Cellular and Molecular Biology

Wang and Sun *Cell. Mol. Biol.*2016, 62 (13): 44-48
ISSN: 1165-158X
doi: 10.14715/cmb/2016.62.13.8

Original Research

Preservation effect of meat product by natural antioxidant tea polyphenol

W-D. Wang, Y-E. Sun*

College of Food Engineering, Xuzhou Institute of Technology, XuZhou, Jiangsu Province, China

Abstract: 1% of tea polyphenol, chitosan solution and potassium sorbate were used as film-forming materials to coat chilled mutton. Total coliforms, TVB-N value and pH value were determined and used as the mutton fresh-keeping indexes. The results showed that after 12th day at the end of the storage, mutton coated with tea polyphenol had best effects comparing chitosan solution and potassium sorbate. pH value of mutton coated by tea polyphenol was 6.0, TVB-N and the total coliforms were both significantly lower than the meat coated by chitosan solution and potassium sorbate. Also, mutton coated by tea polyphenol accorded with the requirements of national standards about fresh meat quality. In summary, the tea polyphenol film was the most suitable film on chilled mutton coating preservation among the three chemicals used in this research.

Key words: Tea polyphenol, chitosan solution, potassium sorbate, coliform, coating preservation.

Introduction

Coating preservation of meat refers to steeping the meat in coating solution, or spraying the coating solution on surface of the meat, to form a layer of film on the meat surface, thus the gas environment beyond the surface is changed to effectively prevent the loss of sap (1-3). The intracellular material permeability is controlled to inhibit the growth of microorganisms, so the meat retains freshness and is protected against decay. Currently, the film forming materials that have been widely used in the field of food preservation include chitosan (1-8), sodium alginate (9,10), tea polyphenol (10-17), carboxymethyl cellulose (18), starch and propolis (6,15). The fresh-keeping film for meat preservation was studied in the late 19th century, the gelatin liquid coated on the meat surface is able to form a layer of film and prolong the shelf life of fresh meat, and prevent the meat from decay (13,16,17).

Many countries have introduced meat coating preservative, which is coated on the meat surface to effectively extend the shelf life of meat. Ming used cellulose membrane containing pediocin or Nisin to cover the surface of ham, beef and turkey to retain freshness, this method effectively inhibited growth of L.monocytogenes (19). Sirugusa added Pediococcus and lactic streptococci into soy protein and zein soluble protein and added organic acid to calcium alginate film to coat meat products for preservation, which inhibit the growth of pathogenic and spoilage bacteria (20). Moreover, sodium alginate solution has been applied to soak fresh pork samples for preservation at normal and lower temperatures (9,10). Chitosan has been used as a fresh-keeping material to coat on the fresh pork or sauce beef for preservation (4-8). Corn alcohol soluble protein containing phytic acid, citric acid and ethanol was used to soak fresh beef for low temperature storage (17,18). These studies have proved that coating preservation has practical significance and feasibility. However, the effects of present coating preservation technologies are not ideal, there are still many problems in application and promotion. The use of film-forming materials needs to be further investigated.

In this study, tea polyphenol, chitosan solution and potassium sorbate were used as film-forming materials to coat chilled mutton. Total bacterium counts, TVB-N value, pH value were determined and used as the mutton fresh keeping indicators to investigate the effect of meat preservation and find the best coating preservation material for chilled mutton.

Materials and Methods

Chilled mutton was purchased in local Wal-Mart supermarket. Tea polyphenol, chitosan solution and potassium sorbate are all edible grade. Acetic acid, glycerin, light magnesium oxide, boric acid, bromocresol green - methyl red indicator and nutrient agar are pure analysis. The solution was prepared and stirred using an OS20-Pro electric blender from Shanghai Jingtian Chengshi experiment instrument factory. The absorption spectra were acquired on a Beckman DU640 UV-Vis spectrophotometer. Color difference of meat was determined with an NR60CP colorimeter supplied by Shenzhen 3nh Technology Co Ltd. pH values of the meat samples were determined with a 4-star portable pH meter from Beijing Kerui Scientific Equipment Co Ltd.

