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Effects of sodium lactate and/or potassium lactate on the microbial and sensory quality of beef frankfurter

(Kesan natrium laktat dan/atau kalium laktat terhadap bakteria dan kualiti cita rasa frankfurter daging lembu)

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Key words: sodium lactate, potassium lactate, beef frankfurter

Abstract

Sodium lactate and/or potassium lactate were incorporated into the beef frankfurter emulsion at concentrations of 1, 2 and 3% sodium lactate, 1% sodium lactate with 2.3% potassium lactate, 2% sodium lactate with 1.2% potassium lactate, and 3.4% potassium lactate. Frankfurter processed without the addition of sodium lactate, potassium lactate or combination of sodium lactate and potassium lactate was served as control. The addition of sodium lactate and/or potassium lactate into the product affected the growth of the bacteria by extending the lag phase. The shelf life of the treated product increased due to delay in the growth of the bacteria. The addition of sodium lactate and/or potassium lactate did not affect the colour and the aroma of the frankfurter.

Introduction

Today, consumers are concerned about food spoilage and are more aware of the danger from consuming food contaminated by microorganisms. Surveillance data from 1968 to 1977 indicated that meat and poultry products were responsible in over 50% of reported outbreaks of foodborne diseases (Bryan 1980). Between 250 and 350 million Americans are estimated to suffer acute gastroenteritis annually, with 25–30% thought to be caused by foodborne illnesses (McCabe and Beattie 2004). In 1999, the foodborne pathogens *Salmonella*, *Listeria*, *Campylobacter*, and *Escherichia coli* (both O157 and non-O157) were estimated to cause more than 6 million illnesses and approximately 9,000 deaths each year (Koohmaraie et al. 2005). Microorganisms are introduced into and onto food by various means such as improper cooling, handling, and storage, inadequate reheating of cooked and chilled foods, and cross-contamination. Bacteria can colonise a range of food preparation surfaces and utensils, from which they can contaminate food (Rusin et al. 2002).

The United States Department of Agriculture (USDA) has approved sodium lactate as a flavour enhancer in meat products at the 2% level (3.33% of the liquid at 60% solids). It is also approved as an antimicrobial agent at up to 4.8% (8.0% of the liquid at 60% solids)

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(Anon. 1987). In support, the Food and Drug Administration (FDA) has affirmed that potassium lactate and sodium lactate are generally recognized as safe (GRAS) for use as direct human food ingredients.

Sodium lactate and potassium lactate are the undissociated form of lactic acid. Lactic acid was first identified as an acidic constituent of foods nearly 200 years ago (Lockwood et al. 1965). It is one of the most widely distributed acids in nature and one of the earliest used in foods (Furia 1968). Sodium lactate can be used in frankfurter-type sausages as a replacement for sodium chloride (Igoe 1989). The bactericidal and bacteriostatic effects of lactic acid are well known and fermentation of foods is in fact one of the oldest ways to prevent microbial spoilage. Maas et al. (1989) revealed that lactate, not the sodium ion, was the principal factor in delaying botulinal toxin formation.

The use of meat product additives such as lactate salts (e.g. sodium, potassium, calcium or ammonium lactate), should be investigated as a possible safeguard against spoilage and pathogenic organisms. It is hoped that there is an effect of lactate salt in suppressing or inhibiting the survival of the organisms without significantly affecting the quality of the products produced. This study was undertaken to determine the bacteriological quality and the possibility of extending the shelf life of beef frankfurter by using sodium lactate and/or potassium lactate.

Materials and methods

Formulation and processing of frankfurter

Meat blocks were divided into lean and fat sources which made up various ratios of lean to fat. These meat blocks were placed in cardboard boxes and then frozen at –16 °C. A day before manufacturing the frankfurters, the meat blocks were removed from the freezer and the lean and fat sources were fabricated separately to produce a 25 kg batch per treatment. The fabricated raw materials were then stored in a chiller at 2 °C for thawing. Once thawed, the lean and fat sources were coarse ground separately through a 0.5 inch plate using a Holly Matic grinder (Model GMG 150). The lean and fat sources were then mixed separately using a Leland Double Mixer Food Mixer (Model L 100 DA) for 1 min and representative samples for fat determination were obtained. Fat determination involves the Foss-let procedure (AOAC 1983). The coarse ground lean and fat sources were frozen overnight and then thawed at 2 °C for 48 h before the frankfurter production.

