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EFFECT OF INCORPORATING FOOD-GRADE LACTIC ACID IN MINCED BEEF ON STORAGE STABILITY AND SENSORY EVALUATION OF THE PRODUCED PATTIES

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Abstract
The objective of this research is to evaluate quality properties and storage stability of beef patties formulated from fresh beef incorporated with food-grade lactic acid (LA). Fresh beef was purchased from the local market immediately after slaughter, minced and formulated using water incorporated with food-grade lactic acid in concentrations of 0.0% (control); 0.5%; 0.75% and 1.00%. The LA-incorporated formulations were used in the preparation of the patties. The prepared patties were stored at a refrigeration temperature of 5 °C for 12 days. pH, instrumental color, texture profile analysis (TPA), water activity and total viable count (TVC) were investigated. At the end of the storage period, the patties were cooked and sensory evaluated. The results revealed a significant ($p \leq 0.05$) decrease in pH of the control patties from 6.2 ± 0.1 to 5.1 ± 0.2–5.4 ± 0.2 from day 8 to day 12 of the storage time. The same trend was observed in the LA-incorporated patties. The LA-incorporated patties did not show any significant differences ($p \geq 0.05$) in the water activity values through all storage time. At the end of the storage time, the control had the TVC value of almost near the spoilage limit, while all LA-incorporated patties had significantly ($p \leq 0.05$) lower TVC compared with the control. The results revealed high stability in the physicochemical properties as well as total microbial growth during the storage period. The hardness of the LA-incorporated patties was significantly ($p \leq 0.05$) lower than that of the control sample. There was no significant ($p \geq 0.05$) difference in overall sensory acceptability of the patties made from beef incorporated with food-grade lactic acid compared to the control. This study suggests that incorporating fresh beef with food-grade lactic acid in the mentioned concentrations could result in great benefits of increasing the storage life of fresh beef products with no effect on sensory quality attributes.

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Introduction

Meat and meat products are considered a unique food source for human nutrition and are recognized as a source of high nutritional value protein, which includes all essential amino acids in adequate proportions, as well as long chain n-3 fatty acids, conjugated linoleic acid, nucleotides, bioactive hydrolysates, antioxidants, and connective tissue components [1–3]. Food-grade organic acids such as citric, acetic, and lactic acids are commonly used in food as antimicrobials, antioxidants, and pH adjusters for shelf-life extension. These acids are generally recognized as safe [4]. Treatment of fresh meat with food-grade organic acids can lead to the stability in physicochemical, antioxidant, and microbiological properties of beef products [5]. Earlier, food-grade organic acids were applied by different methods such as dipping [6,7] and spray washing [7] to reduce the spoilage microorganisms leading to storage life extension. The effects of food-grade organic acids on quality of different types of meat products have been reported in several research works. Ji et al. [8] reported that organic acids including citric acid (CA) and malic acid (MA) have a significant effect on cleaning and disinfection of food. They found that the extracellular alkaline phosphatase (AKP) activity of *Escherichia coli* treated with CA and MA at a concentration of 5120 μg/mL increased 8.16 and 6.95 times compared to the control and reached 3.10 U/L and 2.69 U/L, respectively. These results show that CA and MA at this concentration can have the inhibitory activity against *Escherichia coli* by damaging the cell wall [8]. In the earlier study [9], pork bologna slices were treated with organic acids (lactic acid or acetic acid at concentrations of 2.5% and 5%) or salts (2.5 or 5% sodium acetate or sodium diacetate, 5 or 10% sodium lactate, 5% potassium sorbate or potassium benzoate). The bologna slices inoculated with *L. monocytogenes* were dipped in each solution of acids or salts, and then stored vacuum-packaged at 4 °C for a period of 120 days to evaluate the growth of *L. monocytogenes*. No significant ($p > 0.05$) increase in populations of *L. monocytogenes* was observed on bologna slices treated with 2.5% or 5% acetic acid, 5% sodium diacetate, or 5% potassium benzoate from day 0 to 120. Also, no significant ($p < 0.05$) increase in *L. monocytogenes* was recorded on bologna slices treated with 5% potassium sorbate and 5% lactic acid up to 50 and 90 days of storage, respectively [9]. According to Nkosi et al. [10] the usage of specific food-grade organic acids at lower concentrations can achieve the desired effect of reducing or killing microorganisms without influencing quality (odor, appearance, and texture) of chicken meat.

