

INFLUENCE OF POTASSIUM SORBATE AND SODIUM LACTATE IN COMBINATION WITH MODIFIED ATMOSPHERE PACKAGING ON STABILITY OF REFRIGERATED CHICKEN BREAST MUSCLE

M. A. Kenawi, H. A. Abdel-Aal, H. M. Abbas¹

Abstract: Breast broiler meat treated with 10% potassium sorbate for 5 min or 8% sodium lactate for 2 min, packaged with or without vacuum and stored at 4°C for 24 days. Surface pH, Hunter color values (L*, a*, and b*), expressible water (EW), water holding capacity (WHC), total volatile basic nitrogen (TVBN), aerobic plate counts (APC), anaerobic plate counts, psychrophilic counts, coliform counts, and sensory quality were evaluated during storage period.

Results revealed that The yield of breast meat was 16.68% from the live weight. Slight changes were observed in the surface pH and Hunter color values during the storage time. Potassium sorbate treated sample with or without vacuum packaging had the highest values of WHC%. Total volatile basic nitrogen (TVBN) values of all samples increased with increasing the storage time. Samples treated with potassium sorbate had the lowest levels of TVBN compared to the other samples. Vacuum packaging with potassium sorbate and sodium lactate treatments retarded microbial growth on chicken breast and prolong the shelf life compared to without vacuum packaging. Potassium sorbate and sodium lactate treated samples with vacuum packaging had higher color odor scores than other samples. From these data it could be concluded that the average shelf life of control sample without vacuum was 3 to 6 days and for control with vacuum was 12 to 15 days. The shelf life of sodium lactate or potassium sorbate without vacuum were 12 and 18 days respectively. However, potassium sorbate and sodium lactate treatments with vacuum packaging extended the shelf life of breast chicken to 21 days at 4°C.

Introduction

Poultry meat constitutes a substantial portion of protein in the present day diets, hence the concern to market a safe, high quality product. The presence of pathogenic microorganisms, spoilage microorganisms, or both in poultry is undesirable but unavoidable (Goncalves *et al.*, 2004). Fresh poultry meat undergoes major undesirable changes during storage. Microbiological changes predominate during refrigeration, and the rapid growth of psychrotrophic microorganisms results in microbial spoilage and limited shelf life. The refrigerated shelf life of poultry varies from one to two weeks, depending on the initial microbial load. Spoilage of poultry at refrigeration temperature is mainly caused by high numbers (10^7 cells/cm²) of *pseudomonads* (To and Robach, 1980). Large numbers of additives have been studied as possible preservatives to minimize and control undesirable changes in fresh poultry.

Sodium or potassium salts of lactic acid have been shown to delay growth of meat spoilage microorganisms (Shelef, 1994; Tan and Shelef, 2002; Ahmed, *et al.*, 2003; Goncalves, *et al.*, 2004). O'Connor *et al.*, 1993 reported that 3% Sodium lactate significantly reduced aerobic plate count (APC) based on spoilage level of 10^6 CFU/g of fresh ground pork and extended its shelf life by about 12 days compared to control. 2% lactic acid spray was effective in reducing numbers of *E. coli* and could be useful as pathogen intervention steps in lamb slaughter processing (Ramirez *et al.*, 2001). A concentration of 0.10% Potassium sorbate delayed or retarded total counts, growth of salmonellae, and *Staphylococcus aureus*, and growth and toxin production by *C. botulinum* (Sofos and Busta, 1981; Robach and Sofos, 1982). 10% potassium sorbate dip extended the shelf life of the drumsticks from 6 to 10 days at 4°C (Cunningham, 1981). The shelf life of 2.5% potassium sorbate/CO₂ fresh chicken thighs was extended 3 days over the control/air sample at 10°C (Elliott. *et al.*, 1985).

Modified atmosphere packaging by reducing oxygen and or increasing gases such as CO₂, in the food environment was found to extend the product shelf life. Wolf, 1980; Ogrydziak and Brown, 1982; Sheridan

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et al., 1997; *Marth*, 1998; *Saucier et al.*, 2000 reported that modified or controlled atmosphere packaging extends shelf life of poultry, meat and seafood, and inhibits the growth of gram-negative bacteria and other related psychrotrophs which produce off odors and flavors. In 2004 chicken meat production in Egypt was 547,000 metric ton (FAO, 2005). Within recent years the poultry industry has experienced a dramatic increase in consumer consumption of boneless breast meat. Food processors have met this demand by developing refrigerated foods with extended shelf life. Control of microbial growth with bacteriostatic ingredients and packaging may have adverse effects on a product's color, odor, flavor, appearance or palatability, which can be considered as quality indicators to consumers (*Maca et al.*, 1999; *Loneggan et al.*, 2003). The objective of this study was to determine the effect of sodium lactate and potassium sorbate dip with different packaging materials on microbial counts, chemical, color, sensory attributes and shelf life of chicken meat breast during storage at 4°C.

