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Performance of chitosan/γ-polyglutamic acid/curcumin edible coating and application in fresh beef preservation

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Abstract

A chitosan-based edible coating was prepared by incorporating γ-polyglutamic acid and curcumin. The physical, mechanical and antimicrobial properties of the chitosan/γ-polyglutamic acid/curcumin edible coating were characterized. Furthermore, the effect of chitosan/γ-polyglutamic acid/curcumin edible coating on the shelf-life of fresh beef was investigated. The γ-polyglutamic acid and curcumin incorporation greatly improved the performance of chitosan coating, including coating formation and antimicrobial activity. After the application of coating, the chitosan/γ-polyglutamic acid/curcumin edible coating had a good protection effect on the color of beef and was conducive to prolonging the shelf life of beef with good quality compared to pure curcumin edible coating. These results revealed that application of chitosan/γ-polyglutamic acid/ curcumin edible coating will be a good way to preserve freshness of fresh beef.

Keywords: antibacterial activity; coating; chitosan; curcumin; γ- polyglutamic acid.

Practical Application: In this study, the performance of chitosan/γ-polyglutamic acid/curcumin edible coating and the effect on the shelf life of fresh beef was investigated compared to pure curcumin edible coating. These results revealed that application of chitosan/ γ-polyglutamic acid/curcumin edible coating will be a good way to preserve freshness of fresh beef during storage at 4 °C.

1 Introduction

Currently, beef is one of the main red meat resources and continues to be the major contributor to total meat consumption in China due to its rich nutrition and unique flavor. However, during the distribution processes and storage, chemical interactions and microbial contamination would deteriorate meat quality (Ding et al., 2020; Tian et al., 2022a). Thus, appropriate protection technology must be adopted to maintain the safety and nutritional values of meat (Fang et al., 2018; Wen et al., 2022). Recently, there has been increasing interest in edible packaging technologies to prolong the shelf life of fresh meat and meat products (Umaraw et al., 2020). Compared with petro-based films, edible and biodegradable films made from natural polymers have shown obvious advantage due to their characteristics of biodegradability, barrier and safety (Domínguez et al., 2018).

Chitosan (CS) is a polysaccharide of N-acetyl D-glucosamine and Dglucosamine units, which is mainly obtained by the partial deacetylation of chitin (Kumar et al., 2019). Chitosan has been applied in food preservation and packaging due to its excellent film forming property and antimicrobial activity, as well as biodegradable, nontoxic and biocompatible properties (Kumar et al., 2019; Mihai & Popa, 2015). However, there are still several shortcomings for their practical application, such as poor mechanical property, poor barrier property, and limited antibacterial activity (Wang et al., 2018; Tian et al., 2022b). It has been reported that addition of γ-polyglutamic acid (γ-PGA), curcumin and other components could improve the performance of chitosan-based packaging materials (Hu et al., 2021; Wu et al., 2019).

The γ-PGA is a natural polyamide composed of 50-5000 glutamic acid monomers (Yuan et al., 2016), which is a green biological product with many unique physicochemical and biological properties, such as excellent biodegradability (Fang et al., 2018), film-forming property (Bajestani et al., 2020), and moisture retention, etc. (Yamamoto et al., 2016). Recently, γ-PGA has been used in food preservation and revealed the great development value and application prospects (Bai et al., 2020; Yang et al., 2020). Curcumin is a small molecule substance extracted from the roots and stems of Turmeric or Acorus calamus, which has been considered as a good food grade pigment (Jalal et al., 2018). Moreover, the curcumin has significant antioxidant function and antibacterial activity (Ahmed et al., 2017). Thus, there has been increasing interest in food preservation.

The objective of this study is to develop an antibacterial coating based on chitosan incorporated withγ-PGA and curcumin for fresh beef preservation. The characterization of coating were evaluated on mechanical and barrier properties by scanning electron microscopy (SEM), fourier transform infrared spectrometry (FTIR), X-ray diffraction (XRD) and thermal gravimetric analysis (TGA). Furthermore, the antimicrobial

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activity of coatings was investigated and the application of the coatings to fresh beef preservation was evaluated.

2 Materials and methods

2.1 Materials

Chitosan (CS, DD = 95%; viscosity of 1% chitosan solution at 20 °C = 200 mPa·s) was obtained from Shanghai McLean Biochemical Technology Co., Ltd (Shanghai, China). The γ-polyglutamic acid (γ-PGA, MW=1400~2000kDa) was purchased from Guangzhou Hongyi Food Additive Co., Ltd (Guangzhou, China). Curcumin was supplied by Guangzhou Tianxu food additives Co., Ltd (Guangzhou, China).

Five typical testing bacteria of *Escherichia coli* (*E. coli*, ATCC 8099), *Staphylococcus aureus* (*S. aureus*, ATCC 6538), *Listeria monocytogenes* (*L. monocytogenes*, ATCC 19115), *Pseudomonas fluorescens* (*P. fluorescens*, ATCC 35858) and *Pseudomonas putida* (*P. putida*, ATCC 49128) were purchased from the China Center of Industrial Culture Collection.