Muriana et al. [11] evaluated lactic acid at a concentration of 50,000 ppm and a combination of lactic acid with citric acid at a concentration of 2.4% of concentrate among other antimicrobials against *Escherichia coli* O157: H7 on the surface of lean beef wafers stored for 14 days. In addition, they examined the presence/absence of *Escherichia coli* O157: H7 in meat core samples after spray intervention and blade tenderization of beef. The results showed that the absence of *Escherichia coli* O157: H7 in the meat core samples correlated with the ability of the studied antimicrobials including lactic acid to reduce bacterial levels on the surface of beef before blade tenderization. For safety purpose, chemical preservatives for meat should be replaced with natural ones such as food-grade organic acids to serve as meat antimicrobial agents [12].

Manzoor et al. [13] studied an influence of lactic acid on quality characteristics of buffalo meat. Buffalo half carcasses were sprayed with 2%, 4%, and 6% lactic acid solutions after slaughter. The samples of the sirloin and tenderloin were cut from half carcasses, vacuum packed, and stored at 0 °C for 7 days. Afterward, steaks (2 cm thick) were taken from these cuts, packed under modified atmosphere, stored in a retail display-chiller for 7 days and then evaluated for an effect of lactic acid on microflora, instrumental color, shelf life and sensory parameters of meat. The study revealed that spraying buffalo meat with 2–4% lactic acid solutions after slaughter enhanced microbiological quality of meat. Furthermore, it may also improve its instrumental color.

Food-grade organic acids were also used in beef and beef products such as beef steaks to reduce microbial load without undesirable changes in meat sensory properties [14]. Organic acids are used to treat meat because they are cheap and effective in meat and meat product preservation technology and have no undesirable effects on meat quality [15]. Organic acid solutions such as acetic acid, lactic acid, ascorbic acid, citric acid, tartaric acid and fumaric acid at concentrations of 1%–5% are the most frequently used chemical interventions for beef and lamb [16]. The effect of food-grade organic acids such as citric acid on the physicochemical and sensory properties of meat was demonstrated in [5]. Using the dilute solutions of food-grade organic acids (1%–3%) is generally recognized as safe, and as a rule does not exert an effect on desirable sensory properties of meat [17].

Stamilla et al. [18] evaluated an effect of dietary supplementation of microencapsulated blend of food-grade citric and sorbic acids combined with thymol and vanillin essential oils at a concentration of 0.5% on quality and shelf-life of broiler meat. The results showed that supplementation of microencapsulated blend of food-grade organic acids and essential oils could improve the quality and shelf-life of poultry meat.

Omidi et al. [19] investigated an effect of dietary supplementation of acetic acid at a concentration of 0 and 20 g/ kg combined with *Satureja khuzistanica* essential oil (SkEO) at concentrations of 0, 200, 300, 400, 500, and 600 mg/ bird/day on the composition of fatty acids (FAs) in thigh meat of Ross 308 broiler chickens at days 34, 38, and 42 of age [14]. The acidified diet led to a decrease in MUFA, TFA, CFA and an increase in SFA and the ratio of n-6 to n-3 FAs in chicken thigh meat. The authors concluded that dietary acetic acid and its combination with SkEO inconsistently modified the concentration of certain classes of FAs in broiler thigh meat.

Previous works focused on limited treatments during meat burger processing and chilled storage. Therefore, this study aims at evaluating an effect of lactic acid incorporation at concentrations of 0.5% — 1.0% on quality properties (pH, instrumental color, texture profile analysis, water activity and sensory characteristics) and microbiological parameters (total viable count) of patties formulated using beef treated with lactic acid.

