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Full Length Research Paper

Effect of sodium lactate and sodium acetate on shelf-life of raw chicken breasts

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Two experiments were conducted to evaluate the effects of sodium lactate and sodium acetate on the microbiological population and shelf-life of raw chicken breasts. In both experiments, raw chicken breasts were randomly subjected to treatments containing 0, 0.87 or 1.74% sodium lactate or 1.74% sodium acetate, 3.48% sodium acetate, or the combination of 1.74% sodium lactate and 1.74% sodium acetate. All treatments contained sodium phosphate, sodium chloride and varied levels of distilled water. Samples were refrigerated (2 to 3°C) and aerobic plate counts (APC) were conducted every 3 days. The experimental period was Exp. 1, 0 to 14 days and Exp. 2, 0 to 39 days. In Exp. 1, sodium acetate lowered APC ($P < 0.05$) in samples at days 3, 6 and 14 compared to the control. Either 0.87 or 1.74% sodium acetate was most effective at controlling bacteria growth. In Exp. 2, the addition of 1.74 or 3.48% sodium acetate alone or in combination with sodium lactate had lower APC ($P < 0.05$) than 1.74% sodium lactate and control samples. The combination of 1.74% sodium lactate and 1.74% sodium acetate was the most effective in reducing bacterial growth from days 3 to 15. In both experiments, sodium acetate was the most effective in inhibiting microbial growth.

Key words: Chicken breast, sodium acetate, sodium lactate, shelf-life.

INTRODUCTION

Chicken is produced worldwide and is one of the most consumed meat products in the United States. Over the past 50 years, chicken production has become Industrialized resulting in higher quality poultry products (National Chicken Council, 2008). As retail food prices increase globally, the need for economical, healthy and consumer friendly protein products becomes more important. One segment that may help with these issues is the improvement of product quality and extension of shelf-life of chicken meat. Raw chicken is easily spoiled because it is rich in nutrients favorable for microbial growth. Foodborne disease outbreaks can result from bacterial contamination by food handlers, improper cooking, and during shipment to market. Adding presservatives to the raw meat is a common method to inhibit growth of harmful bacteria. The preservatives most commonly used are sodium lactate, sodium acetate, sodium chloride, and nitrites as these preservatives do not negatively affect human health. Furthermore, adding the preservatives sodium lactate and sodium acetate has been shown to extend shelf-life of meat by inhibiting microbial growth (Miller and Acuff, 2006) and improve sensory attributes of injection enhanced beef (Knock et al., 2006). Extending the shelf-life of poultry products is a major concern of the poultry industry. The shelf-life of poultry depends on several factors, particularly initial bacterial loads, storage temperature, and the gaseous environment around the product (Mead, 1990). In addition, cooking and storage temperature greatly affect microbial development and the subsequent shelf-life of the product. The use of sodium salts or common organic acids, such as sodium acetate and sodium lactate may help in reducing factors associated with short shelf-life. These two preservatives are safe for human consumption and also effectively inhibit the growth of spoilage microorganism and pathogens. Therefore, the objective of this research was to determine the effect of sodium lactate and sodium acetate on the shelf-life of raw chicken breasts and to investigate the effects of levels of

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Table 1. Concentrations of ingredient (%) in solutions after treatment with 15% marinade in experiment 1.

Treatment \ Ingredient	Sodium lactate ($C_3H_5NaO_3$)[a]	Sodium acetate ($C_2H_3O_2Na$)[b]	Sodium chloride (NaCl)[c]	Sodium tripolyphosphate ($Na_5O_{10}P_3$)[d]	Sterile distilled water
1 (Control)	0.0	0.0	1.5	0.75	20.25
2 (0.87% Na lactate)	1.5	0.0	1.5	0.75	18.75
3 (1.74% Na lactate)	3.0	0.0	1.5	0.75	17.25
4 (0.87% Na acetate)	0.0	1.5	1.5	0.75	18.75
5 (1.74% Na acetate)	0.0	3.0	1.5	0.75	17.25

[a]Lactic acid sodium, L7022-50g (1327993), Sigma-Aldrich., St. Louis, MO. [b]Sodium acetate molecular biology reagent, S2889-250g (107K0075), Sigma-Aldrich., St. Louis, MO. [c]Sodium chloride, Eastman Kodak, CAS#7647-14-5 Rochester, NY. [d]Sodium tripolyphosphate, Sigma Chemical CO, St. Louis, MO.

