Fresh pork sausages: Effect of non-meat ingredients on product colour characteristics

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Abstract

The impact of non-meat ingredients (*i.e.*, sodium erythorbate [SE] & lemon juice powder [LJP]) on the colour stability of fresh pork sausage products was assessed over a 10-day storage period. Loss of quality was evident through the discolouration of meat, depletion of endogenous antioxidant activities, proliferation of spoilage microorganisms, and reduction in the meat's redox potential. Results showed no synergistic colour stabilizing effect ($p>0.05$) between SE & LJP during storage. Furthermore, the combination of SE & LJP did not affect antioxidant activity, colour, or the microbiological profile. The addition of SE alone, however, had a significant effect ($p<0.05$) on catalase activity. Catalase was more effective in protecting against oxidation following the addition of SE, resulting in preservation of the redness (*i.e.*, a* value) in fresh pork sausages. Combining SE & LJP did not affect antimicrobial activity, as there was no significant ($p>0.05$) difference in total microbial counts (*i.e.*, *Brochothrix thermosphacta* count and lactic acid bacteria). Redox potential measurements from the middle of fresh pork patties indicated that the addition of SE reduced the redox of fresh pork sausage containing 0.05% SE and those containing 0.05% SE with 0.25% LJP.

Background

Color is a key factor which determines the shelf-life and saleability of fresh port sausages; consumers tend to use meat colour as an indicator of freshness and make a value judgment regarding purchase. A major challenge for the meat industry is to maintain an "acceptable" color in fresh sausages for as long as possible during holding under retail display conditions. Non-meat ingredients are adjuncts included in formulations to obtain a desired effect in the processed product. In this study, SE & LJP, which are often included in Canadian fresh pork sausage formulations, were added as non-meat ingredients. The idea is that SE serves as a primary antioxidant to prolong the meat's desirable bloomed color (*i.e.*, oxymyoglobin concentrations); however, SE is prone to metal-catalyzed oxidation. Thus, the inclusion of LJP, as a chelator, is expected to increase the stability of SE so that it will be more effective in protecting against meat colour deterioration (*i.e.*, metmyoglobin formation). The objective of this study is to evaluate the interactions of both SE & LJP in preserving fresh pork sausage colour during a distribution period of 7 days and a display period of 10 days. Measurements during these periods included the meat's redox potential, key endogenous antioxidant enzyme (*i.e.*, catalase [CAT], superoxide dismutase [SOD], glutathione peroxidase [GSHPx]) activities, and the impact of microbial loads.

Materials and methods

A typical fresh sausage formulation was used to prepare pork patties with targets of 20% (or less) fat and 14-16% protein. The meat utilized was pork picnic shoulder. The non-meat ingredients included water/ice (12%, w/w), sodium chloride (1.5%, w/w), LJP (0.25%, w/w), and SE (0.05%, w/w). Meat and non-meat ingredients were combined in a Hobart® mixer for 60s before portioning into ~120-g pork patties. The patties were then placed on Styrofoam® trays and over-wrapped with a standard O_2-permeable film with a known O_2-transmission rate of 30000cm^3/m^2/24 h. The patties were stored in the dark for 7 days at -1°C (*i.e.*, to simulate a typical distribution scenario) & then under fluorescent lighting (950 lux) at 4°C for up to 10 days (*i.e.*, to simulate retail display conditions). The effect of SE & LJP in the formulations were analyzed by using a factorial design approach, as indicated in fresh sausage A, (0% SE & 0% LJP); B, (0.05% SE & 0% LJP); C, (0% SE & 0.25% LJP); and D, (0.05% SE & 0.25% LJP).

Colour measurements (CIE, L^*, a^*, b*) were performed at the surface of meat samples using a HunterLab Miniscan XE colorimeter with illuminant A and 10° standard observer. This unit was also used to determine the % metmyoglobin at the surface of the meat patties; the relative content of metmyoglobin was estimated by calculating the $K/S_{572/525}$ ratio, as described by Hunt *et al.* (1991). The measurement of meat patty redox potential was assessed using microelectrodes connected to a data logger (51x Micrologger,