Formulations were designed to yield 30% fat, while spices, prague powder, sodium erythorbate, salt, and sugar remained constant. Seven batches of frankfurters were prepared. The first batch contained no lactate and acted as a control group. The second, third and fourth batch were formulated to contain 1, 2 and 3% sodium lactate, respectively, while the seventh batch contained 3.4% potassium lactate. The other two remaining batches were formulated by incorporating sodium lactate with potassium lactate in a ratio of 1:2.3 and 2:1.2 for the fifth and the sixth batch, respectively.

Standardized processing procedures were followed and the lean and fat sources were maintained at 0 °C. The lean source was chopped with ice water using a bowl chopper (RMF-Type RSV 35). Then, the fat source was added followed by other additives and all these ingredients were continuously chopped until an end-point temperature of 18.3 °C was reached. The blended material was transferred to a stuffer (VEMAG Robot 500) and stuffed into a 22 mm cellulose casing. The stuffed product was linked every 125 mm using an automatic linker (MF TY linker – model 90 ACL).

All batches were labelled and weighed separately before the product was smoked and cooked in a Vortron smokehouse (model # 500). The smoking and cooking cycle was as follows: 15 min at 54.4 °C, 30 min at 60 °C with smoke, 30 min at 76.7 °C until the internal temperature of the product was 68.3 °C. The frankfurters were steamed

for 5 min, showered for 30 min, drained for 30 min, weighed and chilled at 1.7 °C for 24 h. After chilling, the frankfurters were weighed again and the casings were then peeled. The product was then vacuum packaged in *Barrier Bag* and stored at 1.7 °C for further analysis.

Microbial analysis

Total aerobic count of psychrotrophs using Plate Count Agar (PCA) were conducted. Initial counts were analysed on the raw materials used in making the frankfurters. Microbiological sampling of frankfurters were conducted at every 7-day interval, whereby, the first sampling started 24 h after chilling the product.

A sample of 25 g of frankfurter was blended for 1 min with 225 ml of sterile Butterfield's diluent in a sterile stomacher bag using a stomacher machine. Following this, appropriate serial dilutions were made with sterile Butterfield's diluent in test tubes. Bacterial counts were obtained by the spread plate technique on the prepoured PCA plates. After absorption of the aliquot, the plates were inverted and incubated at 20 °C for 5 days (FAO 1995).

Aroma and colour evaluation

Six trained panellists were used to evaluate visually the differences among the frankfurters. Training for evaluation of colour and aroma were held prior to actual testing by showing the panellists the characteristic differences among the frankfurters purchased at a retail shop. External colour, internal colour, and aroma were evaluated using the hedonic scale method. All evaluations were done during retail display under fluorescent natural light. A three-digit number was randomly assigned to each package to avoid bias judgement. The first evaluation was done on the day of vacuum packaging of the products and thereby at every 1-week interval.

Statistical analysis

The experimental design for retail evaluation and microbial analysis consisted of a repeated measures experiment utilizing multivariate analysis with the factors being experiment, days of storage and treatments. Specific orthogonal contrasts were conducted for comparisons of the treatment means within each day where appropriate. Others were analysed by univariate analysis and specific orthogonal contrasts were performed. Data collected from this study were analysed using PROC GLM found in Statistical Analysis System (SAS Inst 1985). Significance was determined by the F-test and significant differences were accepted at the 5% level of probability.

Results and discussion

The total bacterial counts for different treatments of sodium lactate and/or potassium lactate and the P-values of specific orthogonal contrasts are shown in *Table 1*. The treatment groups with addition of sodium lactate and/or potassium lactate were found to have lower bacterial counts than the control (without lactate) at day 7 and 14 ($p \leq 0.05$). The control showed a very rapid growth between day 0, 7 and 14 compared to the treated groups. Therefore, the presence of sodium lactate and/or potassium lactate is able to reduce the growth of surviving microorganisms in the product.

Debevere (1989) concluded that 1% and 2% sodium lactate inhibited the growth of lactic acid bacteria in liver patties. It has been theorized that the lactate ion has certain antimicrobial properties (Rubin et al. 1982; Maas et al. 1989). Other researchers proposed that the inhibitory effect of sodium lactate is due to reduction in water activity (Duxbury 1988; Debevere 1989; Tuley 1989).