Table 2. Concentrations of ingredient (%) in solutions after treatment with 15% marinade in experiment 2.

Treatment \ Ingredient	Sodium lactate ($C_3H_5NaO_3$)[a]	Sodium acetate ($C_2H_3O_2Na$)[b]	Sodium chloride (NaCl)[c]	Sodium tripolyphosphate ($Na_5O_{10}P_3$)[d]	Sterile distilled water
1 (Control)	0.0	0.0	2.0	1.0	27.0
2 (1.74% Na lactate)	4.0	0.0	2.0	1.0	23.0
3 (1.74% Na acetate)	0.0	4.0	2.0	1.0	23.0
4 (3.48% Na acetate)	0.0	8.0	2.0	1.0	19.0
5 (1.74% Na lactate + 1.74% Na acetate)	4.0	4.0	2.0	1.0	19.0

[a]Lactic acid sodium, L7022-50g (1327993), Sigma-Aldrich., St. Louis, MO. [b]Sodium acetate molecular biology reagent, S2889-250g (107K0075), Sigma-Aldrich., St. Louis, MO. [c]Sodium chloride, Eastman Kodak, CAS#7647-14-5 Rochester, NY. [d]Sodium tripolyphosphate, Sigma Chemical CO, St. Louis, MO.

sodium lactate and sodium acetate on the shelf-life and microbiological quality of raw chicken breasts.

MATERIALS AND METHODS

Sample preparation: Experiments 1 and 2

All methods used in these experiments related to animal care were approved by the McNeese State University Animal Care and Use Committee. Raw chicken breasts were obtained from the McNeese State University Research Farm in Lake Charles, Louisiana. Breasts were removed, deboned, skinned and stored on ice (± 2 h) until treatment preparation was completed. In Exp. 1, raw chicken breasts were cut into 10 g pieces. Each treatment group consisted of 15 pieces of raw chicken breast. Prepared raw chicken was maintained in the refrigerator at 2 to 3°C. Then each piece was randomly subjected to one of five marinade treatments: 1) Control (distilled water, 0.43% sodium phosphate, and 0.87% sodium chloride), 2) 0.87% Na lactate, 3) 1.74% Na lactate, 4) 0.87% Na acetate, and 5) 1.74% Na acetate (Table 1). Each treatment included 15 pieces of raw chicken breasts (150 g) and 15% marinade in a Ziploc® bag. All treatments were mixed in a beaker and stirred for 5 min with aseptic techniques. Each treatment was replicated 3 times. After all marinade treatments were prepared, the treatment solution was mixed with the raw breast. Air was removed from the Ziploc® bag and breasts and treatment solution was mixed for 3 min. Treatments were then placed in the refrigerator 1 h to allow solution to be absorbed into the meat. The samples were stored in the refrigerator (2 to 3°C) for 0, 3, 6 and 14 days before being removed for evaluation. Data collected were analyzed by analysis of variance (ANOVA) and paired sample T-Test for a completely randomized design using SPSS (SPSS INC, 2008).

In Exp. 2, raw chicken breasts were cut into 10 g pieces using knife, cutting board, and forceps with aseptic technique. During sample preparation, all treatments were stored at 2 to 3°C. Twenty, 10 g pieces were placed into Ziploc® bags for absorption of treatment. Each treatment was replicated 3 times. Bags of raw chicken breasts were randomly allotted to the five treatments: 1) Control (distilled water, 0.43% sodium phosphate, and 0.87% sodium chloride), 2) 1.74% Na lactate, 3) 1.74% Na acetate, 4) 3.48% Na acetate, and 5) Combination of 1.74% Na lactate and 1.74% Na acetate (Table 2). Each treatment group consisted of 15 pieces of raw chicken breast and 15% brine in a Ziploc® bags. All treatments were mixed into a sterile beaker and stirred for 5 min with aseptic technique. Air was removed from Ziploc® bags containing treatments and samples and mixed for 3 min. Samples were stored in the refrigerator (2 to 3°C) until evaluation. All treatments were evaluated every 3 days from day 0 to 15; after day 15, treatments 3, 4 and 5 were evaluated every 3 days until day 39. Data collected were analyzed by analysis of variance (ANOVA) and paired sample T-Test for a completely randomized design using SPSS (SPSS INC, 2008).