Materials and methods

Incorporation process

Fresh hot beef (m. *longissimus dorsi*) was purchased immediately after slaughter from the local fresh meat market located near the university to avoid any changes in meat quality. After that, meat was placed in ethylene vinyl acetate (EVA) bags, covered with ice, and transported fresh to the laboratory within 15 min. Meat was cut into small pieces under the hygienic condition using a filleting sterilized knife. The pieces were then minced using a meat grinder (model Sammic PS-32 Stainless Meat Mincer, Germany). One hundred grams of food-grade lactic acid with the purity of 99.9% (purchased from Melon Food Grade Company, Selangor, Malaysia) and distilled water were used to prepare LA solutions with concentrations of 0.0%, 0.5%, 0.75% and 1.00%. The prepared LA solutions were incorporated individually into minced beef batches (1 kg each). The mixing process was carried out using a silent bowl cutter (model DH901, Ding-Han Machinery Co., Ltd., Taiwan) for 5 min until complete homogenization. A dough-like mixture was obtained and used in preparation of patties. The control patties were prepared using minced beef without adding food-grade lactic acid.

Preparation of patty samples

Patties were formulated using food-grade lactic acid incorporated individually into homogenized dough batches (1kg each). The following ingredients were purchased from Melon Food Grade Company, Selangor, Malaysia and added to the formulation: 1.1% sodium chloride, 1.0% black pepper powder, 0.5% cinnamon powder and 1.5% skimmed milk. Each formulation was mixed in a silent bowl cutter for 5 min and patty samples weighing 80 g each were shaped manually using a patty molding machine. Round-shaped patty samples approximately 85 mm in diameter and 18 mm in thickness were produced. Processed patties were stored in a refrigerator at 5 °C for 12 days. The measurements including pH, instrumental color, instrumental texture, water activity and total viable count (TVC) were taken in all patty samples on the first day of storage and then at 4-day intervals. At the end of the storage period, the patties were cooked and sensory evaluated.

pH measurement

Ten grams of each sample were individually blended with 100 mL of distilled water (in a ratio of 1:10) for 1 min using a Waring blender (model (CB15K, Puchong, Malaysia) at low speed. A pH meter (Toledo 320 pH meter, Mettler- Instrument, Germany) was standardized with two buffer solutions at pH 7.0 and 4.0 before being used. pH of patties was measured on the first day (day 0) and then at 4-day intervals.

Color measurement

Color values were measured on the first day (day 0) and then at 4-day intervals using a Hunter lab Ultrascan Sphere Spectrocolorimeter (Minol Cr- 300 Series U. S.). The instrument was calibrated before being used. Samples were placed individually into plastic Petri dishes before conducting the measurement. Good care was taken to ensure that there were no gaps between the Petri dish lids and the filled sample, and that the lens of the calorimeter touched the lid of the Petri dish in each measurement. The values of color L* (Lightness), a* (Redness), and b* (Yellowness) were measured on the surface of each sample individually through each plastic Petri dish. An average of three replications was determined.

Texture profile analysis (TPA)

The hardness measurement was carried out using the modified method of the texture measurement by Devine et al. [20]. The patty slices with a size of 15 × 6.5 mm (approximately 1 cm^2 cross-section) were sheared with a Warner-Bratzler shear blade (with a thickness of 1.0 mm and a flat edge) attached to a Stable Micro System (SMS) texture analyzer (model TA — T2 I, USA). The instrument was calibrated with a 50 kg load cell and speed at 250-mm/min. Hardness (N), springiness (mm), cohesiveness and chewiness (mJ) were calculated from the computer connected to the instrument and expressed as TPA.

Water activity measurement

Patties were chopped using a Waring chopper (Waring Products Division, New Hartford, USA) and then mixed using a glass rod before water activity determination. The instrument used for measurement of a_w was Aqua Lab model 3TE (Decagon Devices, Inc., USA). The equipment was first standardized and prepared samples were put in the sample cups individually, approximately half-full. The cup was then covered and placed individually in the sample drawer. The drawer was closed carefully and a_w of the samples was read off the instrument directly in about 40s at a temperature of 25 °C. Three replicates of each sample were obtained.