2.2 Preparation of coatings

The chitosan/γ-polyglutamic acid /curcumin edible antibacterial coating labled Group CPC was made of 1.5% chitosan, 4% γ-PGA and 0.25% curcumin. Briefly, 1.5 g chitosan and 4 g γ-PGA were mixed with 100 mL of 1% glacial acetic acid solution (v/v) to transparent liquid, then 0.25 g curcumin was added. Subsequently, the mixture was mechanical mixed by using a magnetic stirrer at room temperature for 2 h. After standing for 30 min, the mixture was degassed by using a centrifuge at 4500 r/ min for 6 min. Finally, 30 mL of the solution was cast on a polytetrafluoroethylene mold (100 × 100 cm), and dried in an oven at 30 °C for 12 h. The chitosan edible coating labled Group C as the control was made of only 1.5% chitosan and cast according to the preparation of Group CPC.

2.3 Characterization of coating

Coating thickness

The thickness of coating was measured to the nearest 0.001 mm by using an electronic micrometer (QuantuMike Mitutoyo, Japan). The thickness measurement of each sample was determined at then random locations and then these readings were averaged.

Barrier property

The barrier property of coating was characterized by the water vapor permeability (WVP) and the oxygen transmission rate (OTR). The WVP was measured according to the method described by Cheng et al. (2019). Briefly, the testing coating was sealed on beakers containing silica gel with 0% relative humidity (RH) and placed in the climate incubator (25 °C, 50% RH). The moisture absorbed was determined by the measure of the beaker weight at each 12 h interval for 3 days. The WVP was calculated according to the following Formula 1:

$$WVP = \frac{w \times x}{A \times t \times \Delta P} \quad (1)$$

Where WVP is in g/Pa·h·m, w is weight in g, x is thickness in m, t is time in h, and A is area of exposed coating in m^2. ΔP (Pa) represents the water vapor partial pressure difference across the two sides of coating determined according to RH and temperature.

The OTR of coating was determined at 25 °C by a N500 gas permeameter and the open area of each circular specimen is about 50 cm^2. The corresponding oxygen permeability (OP) was calculated according to the following Formula 2:

$$OP = OTR \times L \quad (2)$$

Where L is thickness of coating in m and OP is in mol/(m^2·s·Pa).

Scanning electron microscopy (SEM)

The morphology of the surface and the cross section of the coating was examined by using a scanning electron microscope (Regulus 8100, Hitachi Limited, Japan).The coating was first immersed in liquid nitrogen and quickly folded. Coating pieces were mounted on aluminum stubs and coated with platinum (Pt) on the surfaces and fractured coating crosssections. All samples were examined using an accelerating voltage of 10 kV.

Fourier transform infrared spectrometry (FTIR)

Fourier transform infrare spectrometry of coating was recorded by using a FTIR spectroscopy instrument (FTIR, Nicolet iS50, Thermo Fisher Scientific, U.S.A.). The dried coating were ground into powders, mixed with KBr, and then pressed to form a disk for the tests. The scanning frequency is 4 times with a spectral resolution of 4 cm^{-1}. The incident angle is 45°, and the wave number range is from 450 to 4500 cm^{-1}.

X-ray diffraction (XRD)

X-ray diffraction measurements of coating was performed by using a XRD diffractometer (Rigaku D/MAX 2200, Tokyo, Japan).The patterns with Cu Ka radiation (λ=1.543 Å) at 40 kV and 40 mA were recorded in the region of 2θ from 8 to 70° with a step speed of 1 min^{-1}.

Thermal gravimetric analysis (TGA)

Thermal gravimetric analysis of coating was performed by using a thermal gravimetric analyzer (TG/DTAQ500, NETZSCH-Gerätebau Gmb, Germany). The initial mass of the samples was 7-8 mg. The experiments were carried out under nitrogen atmosphere with a flow rate of 50 mL/min and a purge time of 10 min. The experimental temperature rised from 30 °C to 1200 °C with a heating rate of 20 °C/min.

Antibacterial assay

The antibacterial activity of coatings was evaluated by the Oxford cup method (Chen et al., 2016; Zhao et al., 2022). Five typical testing bacteria of *E. coli*, *S. aureus*, *L. monocytogenes*, *P. fluorescens* and *P. putida* were selected as representative microorganisms. Briefly, Oxford cups (8.0 × 6.0 × 10.0 mm) with coatings were put on the surface of the nutrient agar or yeast extract peptone dextrose agar in Petri dishes. Then the testing

bacteria were incubated for 24 h at 37 °C. After incubation, the inhibition zones were measured with a tolerance of 1 mm. The experiment was performed in triplicate for all samples.

