EJFA Emirates Journal of Food and Agriculture

Emirates Journal of Food and Agriculture 36: 1–5
doi: 10.3897/ejfa.2024.122768

RESEARCH PAPER

Preservative effect of tea polyphenols and hydrogen peroxide on quality of chilled meat

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Academic editor: R. Subramanian ♦ **Received** 11 March 2024 ♦ **Accepted** 22 August 2024 ♦ **Published** 21 October 2024

Abstract

The aim of this study was to research the effect of different preservatives on quality and shelf life of fresh chilled meat stored at 4 °C for 12 days. This study used tea polyphenols (0.2%) and hydrogen peroxide (1.27 g/L) to treat chilled pork and measured its pH, TVB-N, TBARS, the total viable bacteria count (TVC) and sensory score. The results showed that the treatments with tea polyphenols and hydrogen peroxide significantly ($p < 0.05$) inhibited the growth of TVC on fresh chilled pork. The TVC of sample treated with tea polyphenols and hydrogen peroxide increased from initial value 3.2 to 6.0 log CFU/g after 10 and 12 days, respectively. It was also found in pH, TVB-N, TBARS and sensory measurement that the tea polyphenols and hydrogen peroxide treatment could extend the storage period of chilled meat as well as hydrogen peroxide was slightly better than tea polyphenols. It could be suggested that both tea polyphenols and hydrogen peroxide treatment has great potential to extend the shelf life of fresh chilled pork.

Keywords

pork, preservative, TVC, shelf life

Introduction

Chilled meat is a kind of fresh meat that the carcass of slaughtered animals is rapidly cooled to 0–4 °C within 24 hours in strict accordance with the requirements of the quarantine system, and is always maintained in the range of 0–4 °C during the subsequent production, circulation and retail process (Baltic and Boskovic 2015). The chilled meat possesses excellent flavor and boasts a high nutritional content that overcomes the defects of frozen meat and hot fresh meat (Ayhan and Brahim 2020). So it is welcomed by the majority of consumers. During the circulation of chilled meat, it is always kept at the low temperature of 0–4 °C, which inhibits the growth of most microorganisms (Chang et al. 2019). However, the surface of chilled meat still exist spoilage microorganisms, particularly cold-tolerant ones capable of thriving at low temperatures, thereby leading to a limited shelf life for chilled meat (Sánchezortega et al. 2014; John et al. 2018). The way seriously affected the sale of chilled meat. How to extend the shelf life of chilled meat is a hot issue in recent year.

Fresh-keeping agent is one of the common methods in food preservation at present. According to the different sources, there are two main types of preservatives: chemical preservatives and natural preservatives. Biological preservatives are non-toxic, easy to extract, and good antibacterial effects (Veronica et al. 2017; Hussain et al. 2021). Tea polyphenols are most commonly use of biological preservative and have antibacterial and antioxidant activities (Ma et al. 2021; Zhang et al. 2021). Chemical preservatives are high purity, less impurities and good stability (Nagma et al. 2020). In particular, hydrogen peroxide is widely used because of its good bactericidal effect and no residue (John et al. 2018). However, there are few comparative studies on the two types of preservatives.

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Therefore, the research used biological preservatives (tea polyphenols) and chemical preservatives (hydrogen peroxide) respectively to deal with chilled pork, and measured its sensory, physical and chemical and microbiological index with storage time, so as to determine the effects of different preservatives on the quality of chilled pork. The way would provide some reference for extending the shelf life of chilled meat.

Materials and methods

Materials

Fresh pork tenderloin material was obtained from the local market (Yantai, Shandong, China), stored in ice and transported back to the laboratory. The meat was cut into pieces with uniform size (2 cm × 2 cm × 2 cm) of approximately 10 g after removing the intramuscular fat and visible connective tissues. Food-grade tea polyphenols was purchased from Nantong Tianxiang Biological Engineering Co., Ltd. (Jiangsu, China). Food-grade hydrogen peroxide was purchased from Jinan Shunyang Chemical Technology Co., Ltd. (Jinan, China). Other reagents were all analytical grade and commercially available.