Preparation of film solutions

Tea polyphenol (1 g) and potassium sorbate (1 g) are dissolved in 100 ml distilled water respectively to prepare the solutions at concentration of 1%. chitosan was dissolved in 100 ml of 0.5% acetic acid solution and stirred with electric mixer at 60 °C in water bath, followed by swelling and ultrasonic degassing. All solutions were stored at 5 °C in a fridge.

Received August 10, 2016; **Accepted** November 20, 2016; **Published** November 30, 2016

*** Corresponding author:** Yue-E Sun, DCollege of Food Engineering, Xuzhou Institute of Technology, 2 Lishui Road, XuZhou, Jiangsu Province, China. Email: yueesun@163.com

Samples preparation

The knives and chopping board were sterilized with alcohol and irradiated with ultraviolet lamp for 30 min. Under aseptic conditions, the chilled mutton bought from supermarket was cut into 50 pieces (each one was about 2 cm thick and around 50 g), the samples were randomly divided into 10 groups with 5 samples in each group, and treated with various film solutions and sterile distilled water (for control group) respectively. The meat samples were dried in a sterile room for 30 min and covered with PVC film. The samples were then transferred into plastic boxes and stored in fridge at temperature of 4-5 °C. Various indexes were determined after 1, 3, 7, 12 and 20 days. The meat samples used for control group were decay after two weeks.

Determination methods

The total number of bacteria was determined according to national standards of food hygiene microbiology GB501d.6-05 using the plate count method, the results were expressed as Log values. Evaluation criteria: total coliform counts below 5 represents fresh meat, the counts between 5 and 8 represents semi-fresh meat, if the counts is greater than 8, then the meat is decay. The culture condition was 25 °C for 2 days, the nutrient agar was used as medium.

Juice loss percentage (%) was calculated by the ratio of juice loss amount and the weight of raw meat. The fresh mutton samples were taken and weighed, the total mass (M1) includes the mass of packaging box, film, meat and juice. The meat was carefully taken after cutting the covering film and loaded into a plate for sensory evaluation, the transudatory juice still remained in box, then the box was weighed again to obtain the weight (M3) of packing box, film and juice. The juice was then removed and the weight (M2) of packaging box and film was determined. Juice loss percentage (JL) was obtained by the equation, JL (%) = [(M3-M2)/(M1-M3)]*100%.

pH value of mutton was determined by a pH meter according to the national standards GB/T1247.3-2002. The ranges of pH value of 5.3-6.4, 6.5-6.8 and above 6.9 represent the meat is fresh, semi-fresh and decay, respectively.

The volatile basic nitrogen (TVB-N) value was determined by semi-automatic Kjeldahl method. The ranges of reference of less than 15 $mg \cdot 100g^{-1}$, less than 20 $mg \cdot 100g^{-1}$ and above 20 $mg \cdot 100g^{-1}$ represent the meat is fresh, semi-fresh and decay, respectively.

Statistical analysis

The software SPSS 15.0 was used for statistical analysis and data processing. The experimental results were expressed by mean ±SD. Single-factor Analysis of Variance (ANOVA) was used to compare the difference between the control group and the experimental group; $p<0.05$ indicates that there are no significant differences.

Results

Changes of the loss rate of mutton juice in coating preservation

The main reason for the loss of meat juice is the irreversible change of protein colloid, which makes the water in the gel structure can not be held and flow out of the tissue. It can be seen from Figure 1 that the loss rates of mutton juice for experimental groups exhibit an increasing tendency, the control group lost a lot of meat juice, the weight loss rate of untreated chilled mutton is significantly high. Juice loss percentage of experimental groups treated by chitosan and tea polyphenol was slightly better than juice loss percentage of chitosan and potassium sorbate, probably because chitosan and tea polyphenol edible film can covered the whole block of chilled mutton surface to prevent loss of meat juice. Therefore, water evaporation of the meat was reduced to a certain extent, which effectively avoid the loss of weight. While in the late stage of storage, juice loss percentage of chitosan coating group was less than that of tea polyphenol coating group, presumbably due to the special molecular structure and water soluble difference of chitosan. Tea polyphenol has the water absorptivity, juice loss percentage of tea polyphenol coating group was more serious comparing chitosan coating group with the extension of time.