In this study, sodium lactate and/or potassium lactate affected the growth of the total bacterial count by extending the lag phase growth period. The different amounts of sodium lactate and/or potassium lactate

Table 1. Total plate counts[a] and P-values of specific orthogonal contrasts of vacuum packaged beef frankfurters which were processed with different amounts[b] of sodium lactate (NaLac) and/or potassium lactate (KLac) stored at 1.7 °C

	Storage interval (days) at 1.7 °C					
	0	7	14	21	28	35
Treatment						
1. Control	2.27 ± 0.51	5.74 ± 1.21	6.76 ± 0.94	6.74 ± 0.81	7.56 ± 0.03	7.79 ± 0.23
2. 1% NaLac	2.28 ± 0.27	2.59 ± 0.12	3.91 ± 1.13	6.01 ± 1.38	6.74 ± 0.87	6.02 ± 1.73
3. 2% NaLac	2.68 ± 0.73	2.84 ± 0.16	3.94 ± 0.24	4.18 ± 0.45	5.32 ± 1.11	6.75 ± 0.61
4. 3% NaLac	1.88 ± 0.44	2.89 ± 0.18	3.60 ± 0.61	6.29 ± 0.16	7.33 ± 0.44	7.60 ± 0.23
5. 1% NaLac + 2.3% KLac	1.99 ± 0.50	2.11 ± 0.51	3.66 ± 0.39	3.59 ± 1.38	4.99 ± 2.35	4.39 ± 1.54
6. 2% NaLac + 1.2% KLac	2.29 ± 0.33	2.59 ± 0.56	2.83 ± 0.44	2.81 ± 0.43	3.68 ± 0.01	5.16 ± 0.27
7. 3.4% KLac	2.47 ± 0.02	1.96 ± 0.16	2.36 ± 0.37	4.63 ± 0.37	4.15 ± 1.15	5.06 ± 2.74
Comparisons[c]						
1 vs 2,3,4,5,6,7	0.9920	0.0011	0.0046	0.0660	0.1003	0.2606
2 vs 3,4,5,6,7	0.9529	0.8453	0.4455	0.1302	0.1998	0.8924
3 vs 4,5,6,7	0.0944	0.4628	0.3388	0.8816	0.8181	0.4926
4,7 vs 5,6	0.8855	0.8957	0.7219	0.0439	0.2261	0.3270
4 vs 7	0.1266	0.2481	0.2628	0.2338	0.0747	0.2632

[a]Expressed in logarithmic form ($\log_{10}$ CFU/g) and standard error
[b]Expressed as percentage of raw meat block weight
[c]Value significantly different if $p \leq 0.05$

used in this study did not kill the bacteria but only inhibited their growth. This is due to the fact that the bacteria populations within the treated groups showed an upward trend in their growth pattern. Snijders et al. (1985) observed a delayed bacteriostatic effect of lactic acid during storage, which was probably the result of a prolonged lag phase of acid-injured bacteria surviving lactic acid decontamination. The length of the lag phase may be expected to reflect the time necessary for the organisms to bring the external environment within their optimum growth range (Jay 1986). A prolonged lag phase is a characteristic feature of bacterial injury and repair (Hurst 1977). This may indicate that with time, some bacteria could adjust to the presence of lactate salts. Once the bacteria are able to bring the external environment within their optimum growth range, growth then occurs.

The means and P-values for external colour scores, internal colour scores, and aroma scores are shown in *Table 2*, *Table 3*, and *Table 4*, respectively. External colour scores showed consistently smaller values for the control compared to the treated groups. Therefore, the control was slightly paler in colour compared to the treated groups. However, for the external colour scores there were no significant differences between the control and the treated groups except on day 28. Similarly, the internal colour of the control samples showed a consistently paler colour when compared to the treated groups. Duxbury (1990) observed that cooked beef roasts injected with sodium lactate were darker red than control samples. This finding was in agreement with the present study where treated groups were generally darker in colour than the control samples.

For the aroma, significant differences between the control and the treated groups were detected only on day 7 and 14 ($p \leq 0.05$) where the former showed lower values indicating less intense aroma. Even though at any sampling point the results indicated statistical significant differences, in practical terms it is not that significant due to very small differences among the samples.