Total plate count assessment

The aerobic plate counts of patties were determined according to the method described by

Elgadir et al. [21]. Samples weighing 10 ± 0.1g were removed individually from each package using a sterilized knife and transferred aseptically to a sterilized stomacher bag which contained 90 mL of peptone water. The samples were then homogenized individually for 2 min in a Stomacher 400 blender (Seward Ltd, UK). Further dilutions of 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6} were made. An amount of 0.1 mL from each dilution was spread on the plate count agar and the plates were incubated at 37 °C for 48 hrs. The total aerobic plate counts were then obtained from plates with 30–300 colonies in all samples in triplicates on the first day (control sample on day 0) and then at 4-day intervals and reported as $\log_{10}$ of the numbers of colony-forming units.

Sensory evaluation

The prepared patties were cooked on a hot plate set at 170–190 °C on one side for 2 min., then they were turned over and cooked on the other side for the same time until the surface became brown. Each cooked patty was then cut into almost equal four parts and served hot to the sensory panelists. Thirty panel members performed the sensory evaluation by the hedonic scale method. The panelists were asked to evaluate patties using the nine-point hedonic scale (9=like extremely; 8=like very much; 7=like moderately; 6=like slightly; 5=neither like nor dislike; 4=dislike slightly; 3=dislike moderately; 2=dislike very much; 1 =dislike extremely), according to the attributes of color, texture, taste, flavor and overall acceptability. Scores were obtained and analyzed.

Statistical Analysis

Analysis of variance (ANOVA) was performed using the Minitab version 17 statistical package (Minitab Inc., PA, USA). Three replicates were performed for each sample. The significance of differences was defined at a p-value of ≤ 0.05.

Results and discussion

pH measurement

The change in the pH values of the samples is shown in Table 1. A gradual decrease in the pH values was observed during storage (interval measurements). The pH of the control patties decreased significantly ($p \leq 0.05$) from

6.2 ± 0.1 to 5.1 ± 0.2 from day 8 to day 12 of storage. The same trend was observed in the LA-incorporated patties. The pH of patties decreased significantly ($p \leq 0.05$) from 5.5 ± 0.2 to 5.0 ± 0.3, from 5.2 ± 0.3 to 4.9 ± 0.2 and from 5.1 ± 0.1 to 4.8 ± 0.1 in the patties incorporated with lactic acid at concentrations of 0.5%, 0.75%, and 1.0%, respectively. This is in good agreement with the finding of other studies, which found that the reduction in pH during storage may be attributed to the accumulation of lactic acid due to the growth of lactic acid bacteria in stored patties [22,23]. This disagrees with Davies and Board [24] who reported that a gradual but harmonious rise in meat pH as storage time and spoilage progressed could be attributed to the tissue breakdown and odoriferous nitrogenous compounds production.

Table 1. pH values of the control and LA-incorporated patties during storage at 5 °C for 12 days

Days of storage	Control sample	Lactic acid 0.5%	Lactic acid 0.75%	Lactic acid 1.00%
0	6.2 ± 0.1[a]	5.5 ± 0.2[a]	5.2 ± 0.3[a]	5.1 ± 0.1[a]
4	5.4 ± 0.2[b]	5.1 ± 0.2[a]	5.2 ± 0.1[a]	5.1 ± 0.1[a]
8	5.1 ± 0.2[b]	5.1. ± 0.3[a]	5.0 ± 0.2[a]	4.9 ± 0.2[a]
12	5.1 ± 0.2[b]	5.0 ± 0.3[b]	4.9 ± 0.2[b]	4.8 ± 0.1[b]

a, b: means within a column with different letters are significantly different ($p \leq 0.5$).
Means are the values obtained from triplicate readings.

