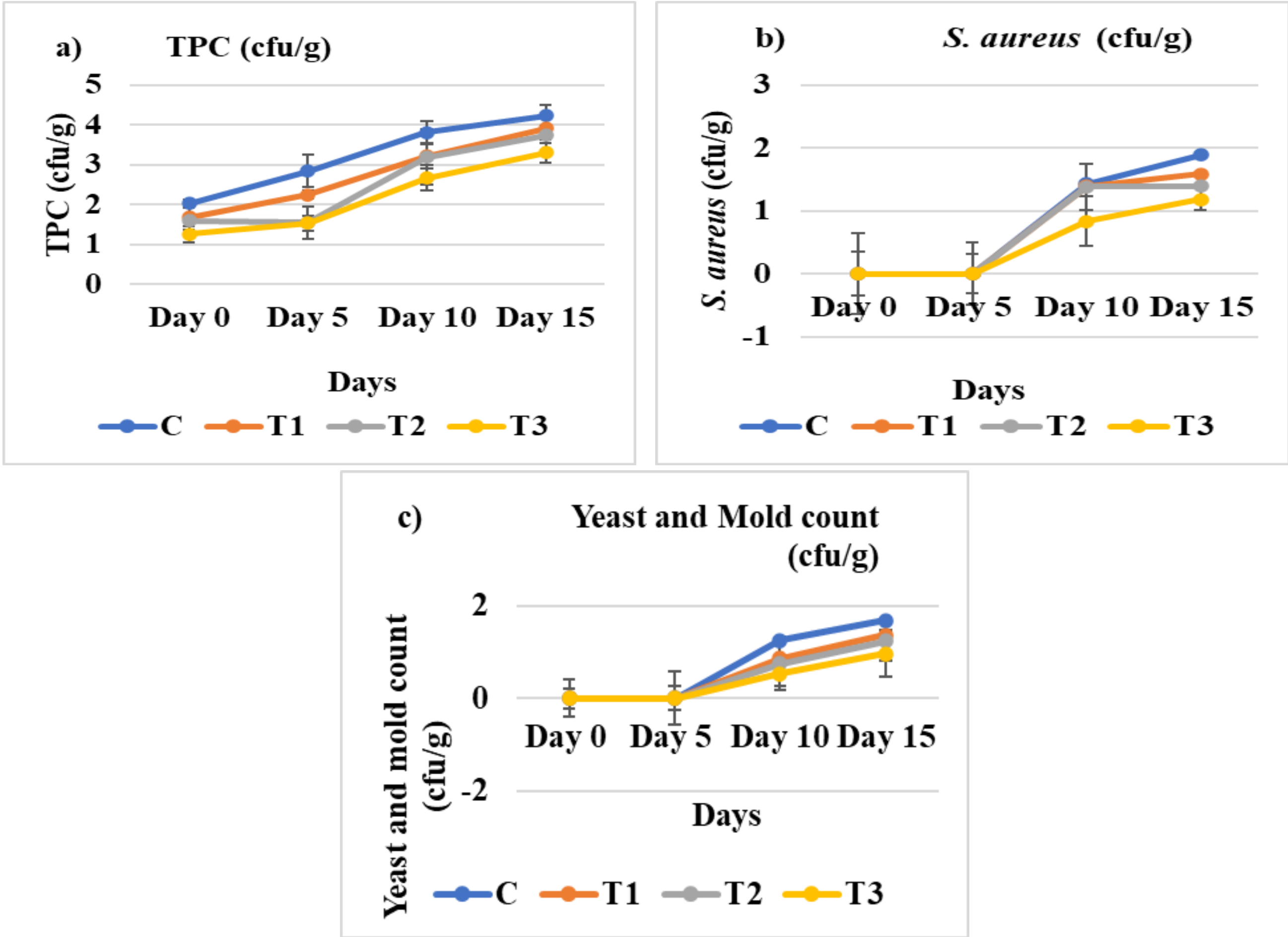

Fig. 3. *Graphical representation of change in microbiological characteristics of CP during 15 days of storage at 4±1 ^{0}C. (a) TPC (cfu/g) (b) S. aureus count (cfu/g) and (c) Yeast and mold count (cfu/g) of C, T_1, T_2, and T_3 during 15-day storage at 4±1 ^{0}C*

decreasing oxidation reactions occurring due to free radicals in food are lost because of environmental stressors (Pandey and Rizvi 2009). The TBARS (mg MDA/1000g) of T_1, T_2 and T_3 was significantly ($p<0.05$) lower than $_{C}$ on 0^{th}, $5^{th,}$ and $10^{th,}$ day of storage, indicating that both SDG-EC and AS SDG-EC were more effective in reducing lipid oxidation during storage. The sodium alginate edible coating acts as an oxygen barrier, thus reducing the exposure of chicken patties to oxygen, thus retarding lipid oxidation (Ruan *et al*., 2019). However, on 15^{th} day of storage, the TBARS (mg MDA/1000g) value of $_{T3}$ was significantly lower than C, T_1, and $T_{2,}$ indicating that 2% *A.stracheyi* infused edible coating was more effective in reducing oxidation reaction during storage.