Microbiological analysis: Experiments 1 and 2

After the appropriate length of storage a 10 g sample from each treatment was collected and homogenized with 90 ml of sterile peptone water in a blender for 1 min. The sample was then placed into a sterile test tube and labeled. The blender was washed using

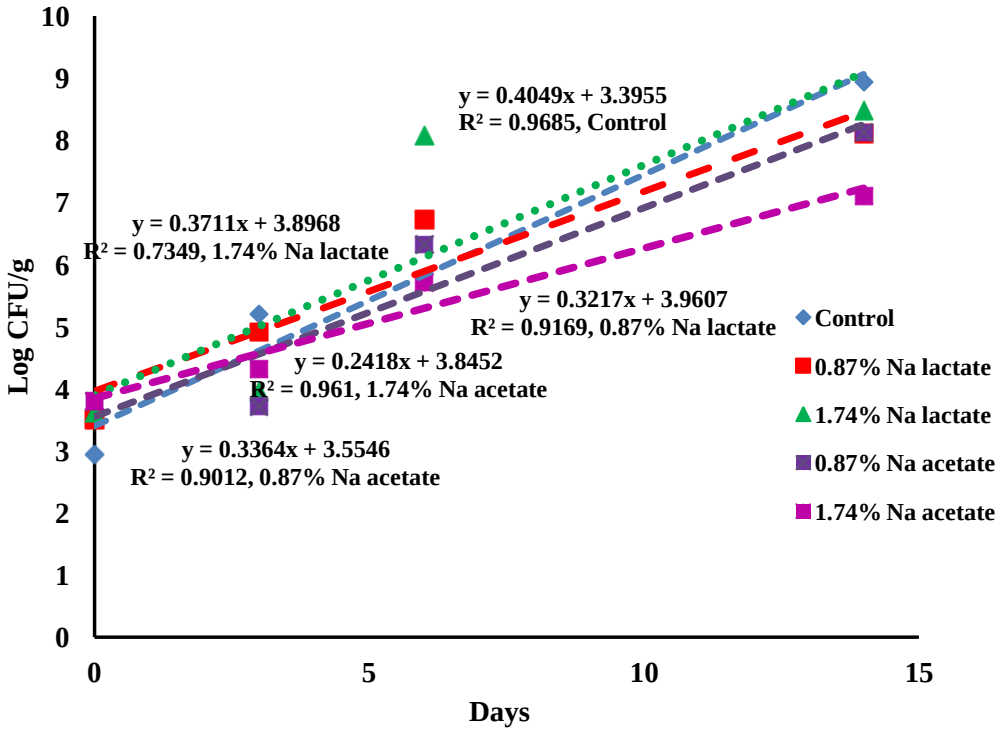

Figure 1. Effect of sodium lactate and sodium acetate treatments on aerobic plate counts (APC) of raw chicken breasts during storage at 2 to 3°C for 14 days. Log CFU/g, 1.74% sodium acetate effect ($P < 0.05$). Values represent means of three replicates per treatment.

tap water and rinsed with 95% ethanol and was allowed time to dry between sample treatment preparation. Each sample treatment was plated in triplicate at 3 dilution levels: 10^{-1}[A], 10^{-2}[B], and 10^{-3}[C] at day 1. Dilution blanks A, B, and C were agitated and aseptically transferred. One ml of dilution A was transferred to dilution B (10^{-2} with 9 ml of sterile peptone), using a sterile 1 ml pipette or micropipette. Pipettes and micropipette tips were discarded after each use. Dilution B was mixed 10 times using a fresh sterile 1 ml pipette, 1 ml of dilution B was transferred to dilution Blank C (10^{-3} dilution) and was mixed 10 times. In Exp. 1, the dilutions were conducted in triplicate and samples were evaluated at days 0, 3, 6 and 14. On days 3, 6 and 14, plates were observed and total bacteria counts calculated to determine further dilutions. In Exp. 2 samples were evaluated every 3 days, from day 0 to 39. Resulting dilutions were 10^{-4} (dilution D), 10^{-5} (dilution E), and 10^{-6} (dilution F). Aerobic plate counts were determined using the pour plate method. Samples were placed into sterile empty Petri-plates. Nutrient agar was poured into ~¾ of the plate and plates were gently swirled to disperse the sample throughout the agar. Then plates were allowed to cool completely (~10 min), inverted and incubated at 36°C for 24 h. After incubation, plates were arranged in order of dilution. Results were obtained by selecting a countable (30 to 300 colonies) plate. Colonies were counted and reported as CFU/g of raw chicken breast.