2.4 Coating application on fresh beef

Sample processing

Fresh beef was supplied by a local market of agricultural products located in Chengdu, Sichuan Province, China, within 12 h after slaughter. The fresh beef was first cut into pieces into 10 g per piece. Then these pieces were randomly classified into three groups. The samples labled as Group CPC were was treated with chitosan/γ-polyglutamic acid /curcumin edible coating. The samples labled as Group C were treated with chitosan edible coating. The samples labled as Group N were treated without edible coating. After treatment, all samples were stored at 4 °C for 7 days.

pH value determination

The pH of fresh beef was measured according to the method described by Wang et al. (2015a) using a pH meter (Testo 205, Testo International Trade Co., Ltd., Shenzhen, China) with automatic temperature compensation (NTC) electrode. After pH value calibration, the pH probe was inserted directly into beef to measure. The pH value in triplicate at each time point and an average was calculated.

Color measurement

The lightness (L^*), redness (a^*) and yellowness (b^*) of fresh beef was evaluated according to the method described by Wang et al. (2015b) using an auto color chromameter (CS-22, Hangzhou CHNSpec Technology Co. Ltd, Hangzhou, China). The color parameters were collected from three different sites in beef sample and then triplicate readings were averaged.

Volatile basic nitrogen (TVB-N) measurement

The TVB-N of fresh beef was measured ccording to the method described by Wang et al. (2018) using an automatic azotometer (KDN-1000, Shanghai Xin Rui instrument and Meter Co. Ltd, Shanghai, China). The TVB-N level was expressed as mg/100g sample. All samples were measured in triplicate and an average was calculated.

Drip loss analysis

Drip loss was measured according to the method described by Wang et al (2022a). Briefly, the initial weight of sample was recorded before treatment. After storage, the samples reweighed after wiping drips from their surface. The drip loss was calculated according to the Formula 3:

$$Drip\ loss(\%) = \frac{\text{initial weight -final weight}}{\text{initial weight}} \times 100\% \quad (3)$$

Total viable counts (TVC) determination

The TVC of beef samples was measured according to the method described by Wang et al. (2021). Briefly, 5 g sample was put into a sterile homogenizing bag containing 95 mL sterile saline containing 0.9% NaCl and was homogenized for 1 min. Then the mixture was serially diluted with sterile saline and 0.1 mL of diluent was plated onto agar plates (CM101, Beijing Luqiao Technology, Beijing, China). The plates were incubated at 36 ± 1 °C for 48 h for colony forming units (CFU) counting. The results were expressed in lg CFU/g.

Sensory evaluation

The freshness of beef samples was assessed by human sensory analyses according to the method described by Wang et al. (2022b). Briefly, The experienced sensory panelists consisted of 11 individuals with age ranging from 20 to 35 years old. All samples were coded with three digit number and were presented to the panelists to evaluate their color, odor, texture, appearance and viscosity, using a 5-point scale based on attribute degrees.

2.5 Statistical analysis

Three replicates were performed for all samples and these results were expressed as mean ± standard deviation (SD) unless otherwise mentioned. Student's *t* test was used to calculate the signifcance, accepting $p<0.05$ as the level of signifcance using the SPSS 15.0 statistics software (IBM, Chicago, Ill., U.S.A.).

3. Results and discussion

3.1 Characterization of coating

Appearance of coating

The physical appearance and cross section morphology of chitosan/γ-polyglutamic acid/curcumin edible coating and chitosan coating is shown in Figure 1. As shown in Figure 1A, the Group CPC appeared smoother than that of Group C. The incorporation of curcumin caused the yellowish color of the in chitosan/γ-polyglutamic acid/curcumin edible coating. The scanning electron microstructure of chitosan/γ-polyglutamic acid/curcumin edible coating was distinguishable with regards to the incorporation of γ-polyglutamic acid and curcumin as shown in Figure 1B. The Group CPC showed smooth surface and compact structure, indicating its structural integrity. In contrast, cross sectional microstructure of Group C appeared some rough texture, some cracks and some pores. The electron microscopy also indicated that chitosan/γ-polyglutamic acid /curcumin edible coating was smoother than that of pure curcumin edible coating. Previous studies have reported that the incorporation of γ-polyglutamic acid can enhance the application prospects of coating because of its unique physicochemical and biological properties, such as excellent biodegradability (Fang et al., 2018), film forming property (Bajestani et al., 2020), and moisture retention, etc. (Yamamoto et al., 2016). Therefore, the Group CPC presented a better film forming characteristic, which maybe attribute to the incorporation of γ-polyglutamic acid.

Structural characterization of coating

Information about structural characterization of chitosan/γ-polyglutamic acid/curcumin edible coating and chitosan coating was obtained by FTIR, XRD and TGA analyses as shown in

