Effects of tea polyphenol on quality and shelf life of pork sausages

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Abstract The effects of tea polyphenol on quality and shelf life of pork sausages stored at 20 °C for 42 days were examined. The control and the treated sausage samples added with 0.03 % tea polyphenol were analyzed periodically for microbiological (total viable counts and lactic acid bacteria counts), physical (Hunter color of L*, a*, b*), chemical (pH, TBA value) and sensory characteristics. It was found that samples added with tea polyphenol showed lower changes in total viable count, pH, TBA value and sensory characteristics than control samples, respectively. The results indicated that the sausage samples with tea polyphenol added was to enable the good quality and sensory characteristics than the control sausage samples and prolonged the shelf life of the sausages.

Keywords Pork sausages · Tea polyphenol · Quality and shelf life

Introduction

Sausage is one of the oldest well-known forms of processed meat products and is very popular in many areas. In China, pork sausage was one of the most favorite traditional processed meat items in the market due to its unique cured meat flavor (Lin and Lin 2001). Traditionally, pork sausages are made of pork meat and fat, which are chopped and thoroughly mixed with seasonings, such as spice paprika, pepper powder, salt, rice wine, sugar, monosodium glutamate and

ginger, etc. After stuffed with the meat mixture in natural casings from the cleaned small intestine of pigs, the sausages are dried under room temperature.

However, due to the high fat content and low water activity, sausages are generally spoiled faster than other meat products. To retain the good quality and sensory characteristics, preservatives such as nitrites, butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) etc., are widely used (Bozkurt and Erkmén 2007; Honikel 2008). At the same time, there is growing consumer awareness and health-consciousness which results in pressure to avoid the use of synthetic additives. These facts bring about the need for research regarding the use of natural additives (Shirin and Jamuna 2011).

Tea polyphenol (TP), which is mainly made from great tea, has beneficial anti-bacterial and anti-oxidative activities, showing good prospects for use as preservatives and anti-oxidants in food industry especially in the field of the preservation of manufactured meat (Chen et al. 2012; Azam et al. 2004). Further studies demonstrated antioxidative activities of TP in some cases are up to five times more effective than vitamin C or vitamin E (Dreosti 2000). However, there have been few studies on the effect of TP quality and shelf life of pork sausage during storage. Therefore, the objective of this study is to evaluate the effects of TP quality and shelf life of pork sausage during storage.

Materials and methods

Sausage formulation and processing

Fresh boneless pork hams and pork backfat were purchased from a local meat market. Lean tissue and pork backfat were ground through a 10 mm plate. Approximate 70 % Lean tissue and 30 % pork backfat were mixed thoroughly with

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other non-meat ingredients (on meat mixtures basis), including 3 % salt, 2 % rice wine, 0.5 % monosodium glutamate, 0.5 % sugar, 1.0 % paprika powder, 0.05 % pepper powder. Then, the meat mixtures were stuffed into natural pork casings, which had been soaked in water. Raw sausages were manually tied with approximate 15 cm-interval and dried at 50 °C for 8 h, and then stored at 20 °C for 42 days.

Two treatments of pork sausage produced were: (1) control (basic formulation); (2) basic formulation with the addition of 0.03 % tea polyphenol.

Microbial counts

Total viable counts (TVC) were determined in plate count agar by the spread plate method (AOAC 2002). Lactic acid bacteria counts were enumerated followed by the previous procedures (Phebus et al. 1991). Microbial counts were reported as colony forming units (CFU)/g meat sample.

Physical evaluation

Colour measurement

Colour measurement was carried out using a colour meter (Spectrophotometer TC-PIIG, China). CIELAB L*, a*, b* values were determined as indicators of lightness, redness and yellowness.

Chemical evaluation

pH

Ten grams sausages were homogenized in 100 ml distilled water and the mixture was filtered. The pH of filtrate was measured by digital pH meter (Cyberscan PC 510 UK).