Campbell Scientific Inc., Edmonton, AB). Two microelectrodes and one reference electrode were inserted into each patty with one microelectrode located near the patty's surface and the other placed into the middle portion of the meat. SOD activity of patties over the storage period was measured according to Markulund & Markulund (1974). The enzymatic activity of GSHPx was assessed by the indirect, coupled test procedure as described by Agergarrd & Thode Jansen (1982). CAT activity was determined by the method of Aebi (1983). Three types of media were employed to assess the microbiological flora present on fresh pork sausages: trypticase soy agar (TSA; BBL, Becton Dickinson, Cockeysville, MD) + 0.1% (w/v) yeast extract (Difco Laboratories, Detroit, MI), incubated for 24 h at 37°C for the isolation and cultivation of a wide variety of heterotrophic microorganisms; de Man-Ragosa-Sharpe agar (MRS; EMD Chemicals, Darmstadt, Germany) for 72 h at 30°C for the cultivation of lactic acid bacteria; and streptomycin thallous acetate actidione agar (STAA; Oxoid, Nepean, ON) incubated for 48 h at 25°C aerobically for the cultivation of *Brochothrix thermosphacta*.

Results & discussion

In this study, no synergistic interactions between SE & LJP treatments for CAT, SOD, and GSHPx activities were found (see Table 1). A significant (p<0.05) interaction was noted, however, between SE & CAT activity; addition of 0.05% SE to fresh sausages B & D had a marked effect on CAT activity compared to fresh sausages A & C.

Table 1. The *p* values for LJP, SE, LJP x SE, Days, and LJP x SE x Days

Variables	***p* Values**				
	LJP	SE	LJP *x* SE	Days	LJP *x* SE *x* Days
Catalase activity (U/g meat)	0.4341	0.0119	0.4653	<0.0001	0.2447
GSHPx activity (U/g meat)	0.6992	0.1876	0.5120	<0.0001	0.8920
SOD activity (U/g meat)	0.3867	0.9139	0.5958	0.0055	0.9674
Relative amt. of metmyoglobin	0.1057	0.0986	0.4656	0.0002	0.7688
L* values	0.1489	0.0377	0.4008	0.0018	0.8919
a* values	0.256	0.0366	0.7020	0.0004	0.9469
b* values	0.3641	0.4546	0.5625	0.0015	0.9664
Total microbial count (log_{10} CFU/g)	0.4309	0.8582	0.9003	<0.0001	0.4749
B. thermosphacta microbial count (log_{10} (CFU)/g)	0.4117	0.9007	0.7362	<0.0001	0.7522
Lactic acid microbial count (log_{10} CFU/g)	0.4544	0.4730	0.5112	<0.0001	0.1525

As indicated in Table 1, only SE had a significant (p<0.05) positive effect on fresh sausage colour, particularly the L* values and a* values. The lightness of fresh pork sausage formulations B and D was significantly (p<0.05) lower than those of A and C. The addition of 0.05% SE increased the retention in redness (*i.e.*, a* value) of fresh sausage formulations B and D. It has been reported that the antioxidant activity of ascorbic acid is limited by the abundance of iron in meat because metal-induced oxidation of reducing agents often makes them inactive (Mancini *et al*., 2007). For this reason, the addition of a chelator, such as citric acid, should improve ascorbic acid's efficacy in muscle food products and therefore, desired meat colour may be improved in the SE formulation by the addition of citric acid. In this study, 0.25% LJP containing 0.07& (w/w) citric acid, which is the typical addition level used by industry, was employed in fresh pork sausage formulations C and D. Unfortunately, this quantity was not beneficial in delaying discolouration of the sausage formulations. From the results of this study, it would be more economical if meat manufacturers just added 0.05% SE alone to their formulations.

Neither sodium erythorbate nor citric acid exhibited antimicrobial activity in comparison to the control. Additionally, there was no synergistic effect between sodium erythorbate and citric acid (Table 1). This result agrees with Rhee *et al*. (1997), who concluded that citrate and ascorbate did not reduce aerobic plate counts in cooked/aerobically refrigerated beef carrageenan patties. In the present study, the initial redox potential in the middle of fresh sausage formulation A ranged between 20 & 40 mV, but after addition of

0.05% SE to fresh sausage B, the redox potential reading for the sausage varied between -40 & -50 mV. Because SE is a reductant, this result was not unexpected. As formulation D also contained 0.05% SE, it was also expected to have a low redox potential. Yet, the redox potential of fresh sausage D ranged between -10 & 0 mV and was not as low as that for fresh sausage formulation B. This finding may suggest an interaction between LJP, containing 26.3% citric acid, and SE, that results in a slight increase in the redox potential value. The high reducing conditions can allow for greater reactivity and interconversion of meat pigments, but these are not desirable from the perspective of meat colour; *in situ* levels of reductants might impact the extent of metmyoglobin reduction to oxymyoglobin thereby giving a better colour stability to fresh pork sausage (Antonini & Brunori, 1971).

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