Color measurement

The red color of meat, especially beef, is an important deciding factor in consumers› assessment of meat quality [25]. The red color values of the samples are presented in Table 2. As the storage time progressed, reduction in red color value (a) of the sample was observed. This fact agrees with the finding of Zhang et al. [26] who observed the same phenomenon in beef storage in the chilled conditions. In the present study, the color values were significantly ($p \leq 0.05$) different. Patties incorporated with lactic acid at all concentrations showed an increase in both L* (Lightness) and b* (yellowness) values. However, a significant ($p \leq 0.05$) decrease in the a* value was observed in the patties incorporated with lactic acid at a concentration of 1.0% compared with the control patties and the patties treated with the lactic acid at concentrations of 0.5% and 0.75%. This finding is in a good agreement with that of Abd Elgadir et al. [5], who investigated an effect of fresh beef treatment with food-grade organic acids including citric, lactic, acetic and tartaric acids at concentrations of 0.5%, 0.75% and 1.0% using the infusion process during storage at a temperature of 5 °C for 28 days. They found significant changes in the red color of the samples treated with acids at different concentrations. The control sample was reddish with the initial a* value of 3.56. The infusion of organic acids at a concentration of 1.0% led to the pale color with a* values in a range of 3.30 to 3.42. Moreover, Hunter L* values increased significantly ($p < 0.05$) upon infusion of all acids.

Table 2. Color values of the control and LA- incorporated patties during storage at 5 °C for 12 days

Days of storage	Color values	Control sample	Lactic acid 0.5%	Lactic acid 0.75%	Lactic acid 1.00%
0	L*	31.5 ± 0.1[a]	44.9 ± 0.5[b]	46.9 ± 0.5[c]	47.9 ± 0.5[d]
	a*	4.6 ± 0.02[a]	4.3 ± 0.2[b]	3.8 ± 0.2[c]	3.3 ± 0.2[d]
	b*	6.5 ± 0.02[a]	7.5. ± 0.4[b]	7.5. ± 0.4[b]	7.7 ± 0.4[c]
4	L*	34.5 ± 0.1[a]	45.9 ± 0.5[b]	47.9 ± 0.5[c]	47.9 ± 0.5[c]
	a*	4.5 ± 0.02[a]	4.2 ± 0.2[b]	3.6 ± 0.2[c]	3.2 ± 0.2[c]
	b*	6.7 ± 0.02[a]	7.3. ± 0.1[b]	7.5. ± 0.2[b]	7.9 ± 0.3[b]
8	L*	36.5 ± 0.1[a]	47.1 ± 0.3[b]	47.9 ± 0.1[b]	48.8 ± 0.5[c]
	a*	4.2 ± 0.02[b]	4.0 ± 0.2[a]	3.6 ± 0.2[a]	3.2 ± 0.2[a]
	b*	6.9 ± 0.02[a]	7.7. ± 0.3[b]	7.6. ± 0.1[b]	7.8 ± 0.2[b]
12	L*	37.5 ± 0.1[a]	47.9 ± 0.1[b]	48.9 ± 0.2[b]	49.9 ± 0.1[c]
	a*	4.1 ± 0.02[a]	3.3 ± 0.2[b]	3.1 ± 0.2[b]	3.1 ± 0.1[b]
	b*	7.5 ± 0.02[a]	8.3. ± 0.2[b]	8.5. ± 0.1[b]	8.8 ± 0.4[b]

a, b, c: means within a row with different letters are significantly different ($p \leq 0.5$).
Means are the values obtained from triplicate readings.

Water activity measurement

The water activity values for different LA-incorporated patties are presented in Table 3. A gradual increase in the water activity of all patties was observed. However, the patties prepared from beef incorporated with lactic acid at different concentrations did not show any significant differences ($p \geq 0.05$) in the water activity values through all storage time. This finding is in good agreement with previously reported investigations [5].

Table 3. Water activity (a_w) values of the control and LA-incorporated patties during storage at 5 °C for 12 days

Days of storage	Control patties	Lactic acid 0.5%	Lactic acid 0.75%	Lactic acid 1.00%
0	0.987 ± 0.001[a]	0.985 ± 0.001[a]	0.984 ± 0.002[a]	0.975 ± 0.001[a]
4	0.989 ± 0.002[a]	0.988 ± 0.002[a]	0.985 ± 0.002[a]	0.979 ± 0.002[a]
8	0.993 ± 0.001[a]	0.990 ± 0.001[a]	0.988 ± 0.001[a]	0.984 ± 0.002[a]
12	0.999 ± 0.001[a]	0.993 ± 0.001[a]	0.992 ± 0.001[a]	0.989 ± 0.001[a]

a: means within a column with the same letters are not significantly different ($p \leq 0.5$).
Means are the values obtained from triplicate readings.