RESULTS

Experiment 1

Raw chicken breasts stored at 2 to 3°C for 0, 3, 6 and 14 days had increased ($P < 0.05$) microbial growth over time (Figure 1). Initial sampling (day 0) found no difference ($P > 0.05$) in treatments compared with the control and between treatments (Table 3). Initially the raw chicken breasts were low in microorganisms (3 to 4 Log CFU/g). However, after the treatments were stored for 3 days, the aerobic bacteria increased 1 to 2 Log CFU/g (Table 3). At day 3, treatments 3, 4 and 5 had lower colony counts ($P < 0.05$) when compared to the control (Table 3). At day 6, control plates were uncountable due to our under-estimation of the increase in aerobic plate count (APC). Additionally, treatments 2 and 3 only had one countable plate due to increased APC. Treatments with 0.87 or 1.74% Na acetate had the lowest APC at day 6. Sampling on day 14 found all treatments to have lower APC ($P < 0.05$) compared to the control. Additionally, plates with 1.74% sodium acetate resulted in lower APC ($P < 0.05$) than any treatment at day 14. Adding 1.74% sodium acetate resulted in slower ($P < 0.05$) bacterial growth in the chicken breasts compared with all other treatments throughout storage (Table 4).

Experiment 2

Initial APC were lower ($P < 0.05$) in plates with 3.48% sodium acetate and the combination of 1.74% sodium acetate lactate and 1.74% sodium acetate compared to

Table 3. Aerobic plate counts (APC) of refrigerated raw chicken breasts over a 14 day period (Log CFU/g)[a].

Day	Control	0.87% Na lactate	1.74% Na lactate	0.87% Na acetate	1.74% Na acetate	SEM
0	2.932[b]	3.499[b]	3.610[b]	3.793[b]	3.806[b]	0.310
3	5.200[b]	4.912[b]	3.952[c]	3.718[cd]	4.315[ce]	0.226
6	-*	6.718	8.079	6.319[b]	5.716[c]	0.027
14	8.937[b]	8.113[c]	8.480[d]	8.126[ce]	7.106[f]	0.031

[a]Data are means of three replicates except 0.87 and 1.74% Na lactate on d 6 means are only one replicate. Means are different P < 0.05 when superscripts differ within rows. *Day 6, control treatment was too numerous to count (TNTC).

Table 4. The growth rate constant of microbial populations in raw chicken breasts in refrigerated storage for 14 days.

Treatment	Days	Slope (y = mx + c)
Control	0 - 14	0.405 ± 0.006[a]
0.87% Na lactate	0 - 14	0.320 ± 0.020[ab]
1.74% Na lactate	0 - 14	0.367 ± 0.006[abc]
0.87% Na acetate	0 - 14	0.336 ± 0.023[abcd]
1.74% Na acetate	0 - 14	0.242 ± 0.024[e]

[a-e]Data are means of nine replicates, days 0 - 14. Means are different P < 0.05 when superscripts differ within columns.

Table 5. Aerobic plate counts (APC) of refrigerated raw chicken breasts during 15 days (Log CFU/g).

Day	Control	1.74% Na lactate	1.74% Na acetate	3.48% Na acetate	1.74% Na lactate + 1.74% Na acetate	SEM
0	5.300[a]	5.229[ab]	5.286[abc]	5.105[d]	4.950[e]	0.050
3	7.716[a]	7.647[ab]	7.491[abc]	6.030[d]	5.772[de]	0.102
6	8.661[a]	8.418[b]	6.784[c]	5.862[d]	5.106[e]	0.097
9	9.073[a]	9.062[a]	7.454[b]	6.079[c]	5.735[d]	0.467
12	9.264[a]	9.230[b]	7.226[c]	5.996[d]	5.613[de]	0.102
15	9.122[a]	9.635[ab]	7.083[c]	5.883[d]	5.618[e]	0.155

[a-e]Data are means of nine replicates except (day 9) 1.74% Na acetate + 1.74% Na lactate means are only seven replicates. Means are different P < 0.05 when superscripts differ within rows, days 0 to15.