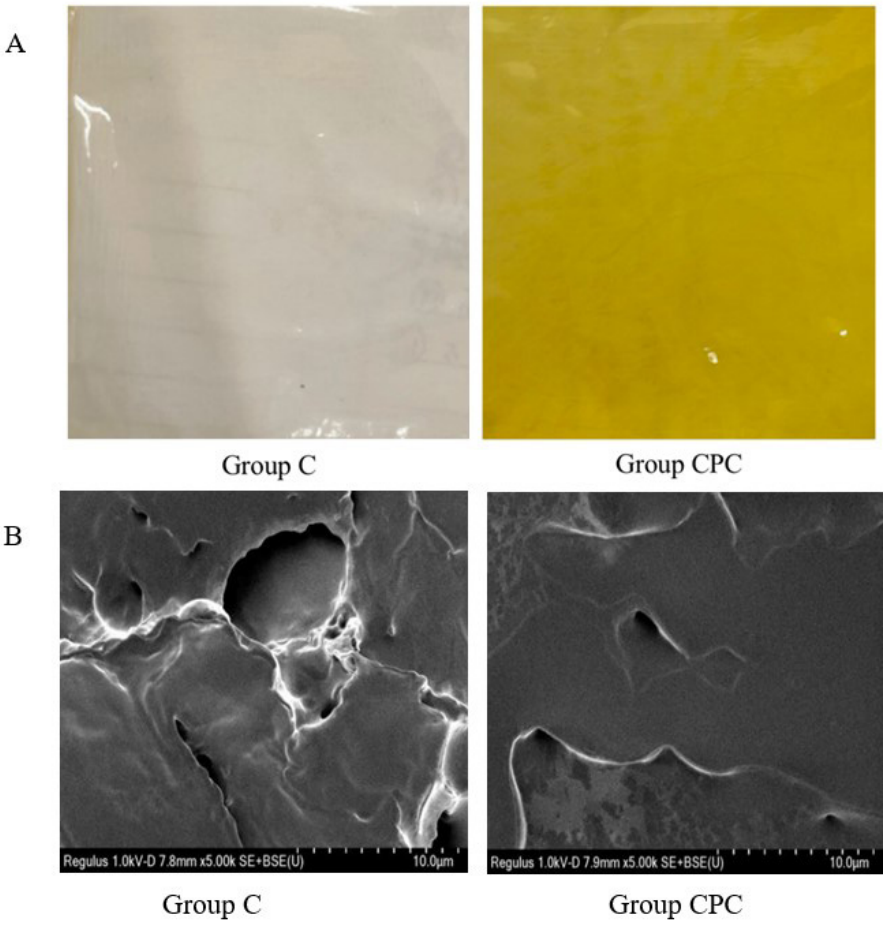

Figure 1. The physical appearance (A) and cross-section morphology by SEM observation (B) of chitosan/γ-polyglutamic acid /curcumin edible coating (Group CPC) and chitosan coating (Group C).

Figure 2. In the FTIR spectra (Figure 2A), five typical peaks of the chitosan coating (Group C) were found at 3288 cm^{-1}, 2866 cm^{-1}, 1412 cm^{-1}, 1031 cm^{-1} and 658 cm^{-1}. Compared to the Group C, there were appreciable changes in the FTIR spectra of the chitosan/γ-polyglutamic acid /curcumin coating (Group CPC). The stretching vibration absorption peaks of Group CPC fluctuated obviously at 3288 cm^{-1} and 1655 cm^{-1}. The peak at 3288 cm^{-1} was assigned to -NH and -OH stretching vibrations. The peaks observed in the spectra of the coating at wavenumber of 1655 cm^{-1} were assigned to C=O and NH (Chen et al., 2016). The result indicated that chitosan, γ-polyglutamic acid and curcumin can be well blended through the interaction between chemical bonds. The XRD profile of the chitosan coating (Group C) as shown in Figure 2B exhibited a broad-band between 20° and 80° with a weak diffraction at 38.43°. In contrast, the XRD profile of the chitosan/γ-polyglutamic acid /curcumin coating (Group CPC) presented some changes in the degree of crystallinity. Compared to the Group C, the Group CPC exhibited three diffraction peaks at 34.61°, 38.43° and 44.65°, respectively. Moreover, the reflection peak at 38.43° of (Group CPC) became extremely sharper. The sharper reflection peak indicated a higher density of coating which can cause a greater crystalline fraction. This discrepancy may be due to the difference in coating formulations. Kumar et al. (2017) showed that during the formation of films, the incorporation of γ-PGA exhibited high crystalline nature in film. In this study, the result is in good agreement with the finding reported by Kumar et al. (2019). The TGA curves of the Group C and Group CPC are shown in Figure 2C. The initial weight loss of Group C was about 100 °C and a marked one step weight loss was about 256 °C. Correspondingly, the initial weight loss of Group CPC was about 190 °C and a marked one step weight loss was about 330 °C. Both the initial thermal degradation temperature and the maximum thermal degradation rate temperature of Group CPC were higher than that of Group C, which indicated that the thermal stability of the chitosan/γ-polyglutamic acid/curcumin edible coating compared to d chitosan coating.