TBA value

The 2-thiobarbituric acid (TBA) value was determined colorimetrically by the method of Porkony and Dieffenbacher (Kirk and Sawyer 1991; Kumudavally et al. 2011). TBA value was expressed as mg/kg meat.

Sensory evaluation

The sensory quality of sausage samples were evaluated by a ten-member trained panelists from the laboratory staff. Descriptive analysis was conducted to evaluate the intensities of sensory characteristics so that each panel member could thoroughly discuss and clarify each attribute to be evaluated. Sausages were grilled in an electrical plate grill to a core temperature at 75 °C. After cooling for 5 min at room temperature, the samples were cut into pieces of 3–5 cm and

served to each panelist, who was provided with purified water for gargling after each sample. And then, panelists evaluated the samples for appearance, color, flavor, juiciness, tenderness and overall acceptability using a nine-point hedonic scale (1, dislike extremely to 9, like extremely) (Meilgaard et al. 1999).

Data analysis

Experiments were replicated triplicate on different occasions with different sausage samples. Data were analyzed using the general linear model (GLM) of Statistical Analysis System's Procedures (SAS 1999). The Duncan's multiple range tests ($p < 0.05$) was used to determine differences between treatment means.

Results and discussion

Microbiological population

Total viable counts

The initial total viable count (TVC) of sausage samples was $7.0 \log_{10}$ CFU/g, and this value was similar to those reported in previous studies (Liu et al. 2010) for low-nitrite Chinese sausages. Changes in total viable counts during storage were shown in Table 1. Total viable counts in sausage samples added with tea polyphenol (TPS) increased with same trend as control but lower value during the storage. The significant reduction ($p < 0.05$) in total viable counts observed in TPS can be attributed to the inhibitory effect of tea polyphenol on spoilage bacteria. These results are consistent with those reported by Valencia et al. (2008), who found that treatment with green tea catechins decreased the total viable counts of the fresh pork sausages stored at 4 °C. And it was also indicated that addition of tea polyphenol was equally effective on inhibiting spoilage bacteria growth and extending the storage life of sausage samples.

Lactic acid bacteria counts

Lactic acid bacteria have been found to be one of the natural microbial flora of meat sausages (Mathenjwa et al. 2012). Several authors indicated that the normal spoilage of cured meat products resulted from souring nature due to the growth of Lactobacilli-ace (Essid and Hassouna 2013). During storage, the growth of lactic acid bacteria probably caused the accumulation of lactic acid, resulting in decrease of pH values. The LAB counts steadily increased and reached the almost same level after 42 days of storage (Table 1). Villani et al. (2007) and Baka et al. (2011) indicated that the dominance of LAB is a basic requirement for the successful production of fermented sausages, which contribute to the

Table 1 Changes in quality of sausage samples with and without tea polyphenol during storage at 20 °C ($n=3$)