the control, 1.74% sodium lactate, and 1.74% sodium (Table 5). Plates with the combination of 1.74% sodium lactate and 1.74% sodium acetate had the lowest (P < 0.05) APC. After 3 days of storage, aerobic counts increased at least 2 Log CFU/g for each treatment (Table 5). At day 3, plates with 3.48% sodium acetate and the combination of 1.74% sodium lactate and 1.74% sodium acetate had lower (P < 0.05) APC than the other treatments and plates with the combination of 1.74% sodium lactate and 1.74% sodium acetate had the lowest (P < 0.05) APC (Figure 2). After 6 days of storage, APC of samples from treatments 2 to 5 were lower (P < 0.05) when compared to the control (Figure 2). Results from day 6 were similar to day 3, 3.48% sodium acetate and the combination of 1.74% sodium lactate and 1.74% sodium acetate performed the best having the lowest (P < 0.05) APC (Figure 2). Results from sampling at days 9, 12, and 15 produced parallel results. Plates with 1.74% sodium acetate, 3.48% sodium acetate, and the combination of 1.74% sodium lactate and 1.74% sodium acetate had lower (P < 0.05) APC than the control and 1.74% sodium lactate samples (Figure 2).

Over the 15 days period, APC increased at least 3 Log CFU/g for the control and 1.74% sodium lactate treatments. Samples with 1.74% sodium acetate increased approximately 2 Log CFU/g and 3.48% sodium acetate and the combination 1.74% sodium lactate and 1.74% sodium acetate increased approximately 1 Log CFU/g (Table 5). After days 15, only samples from three treatments (1.74% sodium acetate, 3.48% sodium acetate, and the combination 1.74% sodium lactate and 1.74% sodium acetate) had countable plates (Table 6). Samples were observed for 39 days. At this point, APC for these three treatments was still below Log CFU/g for

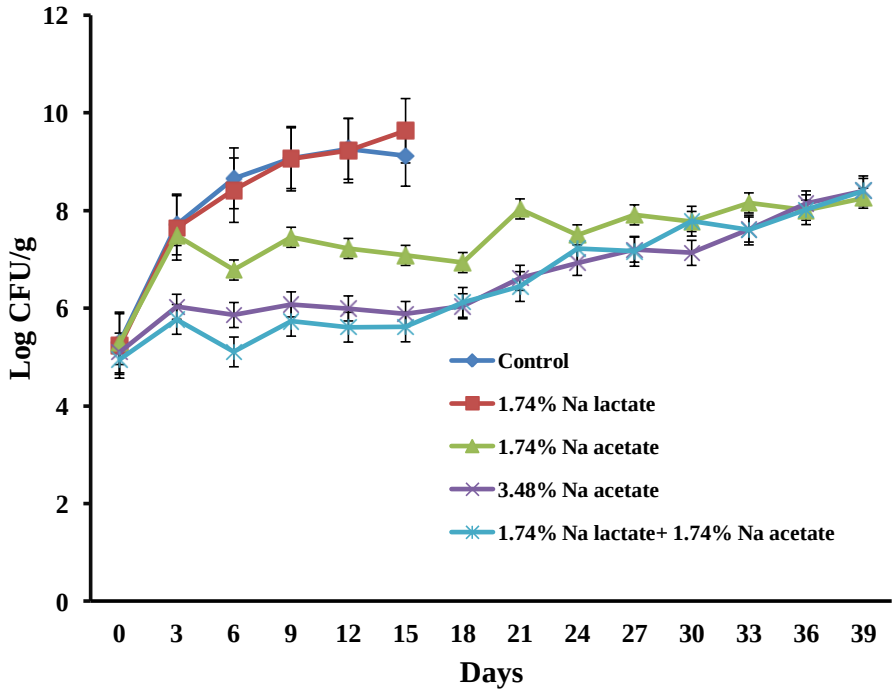

Figure 2. Effect of sodium lactate and sodium acetate treatments on aerobic plate counts (APC) of raw chicken breasts during storage at 2 to 3°C for 39 days. All data points represent means of three to nine replicates (depending on the number of countable plates) of three chicken breasts per treatment. Sodium acetate effect ($P < 0.05$).

Table 6. Aerobic plate counts (APC) of raw chicken breasts containing various shelf-life extenders and levels held in refrigerated storage for 18 to 39 days (Log CFU/g).