Barrier proerties of coatings

The barrier proerties of coatings are shown in Table 1. The water vapor permeability of the Group CPC was lower than that of the Group C. Similar to the variation tendency of water vapor barrier, the oxygen barrier of the Group CPC was lower compared to the Group C. In contrast, the Group CPC was slightly thicker than that of the Group C. This phenomenon was ascribed to the more compact structure of coating at a

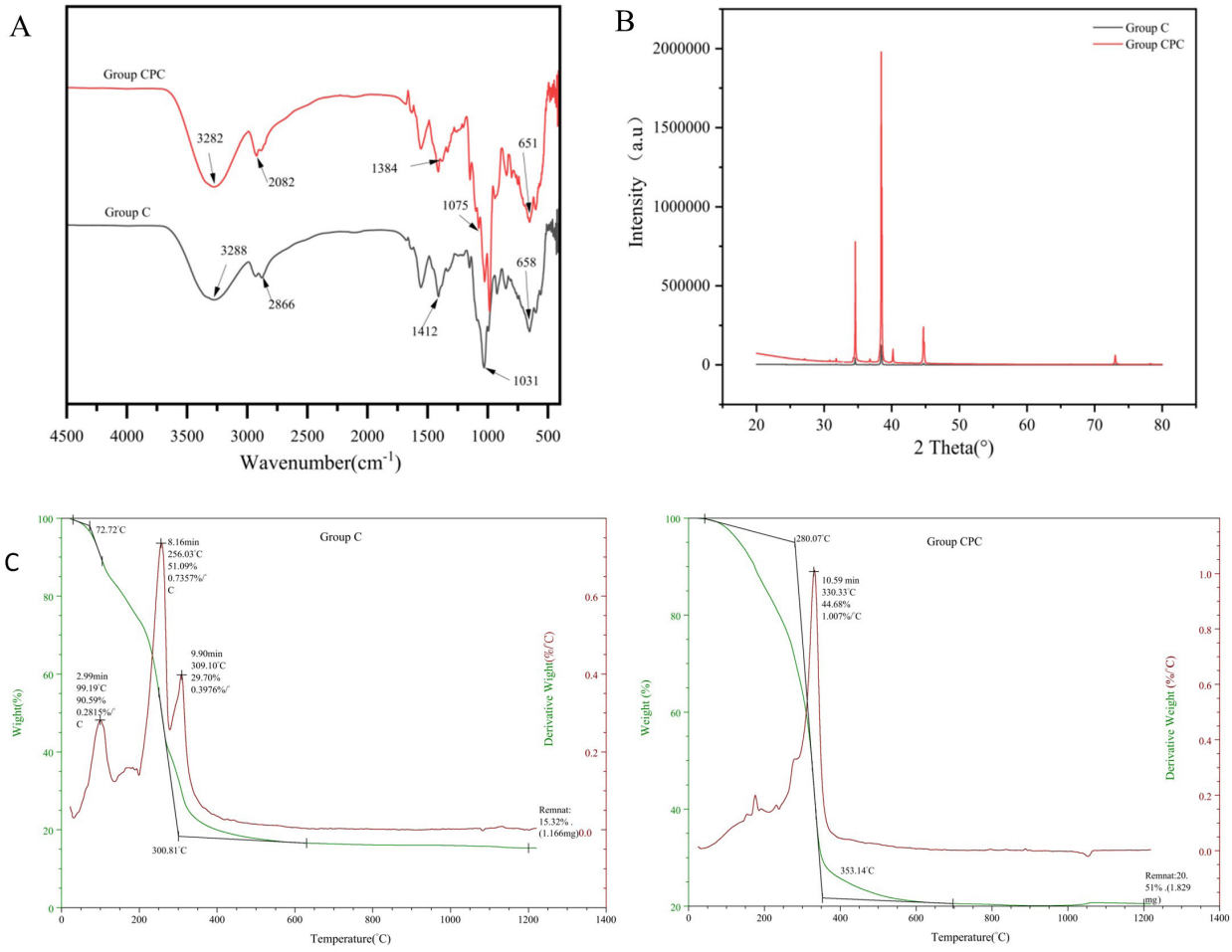

Figure 2. The FTIR spectrum (A), X-ray diffractogram (B) and thermal gravimetric curves (C) of the Group C and Group CPC.

Table 1. The barrier proerties of Group C and Group CPC.

Smaple	Thinkness (mm)	water vapor permeability (10^{-10} g/(Pa.m.s))	oxygen transmission rate *mol* / (m^2·*s*)
Group C	0.0518	2.24	0.075×10^{-16}
Group CPC	0.0628	1.13	0.0565×10^{-16}

Group C: chitosan coating; Group CPC: chitosan/γ- polyglutamic acid/curcumin coating.

higher content based on the SEM analysis, which could hinder the diffusion of water and oxygen molecules.

Antibacterial activity of coatings

The antimicrobial activity of coatings are presented in Figure 3. Both the Group C and Group CPC showed an antimicrobial effect on the five typical testing bacteria of *E. coli*, *S. aureus*, *L. monocytogenes*, *P. fluorescens* and *P. putida*. Compared to the Group C, the Group CPC exhibited a stronger antimicrobial activity. Previous studies have demonstrated that γ-PGA and curcumin had significant inhibition effect on the bacterial strains (Tao et al., 2021; Papadimitriou et al., 2018). In this study, the chitosan/γ-polyglutamic acid/curcumin coating presented a more pronounced inhibition effect of *E. coli*, *S. aureus*, *L. monocytogenes*, *P. fluorescens* and *P. putida*, which may be attributed to the incorporation of γ-PGA and curcumin.