Table 2. Mean values[a] for external colour scores[b] and P-value for F-test of specific orthogonal contrast of vacuum packaged beef frankfurters which were processed with different amounts of sodium lactate (NaLac) and/or potassium lactate (KLac), stored at 1.7 °C and evaluated at 7-day interval during retail display

	Storage interval (days) at 1.7 °C						
	0	7	14	21	28	35	42
Treatments							
1. Control	4.1 ± 0.39	4.0 ± 0.21	3.9 ± 0.18	3.9 ± 0.26	4.3 ± 0.19	4.1 ± 0.25	3.7 ± 0.26
2. 1% NaLac	4.4 ± 0.34	4.4 ± 0.16	4.3 ± 0.34	4.4 ± 0.29	4.3 ± 0.19	4.6 ± 0.21	4.2 ± 0.20
3. 2% NaLac	4.3 ± 0.33	4.2 ± 0.29	4.6 ± 0.22	4.2 ± 0.15	4.7 ± 0.19	4.5 ± 0.21	4.4 ± 0.16
4. 3% NaLac	4.7 ± 0.29	4.6 ± 0.16	4.0 ± 0.26	4.3 ± 0.17	4.9 ± 0.19	4.2 ± 0.30	4.6 ± 0.16
5. 1% NaLac + 2.3% KLac	4.67 ± 0.37	4.2 ± 0.29	4.6 ± 0.22	4.1 ± 0.20	4.8 ± 0.17	4.7 ± 0.14	4.6 ± 0.16
6. 2% NaLac + 1.2% KLac	4.6 ± 0.44	4.5 ± 0.17	4.4 ± 0.22	4.1 ± 0.26	4.8 ± 0.17	4.5 ± 0.21	4.5 ± 0.22
7. 3.4% KLac	4.4 ± 0.41	4.6 ± 0.16	4.5 ± 0.17	4.3 ± 0.24	4.8 ± 0.17	4.9 ± 0.16	4.4 ± 0.27
Comparisons[c]							
1 vs 2,3,4,5,6,7	0.1081	0.1598	0.1862	0.1527	0.0013	0.1464	0.0984
2 vs 3,4,5,6,7	0.7918	0.8442	0.7360	0.3414	0.0005	0.9327	0.4700
3 vs 4,5,6,7	0.3776	0.5923	0.5404	0.9395	0.0430	0.7464	0.7636
4,7 vs 5,6	0.6476	0.4316	0.4510	0.4106	0.5486	0.8950	0.8927
4 vs 7	0.5811	0.9241	0.2978	0.8731	0.4034	0.0621	0.7043

[a]Expressed as mean and standard error
[b]Based on a 8-point scale (8 = very dark; 1 = extremely pale)
[c]Value significantly different if $p \leq 0.05$

Table 3. Mean values[a] for internal colour scores[b] and P-value for F-test of specific orthogonal contrast of vacuum packaged beef frankfurters which were processed with different amounts of sodium lactate (NaLac) and/or potassium lactate (KLac), stored at 1.7 °C and evaluated at 7-day interval during retail display

	Storage interval (days) at 1.7 °C						
	0	7	14	21	28	35	42
Treatments							
1. Control	4.7 ± 0.17	4.2 ± 0.13	4.4 ± 0.37	4.4 ± 0.18	4.4 ± 0.19	4.6 ± 0.20	4.3 ± 0.26
2. 1% NaLac	4.7 ± 0.17	4.3 ± 0.15	4.5 ± 0.22	4.2 ± 0.28	4.5 ± 0.15	4.7 ± 0.14	4.5 ± 0.31
3. 2% NaLac	4.4 ± 0.24	4.2 ± 0.13	4.5 ± 0.22	4.1 ± 0.26	4.6 ± 0.15	4.6 ± 0.20	4.7 ± 0.15
4. 3% NaLac	4.4 ± 0.18	4.1 ± 0.23	4.1 ± 0.31	4.6 ± 0.18	4.8 ± 0.13	4.8 ± 0.12	4.3 ± 0.26
5. 1% NaLac + 2.3% KLac	5.0 ± 0.29	4.3 ± 0.15	4.4 ± 0.31	4.3 ± 0.24	4.8 ± 0.13	4.7 ± 0.24	4.4 ± 0.16
6. 2% NaLac + 1.2% KLac	4.6 ± 0.24	4.3 ± 0.21	4.6 ± 0.31	4.6 ± 0.18	5.0 ± 0.12	4.5 ± 0.21	4.5 ± 0.22
7. 3.4% KLac	4.7 ± 0.17	4.5 ± 0.17	4.6 ± 0.31	4.9 ± 0.11	4.7 ± 0.14	5.3 ± 0.19	4.7 ± 0.15
Comparisons[c]							
1 vs 2,3,4,5,6,7	0.8072	0.6650	0.8754	0.9704	0.0309	0.3099	0.4000
2 vs 3,4,5,6,7	0.7731	0.9625	0.8528	0.0514	0.0554	0.7670	0.9370
3 vs 4,5,6,7	0.2435	0.6088	0.8204	0.0064	0.1009	0.2103	0.3985
4,7 vs 5,6	0.2615	0.8977	0.6149	0.0389	0.1340	0.0171	0.8289
4 vs 7	0.3860	0.0821	0.2578	0.0607	0.5628	0.0469	0.2487