Day	1.74% Na acetate	3.48% Na acetate	1.74% Na lactate +1.74% Na acetate	SEM
18	6.936^{a}	6.041^{b}	6.121^{b}	0.091
21	8.034^{a}	6.624^{b}	6.445^{b}	0.130
24	7.503^{a}	6.929^{b}	7.224^{c}	0.196
27	7.912^{a}	7.202^{b}	7.166^{b}	0.087
30	7.777^{a}	7.135^{b}	7.784^{b}	0.064
33	8.157^{a}	7.613^{b}	7.602^{b}	0.150
36	8.009^{a}	8.146^{a}	8.018^{a}	0.104
39	8.255^{a}	8.402^{a}	8.404^{a}	0.183

$^{a-e}$Data are means of nine replicates except (day 21) 3.48% Na acetate means are only five replicates, (day 27) 1.74% Na acetate + 1.74% Na lactate means are only three replicates, (day 33) 3.48% Na acetate and 1.74% Na acetate + 1.74% Na lactate means are only six replicates, and (day 36) 1.74% Na acetate means are only six replicates. Means are different $P < 0.05$ when superscripts differ within rows, days 18 to 39.

control and 1.74% sodium lactate treatments.

DISCUSSION

Experiment 1

Increasing concentration of treatment provided a greater level of inhibition compared to either the lower amounts or the control. Adding 1.74% sodium acetate was the most effective at inhibiting microbial growth at 14 days of storage. Also at day 14 of sampling, adding 0.87% sodium lactate or 0.87% sodium acetate performed similarly in reducing CFU/g ($P < 0.05$) when compared to the control. Previous research found sodium acetate to be more effective as a microbial growth inhibitor than sodium lactate and sodium citrate (Sallam, 2007). This organic salt can reduce aerobic plate counts in poultry

Table 7. The growth rate constant of microbial populations in raw chicken breasts in refrigerated storage for 39 days.

Treatment	Days	Slope (y = mx ± c)
Control	0 - 6	0.558 ± 0.027^{a}
1.74% Na lactate	0 - 6	0.524 ± 0.043^{ab}
1.74% Na acetate	0 - 39	0.049 ± 0.015^{c}
3.48% Na acetate	0 - 39	0.072 ± 0.017^{cd}
1.74% Na lactate + 1.74% Na acetate	0- 39	0.087 ± 0.003^{de}

[a-e]Values (Means ± SD) Means are different P < 0.05 when superscripts differ within columns. Data are means of three to nine replicates (depending on the number of countable plates), days 0 to 39.

products (Bacus and Bontenbal, 1991) and also inhibit 3 to 4 log CFU/cm^2 of APC (Samelis et al., 2004). Sodium lactate can lower water activity that doubles shelf-life of chicken breast (Anang et al., 2007). In addition, 3.5% sodium lactate stabilizes color during storage, delayed toxin of *Clostridium botulinum* in cook-in-bag turkey products, and protected against oxidation during storage (Maas et al., 1989). In conclusion, 1.74% sodium acetate was the most effective at reducing APC over a 14 day period, however, raw chicken breast at day 14 had APC of 10^7 to 10^8 CFU/g which is not an acceptable quality level. Rozum and Maurer (1997) reported that good quality shelf-life extenders for refrigerated raw chicken breasts needed an APC of less than 10^6 CFU/ml. Further research needs to be conducted to evaluate the level of sodium lactate and sodium acetate needed to inhibit growth of microorganism to acceptable levels and increase shelf-life.

Experiment 2

Regardless of storage duration, 1.74% sodium acetate is more effective than 1.74% sodium lactate at inhibiting microbial growth, and that 3.48% sodium acetate or a combination of 1.74% sodium lactate and 1.74% sodium acetate significantly (P < 0.05) reduced the growth of aerobic microorganisms as compared to controls. These two treatments required 39 days for the number of microorganisms in the chicken to equal the number seen in control treatment breasts after only 3 days of storage. These results are more than double the shelf-life of cooked chicken meat demonstrated by Rozum and Maurer (1997).

In conclusion, 3.48% sodium acetate or the combination of 1.74% sodium lactate and 1.74% sodium acetate were the most effective at inhibiting microbial growth and were excellent raw chicken breasts shelf-life extenders at 3°C for 39 days (Table 7). Further studies are needed to determine sensory attributes of these products. With a growing population and a slower economy, the need for extended shelf-life of raw and cooked poultry and meat products will be an increasing necessity.

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