Storage (days)		0	7	14	21	28	35	42	Sig.
TVC	CONS	7.0±0.01a	7.5±0.02a	7.7±0.03c	7.9±0.01a	8.0±0.02b	8.2±0.02b	8.1±0.02b	$p<0.05$
	TPS	7.0±0.01a	7.4±0.01a	7.5±0.02a	7.6±0.01a	7.7±0.03c	7.8±0.04c	7.7±0.03c	
LAB	CONS	6.4±0.01a	7.0±0.05c	7.4±0.04c	7.6±0.02a	7.8±0.02b	8.1±0.03c	7.9±0.05d	$p>0.05$
	TPS	6.4±0.01a	7.0±0.04c	7.3±0.01a	7.6±0.03c	7.7±0.01a	8.0±0.01a	7.9±0.02b	
pH	CONS	5.8±0.09a	5.6±0.10a	5.4±0.08a	5.3±0.16b	5.0±0.06a	4.8±0.08a	4.9±0.14ab	$p>0.05$
	TPS	5.8±0.09a	5.7±0.11a	5.5±0.12a	5.3±0.12a	5.1±0.09a	4.8±0.09a	4.9±0.11a	
TBA	CONS	0.28±0.01a	0.30±0.03b	0.32±0.04c	0.34±0.02a	0.38±0.04c	0.43±0.06d	0.41±0.07d	$p<0.05$
	TPS	0.28±0.02a	0.30±0.05c	0.33±0.02a	0.37±0.07d	0.41±0.05c	0.47±0.08d	0.44±0.09d	
Hunter L*	CONS	48.5±1.90a	50.2±1.55a	49.5±2.15b	53.4±0.95a	54.4±1.15a	57.7±1.13a	55.8±0.60a	$p<0.05$
	TPS	48.8±2.15b	51.6±1.65a	50.0±2.50b	54.9±1.15a	55.9±0.53a	59.1±0.99a	56.3±0.95a	
Hunter a*	CONS	4.1±0.11a	6.6±0.24a	7.5±0.55c	6.8±0.35c	6.1±0.23a	5.0±0.06a	5.6±0.08a	$p<0.05$
	TPS	4.1±0.15a	7.0±0.33b	8.0±0.06a	7.2±0.25b	6.8±0.15a	5.8±0.04c	6.2±0.15b	
Hunter b*	CONS	13.0±0.99c	16.4±0.05a	15.9±0.06a	14.8±0.21a	13.6±0.21b	13.0±0.09a	13.2±0.36c	$p>0.05$
	TPS	13.0±0.15a	16.1±0.11a	15.9±0.14a	15.0±0.13a	13.8±0.12a	13.0±0.16a	13.4±0.34c	
Sensory evaluation	CONS	4.5±0.07a	5.4±0.14a	7.5±0.02a	8.1±0.10a	7.5±0.11a	6.6±0.14a	7.1±0.08a	$p<0.05$
	TPS	4.6±0.17c	5.3±0.18b	7.8±0.09a	8.3±0.15a	7.8±0.17b	6.9±0.17b	7.3±0.09a	

CONS control sausage samples, TPS sausage samples with tea polyphenol, TVC total viable counts, LAB lactic acid bacteria counts, TBA the 2-thiobarbituric acid

^{a-d} Means with different letters in a column within each treatment differ significantly ($p<0.05$)

development of texture, color and flavor and have a positive effect to inhibit pathogenic and spoilage flora by acidification or production of antimicrobials. According the results of the LAB analyses, there was no significant difference ($p>0.05$) in LAB counts between the CONS and TPS samples during the whole storage. Tea polyphenols, used to inhibit spoilage bacteria growth in sausage samples, seemed not to decrease LAB which has a positive effect on characteristics of sausages.

pH value

Variations of pH during storage were depicted in Table 1. The initial pH of the sausage samples was 5.8. In all sausage samples, the values of pH decreased during the whole storage. Similar observations were reported by Wang et al. (2013), where accumulation of lactic acid due to the growth of lactic acid bacteria resulted in decrease of pH values of sausages samples. The results of the present study were also consistent with those of Karabacak and Bozkurt (2012), who reported a decrease in the pH value with storage time in Turkish dry-fermented sausage at 30 °C for 36 days. In this study, the pH values of the CONS samples significantly decreased from pH 5.8 on day 0 to pH 4.8 on day 42, while the pH values of the TPS samples reached about 4.8 on the 42th day. These pH reductions were probably caused by the fact that lactic acid bacteria were the predominant microorganisms in sausage products. Further, the effectiveness of tea polyphenol is dependent on pH, and the indicated relationship may be due to differences between the control and treated samples (Kim

et al. 2010). However, there was no significant difference ($p>0.05$) of the pH between the CONS and TPS samples. Similar results have been reported that the addition of antimicrobials and antioxidants such as chitosan and nitrites do not affect pH values of meat products (Soultos et al. 2008).