Texture profile analysis (TPA)

The TPA results are presented in Table 4. The food-grade lactic acid had a significant influence ($p < 0.01$) on all texture parameters (hardness (N), springiness (mm), chewiness (mJ) and cohesiveness) of the LA-incorporated patty samples. The patties incorporated with water alone (control) were harder than patties incorporated with food-grade lactic acid. It was observed that the patties treated with LA at a concentration of 1.0% were the softest on the first day compared to other treatments. The same trend was observed at the end of the storage period. It was apparent that the increased concentration of lactic acid led to a significant decrease ($p < 0.05$) in hardness of beef patties on the first day and at the end of the storage period. Adding water incorporated with food-grade lactic acid to the patty formulation significantly ($p < 0.01$) changed both

Table 4. Texture profile analysis of the control and LA-incorporated patties during storage at 5 °C for 12 days

Texture profile analysis of patties on day 0 of storage					
Days of storage	Texture parameter	Control sample	Lactic acid 0.5%	Lactic acid 0.75%	Lactic acid 1.00%
Day 0	Hardness (N)	124.2 ± 1.6^{a}	109.3 ± 1.6^{b}	97.1 ± 1.6$^{a\ c}$	89.5 ± 1.6^{d}
	Springiness (mm)	0.76 ± 0.06^{b}	0.75 ± 0.02^{b}	0.74 ± 0.01^{b}	0.75 ± 0.03^{b}
	Cohesiveness	0.41 ± 0.01^{a}	0.42 ± 0.01^{a}	0.42 ± 0.01^{a}	0.43 ± 0.01^{a}
	Chewiness (mJ)	84.2 ± 1.3^{a}	80.1 ± 1.2^{b}	76.2 ± 1.7^{c}	74.3 ± 1.4^{d}
	Texture profile analysis of patties on day 12 of storage				
Day 12	Hardness (N)	111.5 ± 1.2^{a}	102.1 ± ^{b}	87.5 ± 1.7^{c}	81.5 ± 1.3^{d}
	Springiness (mm)	0.63 ± 0.04^{b}	0.62 ± 0.01^{b}	0.63 ± 0.02^{b}	0.62 ± 0.03^{b}
	Cohesiveness	0.38 ± 0.03^{a}	0.39 ± 0.02^{a}	0.37 ± 0.05^{a}	0.37 ± 0.02^{a}
	Chewiness (mJ)	72.2 ± 1.1^{a}	69.6 ± 1.3^{b}	68.5 ± 0.2^{c}	68.2 ± 1.4^{c}

Means with different letters within the raw are significantly different ($p \leq 0.5$).
Means are the values obtained from triplicate readings.

springiness and chewiness of the samples. However, there was no significant difference ($p > 0.05$) between the patty samples in the cohesiveness values on day 0. The same trend was observed in samples at the end of the storage period. This finding agrees with that of Grajales-Lagunes et al. [27] who reported that an increase in the concentration of lactic acid resulted in a reduction in meat hardness. They also found that the resistance of meat decreased with an increasing lactic acid concentration during the 7-day storage period. Previous studies have already found that injecting lactic acid on beef accelerated meat tenderization and reduced hardness after two days post mortem in beef muscle [28,29].

Total plate count assessment

Total viable counts (TVC) of the samples are shown in Table 5. There was a gradual microbial growth in all samples but it was slower in the LA-incorporated samples compared with the control. By the end of the storage period, the microbial count reached 7.89 ± 0.1 $\log_{10}$ in the control sample and 3.57 ± 0.2 $\log_{10}$, 3.40 ± 0.2 $\log_{10}$, and 3.30 ± 0.1 $\log_{10}$ in the patties incorporated with lactic acid at concentrations of 0.5%, 0.75%, and 1.0%, respectively. It was reported that the value of 8 $\log_{10}$ was regarded as a cause of spoilage in meat products [30,31]. At the end of the storage period, the control had a TVC value almost near the spoilage limit, while all the LA-incorporated patties had significantly ($p \leq 0.05$) lower TVC compared with the control.