[a]Expressed as mean and standard error
[b]Based on a 8-point scale (8 = very dark; 1 = extremely pale)
[c]Value significantly different if $p \leq 0.05$

Table 4. Mean values[a] for aroma scores[b] and P-value for F-test of specific orthogonal contrast of vacuum packaged beef frankfurters which were processed with different amounts of sodium lactate (NaLac) and/or potassium lactate (KLac), stored at 1.7 °C and evaluated at 7-day interval during retail display

	Storage interval (days) at 1.7 °C						
	0	7	14	21	28	35	42
Treatments							
1. Control	5.2 ± 0.49	4.2 ± 0.51	4.3 ± 0.45	5.7 ± 0.53	5.8 ± 0.37	5.1 ± 0.48	5.8 ± 0.42
2. 1% NaLac	5.1 ± 0.56	5.3 ± 0.45	4.4 ± 0.48	5.4 ± 0.53	5.1 ± 0.48	4.7 ± 0.36	5.6 ± 0.37
3. 2% NaLac	5.3 ± 0.37	5.6 ± 0.62	5.5 ± 0.54	4.6 ± 0.53	5.9 ± 0.36	5.8 ± 0.54	6.1 ± 0.35
4. 3% NaLac	5.2 ± 0.52	4.6 ± 0.50	5.0 ± 0.47	5.0 ± 0.58	5.7 ± 0.28	5.5 ± 0.45	5.9 ± 0.43
5. 1% NaLac + 2.3% KLac	5.0 ± 0.58	5.3 ± 0.58	5.3 ± 0.40	5.4 ± 0.44	5.1 ± 0.23	5.2 ± 0.40	6.2 ± 0.36
6. 2% NaLac + 1.2% KLac	5.4 ± 0.60	5.5 ± 0.45	5.1 ± 0.57	5.3 ± 0.41	5.4 ± 0.23	5.6 ± 0.43	5.8 ± 0.42
7. 3.4% KLac	4.8 ± 0.55	5.1 ± 0.48	5.2 ± 0.42	5.8 ± 0.32	5.8 ± 0.37	6.2 ± 0.40	5.2 ± 0.36
Comparisons[c]							
1 vs 2,3,4,5,6,7	0.9682	0.0003	0.0427	0.3739	0.5905	0.2695	1.0000
2 vs 3,4,5,6,7	1.0000	0.5482	0.0382	0.8278	0.3444	0.0344	0.7287
3 vs 4,5,6,7	0.6669	0.0127	0.3108	0.1260	0.3978	0.4279	0.6467
4,7 vs 5,6	0.7800	0.0033	0.7358	0.9547	0.3274	0.2117	0.4835
4 vs 7	0.6504	0.0254	0.6349	0.2283	0.8955	0.1400	0.4429

[a]Expressed as mean and standard error
[b]Based on a 7-point scale (7 = very intense; 1 = none)
[c]Value significantly different if $p \leq 0.05$

Conclusion

The addition of sodium lactate and/or potassium lactate in the product affected the growth of the bacteria. Sodium lactate and potassium lactate when used alone or in combination had similar effect in delaying the growth of surviving microorganisms. The shelf life of the treated product increased due to delay in the growth of bacteria as indicated by an extension in the lag phase period. The extension in the shelf life would be beneficial to the meat industry.

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Abstrak

Natrium laktat dan/atau kalium laktat dicampur ke dalam emulsi frankfurter daging lembu pada kepekatan 1, 2, dan 3% natrium laktat, 1% natrium laktat bersama 2.3% kalium laktat, 2% natrium laktat bersama 1.2% kalium laktat, dan 3.4% kalium laktat. Frankfurter daging lembu yang dirumus tanpa laktat dilabel sebagai kawalan. Penggunaan natrium laktat dan/atau kalium laktat mempengaruhi pertumbuhan bakteria dan dapat meningkatkan jangka hayat simpanan bagi produk ini. Walau bagaimanapun, natrium laktat dan/atau kalium laktat tidak mempengaruhi warna dan aroma frankfurter.

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