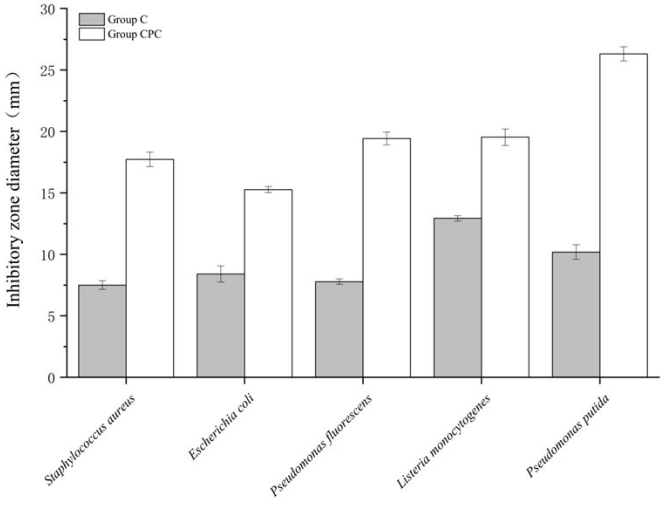

Figure 3. The diameter of inhibition zone against *E. coli*, *S. aureus*, *L. monocytogenes*, *P. fluorescens* and *P. putida* by the Group C and Group CPC.

3.2 Application of coatings in fresh beef preservation

Visual morphology of fresh beef during storage

The appearance of fresh beef within 7 days during storage at 4°C is shown in Figure 4. Meat color has been considered as an indicator of freshness and quality of meat, which influences the consumer preference to purchase fresh meat (Wang et al., 2018, 2021). Particularly, a bright red color is considered a positive attribute for freshness and superior quality of beef (Holman et al., 2016; Wang et al., 2022a). During storage, the color of Group N gradually turned from bright red to dark red since the 4th day and with a slight rancid smell. The color of Group C became grey and there was a slight pungent rancid smell on the 6th day. In contrast, the color of Group CPC kept bright red and had no spoilage phenomenon until the the 7th day.

Furthermore, the changes in color parameters *L*, *a*∗and *b*∗values of beef during storage at 4 °C are shown in Table 2. The L, a∗ and b∗ values of Group CPC were always significantly higher ($p < 0.05$) than that of Group C. The a* value was the red value of meat, which was mainly affected by the color and oxidation state of myoglobin in meat and is associated with consumer defined beef color acceptability. As shown in Table 2, the *a*∗ value of Group CPC maintained 24.08 on the 7th day, suggesting a desirable color acceptability. In contrast, the *a*∗ value of Group N was 14.61 on the 6th day, suggesting an undesirable color acceptability. The results revealed that the chitosan/γ-

Figure 4. The appearance of fresh beef within 7 days during storage at 4 °C. Group N: without coating, Group C: chitosan coating, Group CPC: chitosan/γ-polyglutamic acid/curcumin coating.

Table 2. The changes in color values of beef within 7 days during storage at 4 °C.

		Storage time						
		D1	D2	D3	D4	D5	D6	D7
Group N	L*	27.90 ± 0.81	27.34 ± 0.42	23.50 ± 1.39	21.65 ± 3.11	17.05 ± 2.03	15.51 ± 0.84	12.99 ± 0.49
	a*	32.68 ± 0.60	27.52 ± 1.30	26.48 ± 2.55	24.29 ± 1.36	18.09 ± 3.47	14.61 ± 0.73	12.32 ± 1.83
	b*	4.59 ± 0.79	3.64 ± 0.54	7.30 ± 0.54	0.51 ± 0.52	1.73 ± 0.32	-9.00 ± 0.45	-0.36 ± 1.72
Group C	L*	27.74 ± 0.88	28.26 ± 0.56	30.56 ± 0.86	30.26 ± 1.54	30.22 ± 1.02	30.34 ± 0.46	27.93 ± 0.65
	a*	33.76 ± 2.76	31.29 ± 1.05	29.41 ± 0.90	30.48 ± 5.57	25.01 ± 1.18	24.74 ± 3.18	22.7 ± 2.54
	b*	0.25 ± 0.51	-1.02 ± 0.07	-2.19 ± 0.11	0.35 ± 1.70	1.87 ± 1.34	1.56 ± 1.11	1.38 ± 0.10
Group CPC	L*	26.89 ± 0.10	25.77 ± 0.20	25.84 ± 0.28	26.26 ± 0.12	24.17 ± 0.75	25.34 ± 0.54	24.22 ± 1.11
	a*	36.11 ± 2.36	34.28 ± 3.21	33.06 ± 1.44	32.15 ± 8.15	26.65 ± 3.26	25.22 ± 1.84	24.08 ± 0.69
	b*	3.42 ± 0.29	3.78 ± 0.40	2.24 ± 0.18	4.54 ± 1.36	7.89 ± 0.54	15.04 ± 4.00	3.63 ± 1.30

Group N: without coating; Group C: chitosan coating; Group CPC: chitosan/γ- polyglutamic acid/curcumin coating.

polyglutamic acid/curcumin edible coating effectively maintained the beef color, which was conducive to freshness maintenance.