Material treatment

Based on the previous research of this topic (Vyrostkova et al. 2020; Wang et al. 2023), the optimal concentrations of tea polyphenols and hydrogen peroxide were 0.2% and 1.27 g/L, respectively. The pieces of fresh chilled pork were dipped into different antimicrobial solutions including distilled water (control group), 0.2% tea polyphenol solution and 1.27 g/L hydrogen peroxide solution for 20 min, respectively. The ratio of meat to the treatment solution was 200:1 (g:L). The sample were subsequently drained, transferred into a transparent crisper and stored in a refrigerator at 4 °C for quality measurement. Each treatment was parallel three times for the purpose of conducting quality testing.

pH measurement

The pH value of the samples was determined according to the methods described by Chang et al. (2019).

Total volatile basic nitrogen (TVB-N) measurement

The semimicro-Kjeldahl method was used to determine the TVB-N content of chilled meat according to the Chinese standard (GB/T5009.44).

Thiobarbituric acid-reactive substance (TBARS) assay

The methods described by Witte et al. (1970) were used to measure the TBARS value of the samples.

Bacterial assay

10 g of samples were taken and placed into a sterile stomach bag with 90 mL 0.9% sterile saline. After the sample was homogenized by the stomach machine for 2 min, a 10-fold continuous diluent (using 0.9% sterile saline) was prepared for the following determination. 0.1 mL aliquot from each dilution was plated onto standard plate count agar. The plates were incubated at 37 °C for 48 h and colonies were counted and expressed as log CFU/g.

Determination of sensory profile

The assessment was performed every other day by 10 sensory evaluators specializing in food science, using the 1–9 descriptive hedonic scale (9 is the highest sensory quality, whereas 1 is lowest sensory quality) (Li et al. 2013). Sensory scores were assigned to six sensory parameters (odor, color, elasticity, viscosity, texture and effluent of the pork).

Statistical analysis

All experiments were conducted in three repetitions. Results were presented as means ± SD. Origin 7.0 software was used for data analysis. Significant differences were analyzed using based on Duncan's multiple-range test, and $p < 0.05$ indicated significant differences.

Results and discussion

The effect of different preservatives on pH

pH value is one of the key indicators to measure the quality and freshness of chilled meat (Chang et al. 2019). Fig. 1 showed that the pH of all groups was increased with time significantly ($p < 0.05$). However, the treatment groups had better effect to inhibit the rising of pH ($p < 0.05$). According to the Chinese standard (GB/T 9695.5), the pH value of meat was > 6.7 at the end of the shelf life. The initial value of controls was 5.6 and the final value reached to 6.7 after 8 days. However, the tea polyphenols treatment group reached 6.75 after 10 days, which was later 2 days

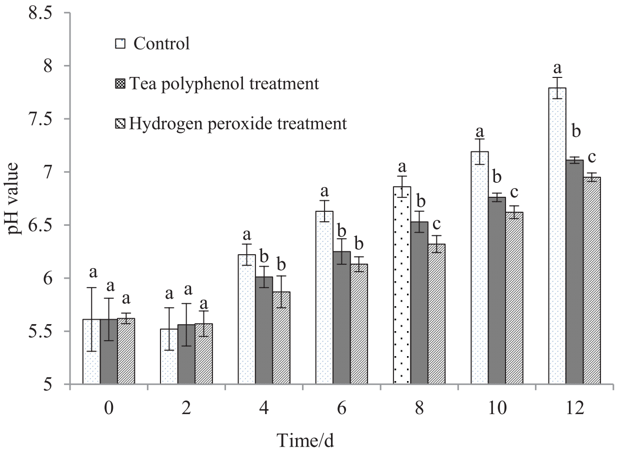

Figure 1. The effect of different treatments on the pH of the chilled meat during storage.

than the control group and hydrogen peroxide treatment was later 4 days. The main reason was that tea polyphenols and hydrogen peroxide could inhibit the protein decomposition for preventing pH value increasing (Sallam et al. 2004; Zhao et al. 2019).

