

Microbial Inhibitors Combined with Modified Atmosphere Packaging for Improved Control of *Salmonella* Typhimurium on Pork Products

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Summary and Implications

Lactate and diacetate in combination with modified atmosphere packaging composed of 99.5% carbon dioxide and 0.5% carbon monoxide were investigated for effects on initial *Salmonella* Typhimurium populations and suppression of growth of survivors. Results showed that lactate and diacetate in pork chops combined with modified atmosphere packaging improved shelf life compared to vacuum packaged pork chops without lactate and diacetate. Sensory analysis indicated that pork chops in modified atmosphere packages with lactate and diacetate had a greater pink color, but also a vinegar-like flavor and odor. This means that the combination of modified atmosphere packaging with lactate and diacetate has microbial benefits, but may not be accepted by consumers because of the vinegar-like aroma and flavor of the pork chops.

Introduction

Ingredients such as lactate and diacetate in meat products have been well-established as an effective means of microbial control. The meat industry is currently utilizing these compounds as sodium or potassium salts in fresh meat products such as moisture-enhanced pork. Lactate and diacetate are effective inhibitors of spoilage organisms and *Salmonella* spp.

Carbon dioxide in modified atmosphere packaging at high concentrations (90-100%) can be a very effective inhibitor when the initial number of microorganisms is relatively low. However, discoloration of fresh meat typically occurs with levels of carbon dioxide above 30%. To prevent the discoloration problem, carbon monoxide at 0.4%-0.5% may be added as a component of the MAP system, and has been shown to be effective for retention of desirable fresh meat color. Carbon monoxide has not been used in the past because of concern for toxicity of the gas packaging to personnel and consumers. Gas mixtures containing less than 1% carbon monoxide, however, are not considered a risk.

Materials and Methods

Ten pork loins were used for each of the three replications (30 loins in total). Loins were randomly assigned to two

groups of 15 each (one group injected with potassium lactate/sodium diacetate and one injected with brine but without lactate/diacetate). The two groups were injected to a target of 113% of initial green weight. One brine was composed of 2.2% sodium chloride, 3.1% sodium tripolyphosphate, 20.8% potassium lactate, and 2.2% sodium diacetate and the other was composed of 2.2% sodium chloride and 3.1% sodium tripolyphosphate. If 113% pump was not achieved by injection then brine was added to the tumbler to achieve desired pump retention during tumbling of the loins.

The loins were vacuum-tumbled continuously for one hour at 15 revolutions/minute. Loins were cut into 1-inch thick chops and placed in high-barrier flexible pouches. Prior to sealing the packages, the pork chops were inoculated with 10^5 CFU/g of *S. Typhimurium*. The packaging treatments included vacuum packaging (VP) and modified atmosphere packaging (MAP) using a composition of 99.5% carbon dioxide and 0.5% carbon monoxide. The packages then were randomly assigned to two different groups to be stored at different temperatures (4°C and 10°C) in lighted display. Surviving *S. Typhimurium* were enumerated during storage until the pork chops had spoiled. Un-inoculated samples were also evaluated for quality differences including, odor, color, tenderness and flavor, by a trained sensory panel.

Results and Discussion

Results indicate that pork chops in vacuum packages (VP) without lactate and diacetate stored at 10°C had significantly ($P < 0.05$) greater *S. Typhimurium* growth than the rest of the treatments. When stored at 4°C, VP without lactate and diacetate also had significantly ($P < 0.05$) greater microbial growth than MAP without lactate and diacetate.

Sensory results showed that MAP pork chops received significantly ($P < 0.05$) higher scores for pinkness from the panel than VP pork chops. Results indicated that the pork chops that were not injected with lactate and diacetate had a significantly ($P < 0.05$) greater raw pork aroma than pork chops injected with lactate and diacetate. Pork chops injected with lactate and diacetate showed significantly ($P < 0.05$) greater vinegar-like raw aroma.

When the pork chops were cooked, there were no significant ($P < 0.05$) differences in juiciness, pork flavor, saltiness, and sourness. The pork chops injected with lactate and diacetate and MAP had a significantly ($P < 0.05$) greater vinegar-like aroma than the un-injected lactate and diacetate MAP pork chops. VP pork chops without lactate and diacetate was significantly ($P < 0.05$) more tender than the MAP pork chops also without lactate and diacetate. Consequently, MAP packaging is effective

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for improved control of *S. Typhimurium* on pork chops
but the use of lactate and diacetate may impart
undesirable flavor and odor.

LS Means¹ of *S. Typhimurium* Growth²

Storage Temperature	Treatments ³				
	VP	VP/LD	MAP	MAP/LD	SEM ⁴
4°C	4.29a	3.99ab	3.95b	4.08ab	0.108
10°C	5.20b	3.98a	4.12a	4.06a	0.108

¹ Means in a row followed by a different superscript are significantly different ($p < 0.05$).

² Values in table are least squares means of microbial growth (CFU/cm²)

³ VP = vacuum packaging-without lactate & diacetate; VP/LD = vacuum packaging with lactate & diacetate; MAP = modified atmosphere packaging without lactate & diacetate; MAP/LD = modified atmosphere packaging-with lactate & diacetate.

⁴ ± Standard error of the mean.

LS Means¹ of Sensory Attributes of Raw Pork Chops

Treatments ²	Sensory Attributes ³			
	Pink Color	Brown Color	Raw Pork Aroma	Vinegar-like Aroma
VP	1.7 ^a	10.1 ^b	10.2 ^a	2.0 ^a
VP/LD	1.7 ^a	10.2 ^b	3.0 ^b	9.5 ^c
MAP	13.2 ^c	0.3 ^a	9.1 ^a	1.9 ^a
MAP/LD	11.7 ^b	0.8 ^a	5.3 ^b	6.4 ^b
SEM ⁴	0.4	0.7	0.9	0.9

¹ Means in a column followed by a different superscript are significantly different ($p < 0.05$).

² VP = vacuum packaging-without lactate & diacetate; VP/LD = vacuum packaging with lactate & diacetate; MAP = modified atmosphere packaging without lactate & diacetate; MAP/LD = modified atmosphere packaging-with lactate & diacetate.

³ 15 point line scale; none = 0, intense = 15.

⁴ ± Standard error of the mean.

LS Means¹ of Sensory Attributes of Cooked Pork Chops

Treatments ²	Sensory Attributes ³					
	Vinegar-Like Aroma	Tenderness	Juiciness	Pork Flavor	Saltiness	Sourness
VP	0.7 ^{ab}	11.3 ^b	11.0	4.9	1.1	0.5
VP/LD	0.9 ^{ab}	11.0 ^{ab}	9.9	5.6	1.9	0.7
MAP	0.6 ^a	9.5 ^a	9.8	5.5	1.9	1.1
MAP/LD	1.5 ^b	10.2 ^{ab}	10.1	4.8	2.2	1.4
SEM ⁴	0.3	0.6	0.6	0.8	0.5	0.4

¹ Means in a column followed by a different superscript are significantly different ($p < 0.05$).

² VP = vacuum packaging-without lactate & diacetate; VP/LD = vacuum packaging with lactate & diacetate; MAP = modified atmosphere packaging without lactate & diacetate; MAP/LD = modified atmosphere packaging-with lactate & diacetate.

³ 15 point line scale. Vinegar-Like Aroma, Pork Flavor, Saltiness, Sourness, none = 0, intense = 15; Tenderness, not tender = 0, very tender = 15; Juiciness, not juicy = 0, very juicy = 15.

⁴ ± Standard error of the mean.