Quality of fresh beef during storage

The quality of fresh beef coud be reflected by some physical, chemical and microbial parameters such as weight, pH, TVB- N, and total viable counts. The freshness of beef could be evaluated by pH, which can be divided by the first degree (pH within 5.8-6.2) and the second degree (pH within 6.2-6.4). As shown in Figure 5A, the pH values of Group C increased markedly with the storage times extend, and increased from the initial 5.52 to 5.95. In contrast, the pH values of Group CPC maintained at a stable level (5.52-5.31) within the initial 5 days, and the pH values increased to 5.72. The results revealed that the chitosan/γ-polyglutamic acid/curcumin edible coating effectively maintained the pH value, which was conducive to freshness maintenance.

The changes in water-holding capacity of Group C and Group CPC during storage are shown in Figure 5B. The drip loss both in Group C and Group CPC significantly increased ($p < 0.05$) with storage time extension, in which the drip loss of Group CPC was lower than that of Group C at each time point of storage. The TVB-N concentration of Group C and Group CPC increased with storage time extension as shown in Figure 5C. The TVB-N concentration of Group N exhibited the highest rate of growth from 5.90 mg/100 g to 27.84 mg/100 g on the 7th day, and the TVB-N concentration increased up to 15.91 mg/100g on the 3rd day. In contrast, the TVB-N level of Group CPC was lowest among the three samples and still maintained 11.53 mg/100g on the 7th day. As shown in Figure 5D, the total viable counts in Group N had a slight increase within 3 days and then sharply increased to 8.11 lg CFU/g on the 6th day, suggesting that the sample has been seriously spoilage. Compared to Group N and Group C, the Group CPC presented good microbial quality