Table 5. Total plate count (TVC) values of the control and LA-incorporated patties during storage at 5 °C for 12 days

Days of storage	TVC ($\log_{10}$ cfu/g)			
	Control sample	Lactic acid 0.5%	Lactic acid 0.75%	Lactic acid 1.00%
0	4.30 ± 0.4^{a}	3.15 ± 0.2^{a}	3.10 ± 0.1^{a}	3.10 ± 0.2^{a}
4	4.54 ± 0.1^{a}	3.33 ± 0.3^{a}	3.20 ± 0.2^{a}	3.11 ± 0.3^{a}
8	5.57 ± 0.2^{b}	3.34 ± 0.1^{a}	3.30 ± 0.1^{a}	3.20 ± 0.2^{a}
12	7.89 ± 0.1^{c}	3.57 ± 0.2^{b}	3.40 ± 0.2^{b}	3.30 ± 0.1^{a}

a-c: means within a column with different letters are significantly different ($p \leq 0.5$).
Means are the values obtained from triplicate readings.

Sensory evaluation

Sensory evaluation of meat products is widely applied to both fresh and processed meat products and is considered an important factor affecting quality of meat and meat products [32]. Table 6 presents sensory properties of patty samples. The lower scores for taste and flavor in the patties incorporated with 0.75% and 1.0% could be attributed to the slight odor of lactic acid generated during cooking. The results of the sensory evaluation of the patties incorporated with food-grade lactic acid at different concentrations show high overall acceptability values of 8.0 ± 0.2–8.1 ± 0.1, which are comparable to the high values of 8.2 ± 0.2 in the control. This finding agrees with that of Abd Elgadir et al. [33], who performed sensory evaluation of beef burgers formulated from fresh beef infused with food-grade citric acid at a concentration of 1.00% and stored for 8 days at 4 °C. They found that sensory scores for fresh beef burgers were in a range of 6.93–8.20 on the first day (day 0) and decreased to 4.43–5.17 at the end of the storage period (day 8). The differences between scores on day 0 and day 8 of storage were significant ($p > 0.05$). At the end of the storage period, they observed that burgers formulated from beef treated with food-grade citric acid had high overall sensory acceptability.

There was no significant difference ($p \geq 0.05$) in the overall acceptability of the patties. This suggests that patties made from beef incorporated with food-grade lactic acid were comparable to the control in terms of sensory properties.

Table 6. Sensory evaluation attributes of the control and LA-incorporated patties

Lactic acid concentration	Color	Texture	Taste	Flavor	Overall acceptability
0	7.7 ± 0.2^{a}	7.4 ± 0.1^{a}	8.4 ± 0.2^{a}	7.1 ± 0.3^{a}	8.2 ± 0.2^{a}
0.5	7.5 ± 0.1^{a}	7.4 ± 0.3^{a}	7.9 ± 0.3^{a}	7.3 ± 0.2^{a}	8.0 ± 0.3^{a}
0.75	5.7 ± 0.3^{b}	5.3 ± 0.2^{b}	7.3 ± 0.1^{b}	5.6 ± 0.4^{b}	8.0 ± 0.2^{a}
1.00%	5.5 ± 0.2^{b}	5.3 ± 0.4^{b}	5.9 ± 0.2^{c}	5.4 ± 0.1^{b}	8.1 ± 0.1^{a}

a-c: means within a column with different letters are significantly different ($p \leq 0.5$).
Means are the values obtained from triplicate readings.

Conclusion

High stability in physicochemical and microbiological properties during storage of patties was obtained. There was no significant difference in the overall sensory acceptability between the patties made from beef incorporated with food-grade lactic acid and the control. This suggests that incorporating beef with food-grade organic acids can have great benefits of increasing the storage life of beef products. Utilization of food-grade organic acids in meat products, such as patties, meatballs, and sausage, is highly recommended.

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