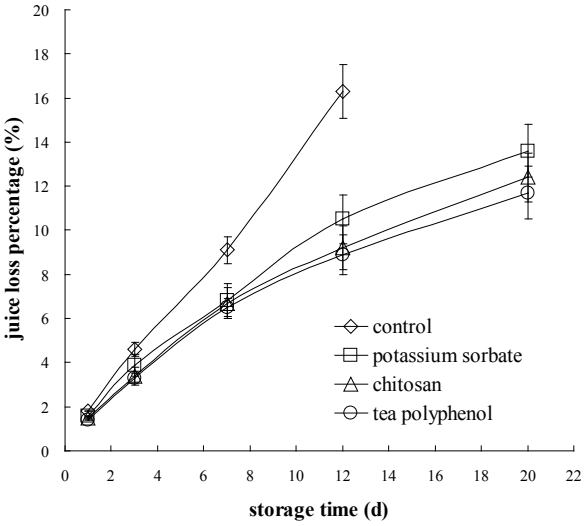

Figure 1. Changes of juice loss of chilled mutton in coating preservation.

Changes of pH value of mutton in coating preservation

As shown in Figure 2, pH value of fresh mutton is around 5.4-5.7. With the extension of storage time, protein is broken down into basic amine and ammonia, the pH value gradually increases, and the degree of decay also increases. The pH increment of control group was significantly higher than that of experimental groups, after one week the pH value of meat in control group was beyond maximum pH of 6.8 for fresh meat. However, the pH value of the fresh mutton coated by chitosan still maintained at around 5.8. The reason can be attributed to two aspects. First, chitosan itself and the dilute acetic acid which dissolve chitosan have bacteriostasic activity, which slowed down the decomposition rate of protein; Second, dilute acetic acid reduces pH of mutton samples as a whole, while mutton coated by tea polyphenol and potassium sorbate showed no significant difference in changing tendency of pH value. The pH reaches upper limit of fresh meat (pH=6.8) in approximately 12 days, indicating that tea polyphenol

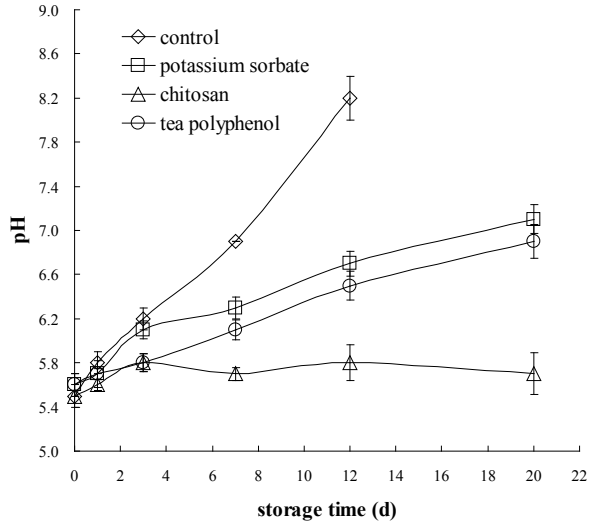

Figure 2. Changes of pH of chilled mutton in coating preservation.

and potassium sorbate coating has obvious fresh-keeping effect ($p<0.05$).

Changes of the volatile basic nitrogen (TVB-N) value of mutton in coating preservation

Figure 3 shows that TVB-N values from all groups exhibit an increasing tendency with the extension of storage time. This result is probably due to the production of alkaline substances such as nitrogen and amines resulting from decomposition of protein in mutton under the action of enzymes and bacteria. TVB-N values of all experimental groups were significantly lower than that of control group. For control group, TVB-N value reached 17 mg•100g^{-1} on the 7th day, and reached 25 mg•100g^{-1} on the 12th day, respectively, which significantly higher than the grade of fresh mutton. Potassium sorbate coating group did not show any obvious effects, but TVB-N values from tea polyphenol and chitosan coating groups were still less than 20 mg•100g^{-1} on the 12th day and maintained within the acceptable range for fresh meat, the differences were significant ($p<0.05$). The increasing rate of tea polyphenol coating group is slightly slower than chitosan coating group, probably due to the higher viscosity of tea polyphenol film, which formed a more homogeneous and compact film on the surface of the mutton. Consequently it has a better effect on oxygen wan moisture resistance, and effectively inhibits the growth of bacteria to relieve decomposition rate of protein.