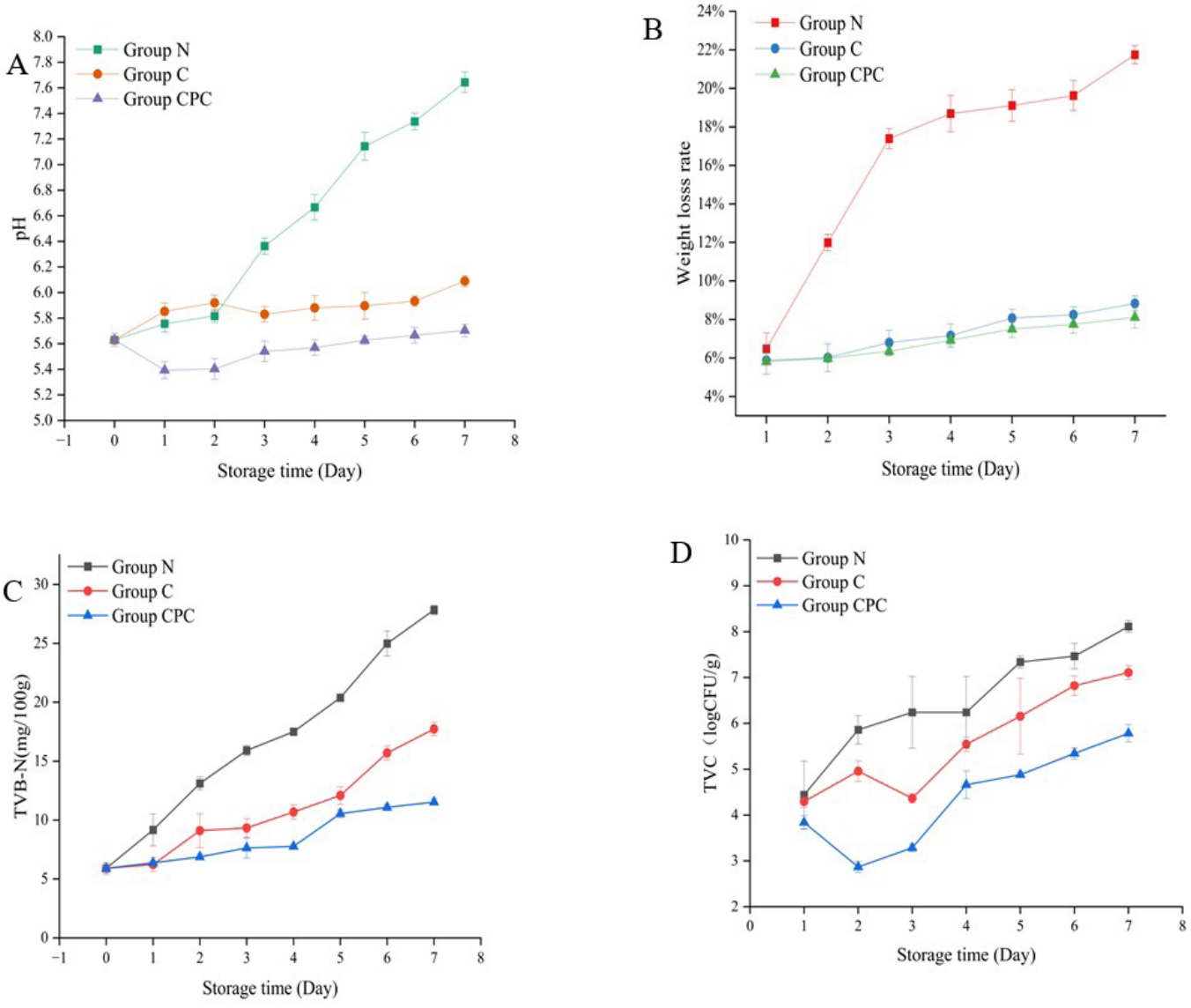

Figure 5. The changes of pH (A), weight loss (B), TVB-N (C) and TVC (D) in Group N Group C and Group CPC during storage at 4 °C.

with 5.75 lg CFU/g on the 6th day. Based on the results, the chitosan/γ-polyglutamic acid/curcumin edible coating could effectively prolong the shelf life of fresh beef.

Sensory quality of fresh beef

The sensory evaluation is a scientific discipline to evaluate the changes of raw meat quality during storage (Paglarini et al., 2020; Vidal et al., 2020). As shown in Figure 6, the Group CPC had the highest smell and overall impression scores among the three groups, showing a good appearance. The sensory analysis showed that the chitosan/ γ- polyglutamic acid /curcumin coating did not have a negative impact on consumer perception. The sensory evaluation is in agreement with these results of the color value, TVB- N level, and total viable counts.

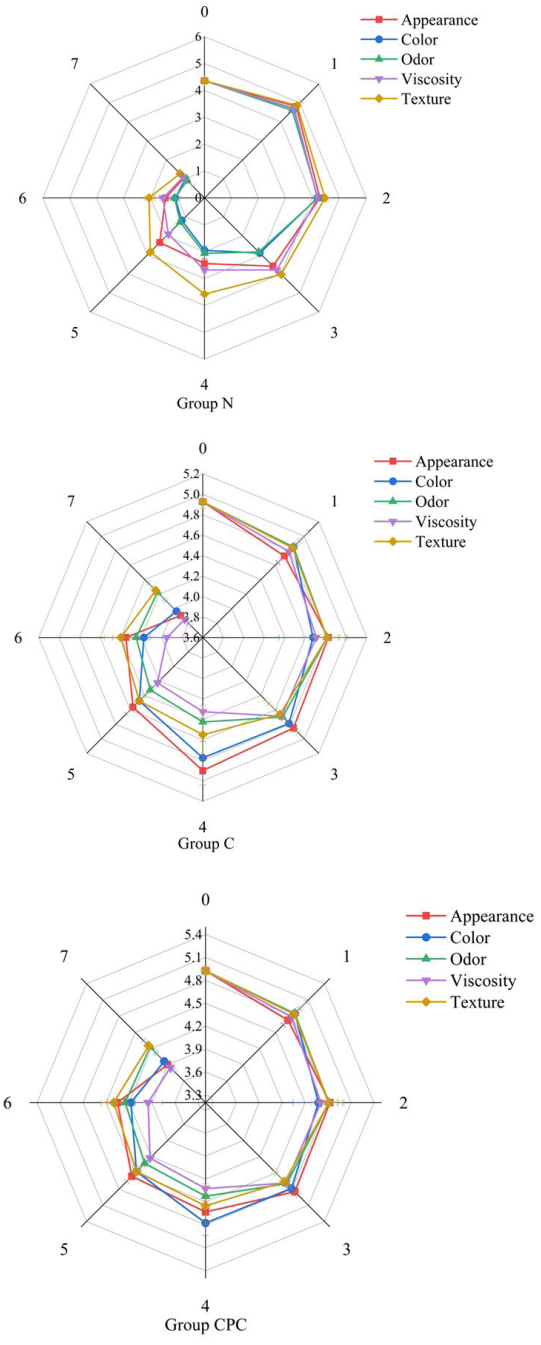

Figure 6. The radar map of sensory evaluation of of Group N, Group C and Group CPC during storage at 4 °C.

4 Conclusion

In this study, a chitosan based edible coating was prepared by incorporating γ-polyglutamic acid and curcumin. The characterization of the chitosan/γ-polyglutamic acid/curcumin edible coating, including physical, mechanical and antimicrobial properties, were investigated. The γ-polyglutamic acid and curcumin incorporation greatly improved the performance of chitosan coating, including coating formation and antimicrobial activity. Furthermore, the chitosan/γ- polyglutamic acid/curcumin edible coating had an excellent antibacterial effect on *E. coli*, *S. aureus*, *L. monocytogenes*, *P. fluorescens* and *P. putida*, and inhibited the microbial growth in fresh beef and the total viable counts was less than 6 lg CFU/g. The chitosan/γ-polyglutamic acid/curcumin edible coating was conducive to prolonging the shelf life of beef with good quality compared to pure curcumin edible coating. These results revealed that application of chitosan/γ-polyglutamic acid/curcumin edible coating will be a good way to preserve freshness of beef.

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