Lipid oxidation

2-thiobarbituric acid (TBA) is an index of lipid oxidation. Changes in TBA value were shown in Table 1. The respective treatments significantly influenced the TBA values over time. The initial TBA value of sausage samples was 0.28 mg/kg and it increased to 0.51 mg/kg for CONS samples. This increase of TBA value may be attributed to the partial dehydration of sausages and to the increased oxidation of unsaturated fatty acids. This observation of the increase of the TBA value is similar to the results reported by Tan et al. (2007). TBA value of the TPS samples were significantly lower ($p<0.05$) than corresponding value of the CONS samples. Therefore, tea polyphenol can afford greater antioxidant activity to protect sausage from lipid oxidation. Further, this result also demonstrated that the lipid oxidation rate was much faster in the CONS samples than in TPS samples, suggesting that tea polyphenol clearly inhibited the lipid oxidation in pork sausages. These results are consistent with those reported by Tang et al. (2001), who found that tea catechins can efficiently inhibited minced muscle lipid oxidation in meat and poultry products.

Hunter color measurement

Hunter color values for sausage samples were shown in Table 1. In general, no significant difference in Hunter b^* value ($p>0.05$) was found between the CONS and TPS samples. Slight differences in Hunter b^* value could be attributed to the coarse ground meat particles of sausages resulting in variation on cross section surface during color determination (Osterlie and Lerfall 2005).

Hunter a^* value increased in both sausage samples during the first 14 days of the storage. This increase of redness may be caused by the formation of nitrosyl-myoglobin due to the reaction of myoglobin with nitrites under the mildly acidic conditions (Turantaş and Kemahloğlu 2010). After 14 days of storage, a decrease in Hunter a^* value were observed in both samples, this decrease in redness may be attributed to the oxidation of nitrosyl-myoglobin (Sachindra and Mahendrakar 2010). From Table 1, the a^* values of the CONS samples significantly decreased from 7.5 on day 14 to 5.0 on day 42, while the values of TPS samples reached about 5.8 on the 42th day. It means that addition of tea polyphenol did significantly increased ($p<0.05$) Hunter a^* value than that of the CONS samples. Fernández-Ginés et al. (2005) had related the redness in meat products with lipid oxidation, reporting that lipid oxidation resulted in decreases redness.

Significant changes ($p<0.05$) in lightness (L^*) values also occurred. L^* values were higher for the TPS samples, compared to the CONS. The final L^* values of the TPS samples was 59.1, while the values of the CONS samples only reached about 57.6 on the 42th day. Hayes et al. (2011) and Stasiewicz et al. (2012) reported variations in muscle structure might affect the reflectance of light scattering, and the extent of denaturation of muscle protein differed in pale color meat. Nuñez de Gonzalez et al. (2009) reported that the color of precooked pork sausage with dried plum (3 % or 6 %) is dark due to the original dark purple color of the plum. Therefore, it is assumed that the darker color was likely caused by tea polyphenol by changing the meat particles and absorbing more light. Thus, the addition of tea polyphenol could improve the color quality of pork sausages by decreasing lightness and increasing redness.

Sensory evaluation

The results of the sensory evaluation of sausage samples were given in Table 1. In all sausage samples, the values of overall sensory quality increased initially and then decreased. The initial overall sensory quality increase was attributed to the better appearance and flavour which were caused by their lower met-myoglobin content and the higher lipid oxidation in the sausages (Thomas et al. 2008). The changes in the overall sensory quality of TPS samples have

the same trend as CONS samples. Besides, the overall sensory qualities of TPS samples were higher. This observation indicated that TPS samples were judged more acceptable than CONS samples and tea polyphenol had a beneficial effect on sensory of the pork sausage.

Conclusions

This study showed that tea polyphenol could be used to effectively improve the quality characteristics and extend the shelf life of the pork sausages. Based on present results, both the antimicrobial and antioxidant effects of tea polyphenol were more pronounced compared to the control. Moreover, incorporation of tea polyphenol into the pork sausages resulted in better quality from color retention to the sensory of the pork sausage. Therefore, this study should provide a possible application of tea polyphenol to the pork sausage.

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