Changes of total coliforms of mutton in coating preservation

The changes of total coliforms with storage time from all groups are shown in Figure 4. The total number of coliforms of fresh mutton is approximately 4.3. After a long period of storage, the number from all groups exhibited an increasing tendency. Especially for control group, the total number of coliforms increased dramatically. The antibacterial effect of potassium sorbate coating group was not as good as the other two groups. The total number of coliforms on the 12th day was still less than 5.5 for tea polyphenol and chitosan coating groups. Therefore, tea polyphenol and chitosan film can effectively inhibit the increase of total number of coliforms of mutton and extend the preservation time. The antibacterial effect of tea polyphenol group was better than that of chitosan group, because chitosan itself is an antibacterial substance, and chitosan can dissolve in dilute acetic acid, the acid solute also has a certain inhibitory effect.

Discussion

The strength and flexibility of potassium sorbate film is good, and the film has a bright and clean surface, good transparency and resistance to oxygen, potassium sorbate film can be applied for preservation of fruits, vegetables, candy, nuts and meat products (21-27). In this study, potassium sorbate film was used for coating preservation of mutton, the results show that it can improve the total coliforms and TVB-N value, but the effect is not that obvious, the possible reason is that the membrane liquid and the surface of mutton did not closely contact with each other, it was failed to form a complete and uniform structure of membrane. Also, it is possible that the membrane permeability of potassium sorbate is higher. The film is easy to expand and damage

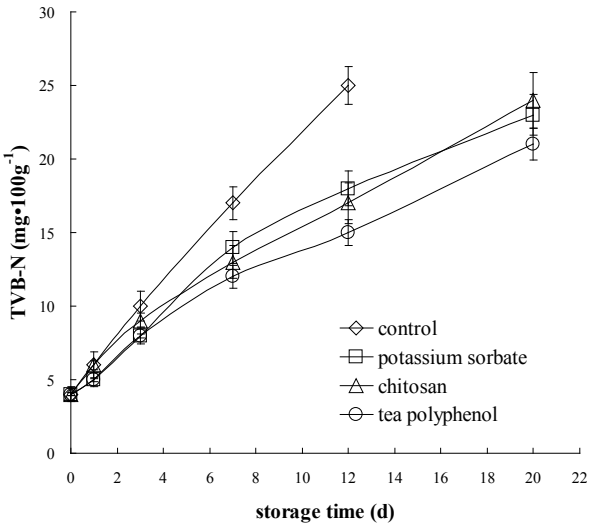

Figure 3. Changes of TVB-N values of chilled mutton in coating preservation.

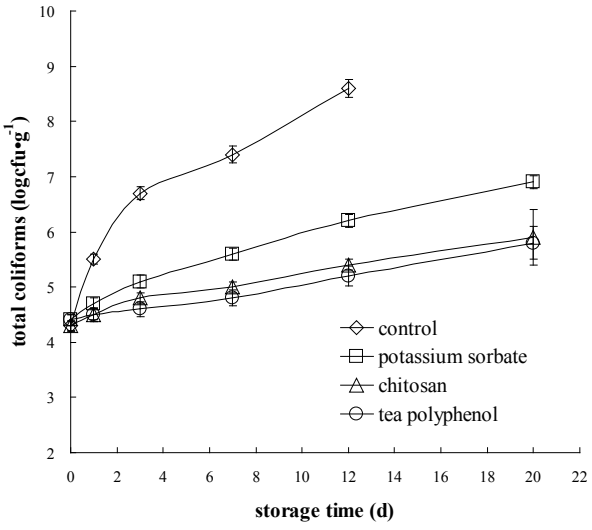

Figure 4. Changes of total coliforms of chilled mutton in coating preservation.

when it contacts with water, and the water content of the chilled mutton is high. In addition, it was also found that the meat of potassium sorbate film coated mutton became more and more stiff and was not acceptable for food with the extension of storage time, which might also due to the high permeability of the film. Therefore, the film is not suitable for the preservation of mutton.