The effect of different preservatives on TVB-N

TVB-N, which is mainly composed of ammonia and primary, secondary and tertiary amines, is always used as an indicator of meat spoilage (Cao et al. 2013). The TVB-N values of the three groups were all increased during storage ($p < 0.05$) (Fig. 2). However, the control group was higher than treatment group significantly during storage ($p < 0.05$). The tea polyphenol has a better effect on oxygen wan moisture resistance, and effectively inhibits the growth of bacteria to relieve decomposition rate of protein (Wang et al. 2016). Hydrogen peroxide had strong oxidation that inactivated spoilage bacteria for preventing the degradation of proteins and amino acids (Vyrostkova et al. 2020). According to the Chinese standard (GB/T 9959.1), when TVB-N > 20 mg/100 g, the meat reached the end of shelf life. The TVB-N value of control group increased from 8.24 to 20.15 mg/100 g after 8 days. The TVB-N value of tea polyphenols treatment after 10 days and hydrogen peroxide treatment after 12 days were all more than 20 mg/100 g. Hydrogen peroxide treatment group was better than tea polyphenols treatment group ($p < 0.05$). The reason was that hydrogen peroxide was more effective than tea polyphenols in inhibiting bacteria.

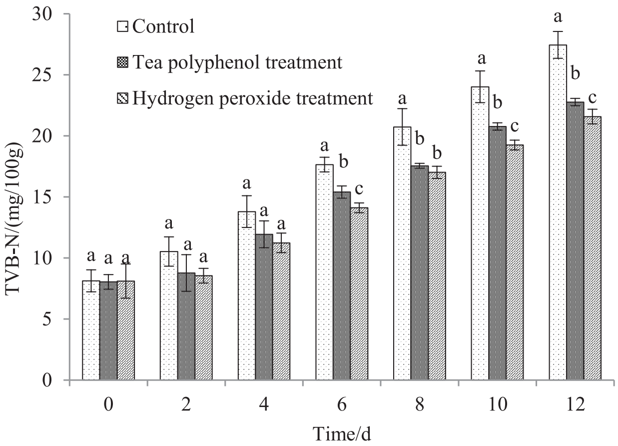

Figure 2. The effect of different treatments on TVB-N of the chilled meat during storage.

The effect of different preservatives on the TBARS

TBARS could be used to indicate the degree of lipid oxidation of meat (Xiong et al. 2015). As shown in Fig. 3, the value of TBARS of chilled meat increased during storage ($p < 0.05$). The oxidation rate of control group was higher than treatment groups ($p < 0.05$). Tea polyphenols and hydrogen peroxide can inhibit enzymes involved in fat oxidation, thereby preventing excessive oxidation of fat (Tang

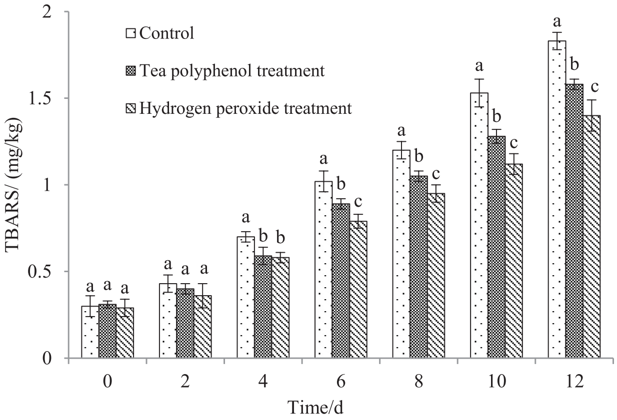

Figure 3. The effect of different treatments on TBARS of the chilled meat during storage.

et al. 2001; Hernandez et al. 2019). According to the general standard of TBARS value of chilled meat (Suman et al. 2010), the meat reached the end of shelf life when TBARS > 1.000 mg/kg. The control group increased from 3.12 to 1.00 after 6 days, tea polyphenol treatment group after 8 days and the hydrogen peroxide treatment group after 8 days were all bigger than 1.000 mg/kg, indicating that the preservative could slow down the fat oxidation and reduce the deterioration rate of chilled meat.