Total volatile base nitrogen (TVB-N mg/100g)

Activity of meat enzymes and spoilage bacteria is closely correlated with Total volatile base nitrogen TVB-N (mg/100g), Fig 2c; Table 2) which is a measure of ammonia and amino acids (Fan *et al*., 2006). In this study, TVB-N (mg/100g) of T_1, T_2 and T_3 was significantly ($p<0.05$) lower than C during 5^{th}, 10^{th}, and 15^{th} day. However, TVB-N of T_3 was significantly lower than T_1 and T_2 indicating that 2% *A.stracheyi* infused edible coating was more useful in controlling bacterial growth and associated decomposition in chicken patties.

Microbiological study

The TPC ("Fig. 3a, Tab. 3") of C was significantly ($p<0.05$) higher than all other treatments. Similar results were demonstrated by Chidanandaiah *et al.* (2009) where fresh beef coated with 2% sodium alginate had significantly ($p<0.05$) lower TPC than uncoated beef samples during a storage period of 21 days at 4±1^{0}C. TPC (cfu/g) of chicken patties coated with T_3 was significantly ($p<0.05$) lower than T_1 and T_2 on 0^{th}, 10^{th}, and 15^{th} day of storage. Similar findings were reported by Song *et al.* (2011) where fresh bream (*Megalobrama amblycephala;* Fish) treated with sodium alginate containing vitamin C and tea polyphenols had significantly ($p<0.05$) lower TPC than those treated by SDG-only and untreated samples.

S. aureus is one of the most common bacterial contaminants in meat food products and is of great concern to public health (Kadariya *et al*., 2014). No *S. aureus* (Fig.

Table 3. *Microbiological characteristics TPC (cfu/g), S. aureus (cfu/g) and Yeast and mold (cfu/g) count; each value (Mean ± S.E.) bearing different superscripts in each row by small alphabet (a, b, c, d) and in each column by capital alphabet (A, B, C, D) differ significantly (p<0.05)*

	Storage days			
Treatment	**0^{th} day**	**5^{th} day**	**10^{th} day**	**15^{th} day**
Total plate count				
C	$2.02±0.19^{dA}$	$2.84±0.23^{cA}$	$3.81±0.11^{bA}$	$4.24±0.12^{aA}$
T_1	$1.67±0.22^{dB}$	$2.24±0.14^{cB}$	$3.21±0.03^{bB}$	$3.90±0.09^{aB}$
T_2	$1.58±0.09^{cB}$	$1.54±0.16^{cC}$	$3.19±0.06^{bC}$	$3.74±0.14^{aC}$
T_3	$1.26±0.11^{cdC}$	$1.53±0.44^{cC}$	$2.66±0.21^{bD}$	$3.30±0.12^{aD}$
***S. aureus* count (cfu/g)**				
C	0	0	$1.43±0.04^{bA}$	$1.89±0.06^{aA}$
T_1	0	0	$1.39±0.10^{bA}$	$1.58±0.03^{aB}$
T_2	0	0	$1.38±0.07^{aA}$	$1.39±0.01^{aC}$
T_3	0	0	$0.83±0.02^{bB}$	$1.18±0.02^{aD}$
Yeast and Mold count (cfu/g)				
C	0	0	$1.24±0.10^{bA}$	$1.68±0.05^{aA}$
T_1	0	0	$0.86±0.21^{bB}$	$1.36±0.12^{aB}$
T_2	0	0	$0.74±0.09^{bC}$	$1.23±0.04^{aC}$
T_3	0	0	$0.53±0.03^{bD}$	$0.96±0.11^{aD}$

3b, Table 3) was detected in any treatment on the 0^{th} and 5^{th} day of storage. There was a non-significant difference between C, T_1, and T_2 on 10^{th} day of storage however, T_3 had the lowest *S. aureus* count (cfu/g) during the same. On the 15^{th} day, the *S. aureus* count (cfu/g) was significantly ($p<0.05$) lower in T_1, T_2 and T_3 as compared to C.

The yeast and mold count (Fig. 3c, Tab. 3) of T_3 was significantly ($p<0.05$) lower than C, T_1, and T_2 on 10^{th} and 15^{th} day of storage. No coliforms were detected throughout the storage period in any treatment.

Conclusion

The increase in pH of T_3 was significantly lower ($p<0.05$) than C, T_1 and T_2. TBARS value of T_3 was significantly lower ($p<0.05$) than all other treatments on 15^{th} day of storage. TVB-N of T3 was significantly lower ($p<0.05$) than T_1 and T_2 and C. Microbiological study revealed that TPC, *S. aureus,* yeast and mold count of T_3 was significantly lower ($p<0.05$) than all other treatments during storage. In all treatments, no coliforms were found. The results suggest that adding *A.stracheyi* extract to an edible coating of sodium alginate effectively slowed the pace at which the chicken patties spoiled due to oxidation and microbial action. An active physical barrier against gaseous exchange and foreign invasion was created by AS-SDG-EC, which resulted in a restricted rise in pH, TBARS, TVB-N, and microbial count in CP during storage. More precisely, throughout 15-day storage at $4±1^0$C, 2% *A.stracheyi* infusion in SDG coating outperformed 1% infusion in terms of CP preservation.

Conflict of interests

The authors declare that they have conflicts of interest.

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