Chitosan has been widely used in the storage of fruits and vegetables as well as meat products because of its good performance (1-8). Chitosan itself has the antibacterial effect. The increase of total coliforms suggested that the mutton preserved by chitosan membrane liquid coating can delay the growth time of coliforms and reduced the total coliforms in mutton during the process of storage. However, TVB-N value, color effect were not very good probably because the chitosan membrane and the mutton were not closely contact with each other, the resulting film has poor physical properties, which can not completely resist oxygen. In addition, due to the use of the dilute acetic acid solution, the volatilization of a small amount of acetic acid during the process of storage will hamper the flavor of mutton. Therefore, chitosan is not suitable for the preservation of chilled mutton.

In this study, the effect of tea polyphenol film coating preservation is the best, presumably because the main antibacterial mechanism of film preservation is the role of the barrier of external coliforms and resistance to oxygen and moisture (11-17). Tea polyphenol solution is highly viscous, it can be better coated on the surface of the mutton to form a layer of dense and complete membrane. On the one hand, the mechanical properties of the film play a significant role to meat preservation; On the other hand, the barrier effect of the membrane has been fully exhibited. However, the loss amount of mutton juice is larger with the extension of storage time due to the strong water absorption of tea polyphenol. The technology needs to be modified for better performance of meat preservation.

Three different films were investigated for coating preservation of mutton in refrigerated conditions. The results showed that the fresh-keeping effects of coating with tea polyphenol are best among the three films. Comparing the control group, tea polyphenol coated mutton can extend the shelf life for around one week. Total coliforms, TVB-N value, etc were obviously lower than those of the control group. The comprehensive preservation effects are better than chitosan and potassium sorbate membrane.

Acknowledgements

This research was funded by “major projects of natural science research in Universities of Jiangsu Province (13KJA550002)” and sponsored by “Qing Lan Project”.

References

1. Mi FL, Shyu SS, Wu YB, Lee ST, Shyong JY, Huang RN. Fabrication and characterization of a sponge-like asymmetric chitosan membrane as a wound dressing. Biomaterials, 2016, 12(1):1-14.

2. Bai H, Zhang H, He Y, Liu J, Zhang B, Wang J. Enhanced proton conduction of chitosan membrane enabled by halloysite nanotubes bearing sulfonate polyelectrolyte brushes. Journal of Membrane Science, 2014, 454(454):220–232.

3. Ma B, Qin A, Li X, Zhao X, He C. Bioinspired design and chitin whisker reinforced chitosan membrane. Materials Letters, 2014, 120(120):82–85.

4. Rangel-Rodríguez A M, Conxita S, Susana V, Flores-Gallardo SG, Contreras-Esquivel JC, Licea-Jiménez L. Immobilization of pectinesterase in genipin-crosslinked chitosan membrane for low methoxyl pectin production. Applied Biochemistry & Biotechnology, 2014, 174(8):2941-2950.

5. Ramasamy P, Shanmugam A. Characterization and wound healing property of collagen–chitosan film from Sepia kobiensis. International Journal of Biological Macromolecules, 2014, 74:93-102.

6. Rubentheren V, Ward T A, Chee C Y, Nair P. Physical and chemical reinforcement of chitosan film using nanocrystalline cellulose and tannic acid. Cellulose, 2015, 22(4):2529-2541.

7. Saito Y, Luchnikov V, Inaba A, Tamura, K. Self-scrolling ability of differentially acetylated chitosan film. Carbohydrate Polymers, 2014, 109(9):44-48.

8. Qin YY, Zhang ZH, Li L, Yuan ML, Fan J, Zhao TR. Physiomechanical properties of an active chitosan film incorporated with montmorillonite and natural antioxidants extracted from pomegranate rind. Journal of food science and technology, 2015, 52(3):1-9.

9. Yeom C K, Lee K H. Characterization of sodium alginate membrane crosslinked with glutaraldehyde in pervaporation separation. Journal of Applied Polymer Science, 1998, 67(67):209-219.

10. Chiabrando V, Giacalone G. Effect of chitosan and sodium alginate edible coatings on the postharvest quality of fresh-cut nectarines during storage. Fruits, 2016, 71(2):79-85.

11. Fan W, Chi Y, Zhang S. The use of tea polyphenol dip to extend the shelf life of silver carp (Hypophthalmicthys molitrix) during storage in ice. Food Chemistry, 2008, 108(1):148-153.