The effect of different preservatives on TVC

The growth of microorganism is one of the main causes of meat spoilage. During storage, chilled meat was easily contaminated by psychrophile such as *Pseudomonas* spp., thermophores, lactic acid bacteria and so on, resulting in meat spoilage (Li et al. 2021). Fig. 4 showed that the value of TVC of chilled meat increased during storage ($p < 0.05$). However, the control group was significantly higher than treatment group during storage ($p < 0.05$). Tea polyphenols and hydrogen peroxide could change cell morphology, retard protein synthesis and expression, and damage genetic material that inhibit the growth of bacterium (Checinska et al. 2011; Zhao et al. 2019). According to the Chinese standard (GB/T 18406.3), the meat was

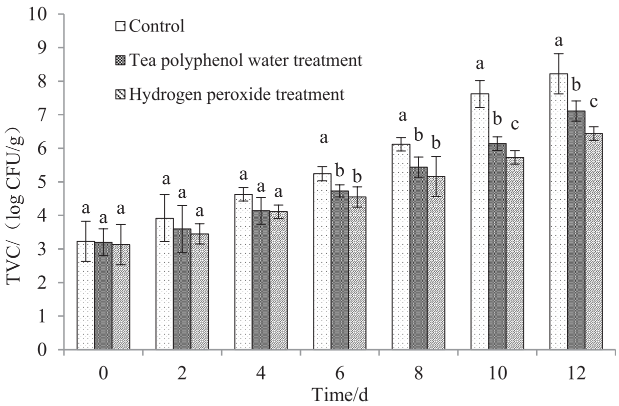

Figure 4. The effect of different treatments on TVC of the chilled meat during storage.

Table 1. The effect of different treatments on sensory score of chilled meat during storage.

Storage days/d	Sensory score		
	Control	tea polyphenol	hydrogen peroxide
0	8.3 ± 0.26[a]	8.2 ± 0.23[a]	8.1 ± 0.43[a]
2	7.8 ± 0.37[a]	7.9 ± 0.19[a]	8.0 ± 0.25[a]
4	6.7 ± 0.30[a]	7.6 ± 0.36[b]	7.2 ± 0.23[b]
6	6.0 ± 0.31[a]	7.2 ± 0.13[b]	6.7 ± 0.17[c]
8	5.6 ± 0.29[a]	6.6 ± 0.28[b]	6.2 ± 0.25[b]
10	5.0 ± 0.28[a]	6.0 ± 0.16[b]	5.5 ± 0.16[c]
12	4.4 ± 0.32[a]	5.6 ± 0.15[b]	5.1 ± 0.18[c]

spoilage when TVC > 6.0 log CFU/g. The TVC of control groups increased from 3.2 to 6.0 log CFU/g after 8 days. However, tea polyphenol treatment group was 10 days and the hydrogen peroxide treatment group was 12 days. That indicated that the treatment of tea polyphenol and hydrogen peroxide could effectively inhibit the growth of TVC in the chilled meat and extend their shelf lives.

The effect of different preservatives on the sensory

When the comprehensive score was less than 6, the sensory quality of chilled meat became unacceptable. Table 1 showed the sensory score of treatment group was significantly higher than the control group during storage ($p < 0.05$). After 8 days of storage, the control group showed fishy odor, viscosity, loss of elasticity and brown color. Tea polyphenols treatmeat group were delayed 2 days and hydrogen peroxide treatment group were delayed 4 days. The above results indicated that the fresh chilled pork treated with tea polyphenol and hydrogen peroxide significantly extended shelf life.

Conclusion

Two different preservatives were selected to treat the chilled pork and the changes of quality within 12 days were studied. The important indicators of food spoilage, pH, TVB-N, TBARS and TVC were all determined. Compared with the control group, the chilled meat treated with tea polyphenols extended shelf life 2 days while hydrogen peroxide extended 4 days. That was consistent with the sensory evaluation results. Therefore, tea polyphenols and hydrogen peroxide can be effectively used to improve shelf-life and sensory quality of fresh chilled pork and hydrogen peroxide is better than tea polyphenols. For further study, the combination application of various preservatives and the residue of preservatives in chilled meat need to be studied.

Author contributions

Wenming Xing: Conceptualization, Investigation, Writing – original draft. Wenli Liu: Investigation. Huamin Li: Methodology. Shaohua Xing: Conceptualization, Writing – review & editing.

Acknowledgements

This research is supported by the Support plan for youth entrepreneurship and technology of colleges and universities in Shandong Province (2019KJN002).

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