12. Lambert JD, Hong J, Kim DH, Mishin VM, Yang CS. Piperine enhances the bioavailability of the tea polyphenol (-)-epigallocatechin-3-gallate in mice. Journal of Nutrition, 2004, 134(8):1948-52.

13. Liang HH, Huang HH, Kwok KC. Properties of tea-polyphenol-complexed bromelain. Food Research International, 1999, 32(8):545-551.

14. Huang Q, Hao L, Xie J, Gong T, Liao J, Lin Y. Tea Polyphenol-Functionalized Graphene/Chitosan as an Experimental Platform with Improved Mechanical Behavior and Bioactivity. Acs Applied Materials & Interfaces, 2015, 7(37):20893-20901.

15. Shen F, Niu F, Li J, Su Y, Liu Y, Yang Y. Interactions between tea polyphenol and two kinds of typical egg white proteins-ovalbumin and lysozyme: Effect on the gastrointestinal digestion of both proteins in vitro. Food Research International, 2014, 59(4):100–107.

16. Liu F, Antoniou J, Li Y, Yi J, Yokoyama W, Ma J, et al. Preparation of Gelatin Films Incorporated with Tea Polyphenol-Nanoparticles for Enhancing Controlled Release Antioxidant Properties. Journal of Agricultural & Food Chemistry, 2015, 63(15):3987–3995.

17. Tao YY, Shu KY, Zhang CM, Xu CD. Using the Tea Polyphenol and Chitosan to Preserve Cherry and the Study on Their Preservation Effect. Food Research & Development, 2014, 8:115-119.

18. Segovia-Bravo K A, Lopez-Lopez A, Garcia-Garda P. Effect of bruising on respiration, superficial color, and phenolic changes in fresh Manzanilla olives (Olea europaea pomiformis): development of treatments to mitigate browning. Journal of Agricultural & Food Chemistry, 2011, 59(10):5456-64.

19. Ming X, Weber G H, Ayres J W, et al. Bacteriocins applied to food packaging materials to inhibit Listeriamono cytogenes on meats. Journal of Food Science, 1997, 62(2): 413-415.

20. Siragusa G R, Cutter C N, Willett J L. Incorpo-ratio no bacteriocin in plastic retains activit yand inhibits surface growth of bacteria on meat. Food Microbiology, 1999, 16: 229-235.

21. Casas E, Ancos BD, Valderrama MJ, Cano P, Peinado JM. Pentadiene production from potassium sorbate by osmotolerant yeasts.

International Journal of Food Microbiology, 2004, 94(1):93-96.
22. Barzegar H, Azizi M H, Barzegar M, Hamidi-Esfahani Z. Effect of potassium sorbate on antimicrobial and physical properties of starch–clay nanocomposite films. Carbohydrate Polymers, 2014, 110(18):26-31.
23. Liu K, Wang X, Young M. Effect of bentonite/potassium sorbate coatings on the quality of mangos in storage at ambient temperature. Journal of Food Engineering, 2014, 137(8):16-22.
24. Aouadhi C, Mejri S, Maaroufi A. Inhibitory effects of nisin and potassium sorbate alone or in combination on vegetative cells growth and spore germination of Bacillus sporothermodurans in milk. Food Microbiology, 2015, 46(101):40-45.
25. Parjo UK, Sunar NM, Leman AM, Gani P, Emparan Q, Er CM. Coating Bio-Resistance Test of Different Wall Finishing for Isolated Indoor Fungal Treatment by Using Potassium Sorbate Biocide on Wood. Applied Mechanics & Materials, 2015, 773-774(2015):1384-1388.
26. Mehyar GF, Al-Qadiri HM, Swanson BG. Edible Coatings and Retention of Potassium Sorbate on Apples, Tomatoes and Cucumbers to Improve Antifungal Activity During Refrigerated Storage. Journal of Food Processing & Preservation, 2014, 38(1):175–182.
27. Kowalczyk D, Kordowska-Wiater M, Sołowiej B, Baraniak, B. Physicochemical and Antimicrobial Properties of Biopolymer-Candelilla Wax Emulsion Films Containing Potassium Sorbate - A Comparative Study. Food & Bioprocess Technology, 2014, 8(3):1-13.