Materials and Methods

Thirty broilers chicken 7 weeks age and 1940±50g live weight were slaughtered, scalded, mechanically picked in commercial picker, eviscerated and washed. Breast muscles were removed from carcasses trimmed, weighed, immediately breast fillet divided into 3 groups.

Treatment and packaging

The first group was submerged for 5 min in 4-liter solution of 5% (W/V) potassium sorbate, drained for 10 min (*Toledo-Flores and Zall*, 1992). The second group was dipped for 2 min in 4-liter of 8% sodium lactate, drained for 10 min 2 (*Huang and Huang*, 1993). The third group was left as control. Each group was divided into two portions. The first one packaged in 1 mil low-density polyethylene (LDPE), from Dow Co. Midland, MI. USA) 150 ±10g each package. The second one was packaged under vacuum in 3 mil laminated (Nylon/PE) from Koch Co. Kansas City, MO. USA. (1 mil=0.001 inch). All samples treated or untreated were stored at 4°C for 24 days. Sample of each treatment was randomly removed from refrigerator at a 3 days interval for analysis.

Microbiological analysis:

Aerobic plate count (APC), Anaerobic count, Psychrophilic count, and coliform count of treated and untreated packaged chicken breast were determined as (CFU/g) according to the methods described in the standard methods of (*APHA*, 1985; and *Vaderzant and Splittstoesser*, 1992). The BBL GasPak^R anaerobic chamber with BBL GasPak Co₂ gas packs (Becton Dickinson Microbiology System, Boston, MA) were used to create an anaerobic environment for incubation.

Color evaluation:

Hunter color values (lightness L*, redness a*, and yellowness b*) were measured for treated and untreated packaged chicken breast meat at zero time and during storage period with a colorimeter (Color Tec PCM Color Meter Tec. NJ. USA). Four random measurement spots on each sample were made and the average data were recorded according to (*Holownia et al.*, 2003)

Surface pH measurement:

Triplicate pH reading was taken from the surface of each breast meat sample by using a pH meter (Model 41250, ICM, OR, USA).

Determination of expressible water (EW) and water holding capacity (WHC):

Expressible water was determined according to Alvarez et al., (1992). Whereas, the water holding capacity (WHC) was calculated.

Total volatile basic nitrogen (TVBN)

Total volatile basic nitrogen was measured according to the *Person*, (1975)

Sensory evaluation:

Samples from each group were randomly assigned for sensory evaluation according to *Sahoo and Anjaneyulu*, (1997); *Jimenez-Villarreal, et al.*, (2003). Twelve panel members with previous panel experience were used to evaluate chicken breast odor and color discoloration during storage. Sensory score for odor was obtained by following a 5-point scale where 1 = very unpleasant, 2 = moderately unpleasant, 3 = moderately pleasant, 4 = pleasant and 5 = very pleasant. The score for color discoloration was 1 = total discoloration, 2 = moderately discoloration, 3 small discoloration, 4 slight discoloration and 5 = no discoloration).

Results and Discussion

Data in table 1 showed that dressed carcass with edible organs was 74.74% from live body weight, while the percentage of thigh part breast part and breast meat was 31.91 and 32.29 and 16.68%, respectively. *Berri et al., 2001* reported that poultry body composition has been largely improved by selection and breast yield of broilers ranged from 11.5 to 18.5%.

Table 1. Weight composition of broiler chicken

Components	Weight (g)	100%
Carcass weight without legs head and viscera	1322.75 \pm 15.00	68.18
Carcass with edible organs	1450.00 \pm 33.04	74.74
Thigh weight	619.00 \pm 57.45	31.91
Breast weight	626.5 0 \pm 45.48	32.29
Breast meat	323.5 0 \pm 44.87	16.68
Feather	127.50 \pm 18.92	6.57
Blood	35.00 \pm 5.77	1.80
Head	43.75 \pm 2.75	2.26
Wings	77.25 \pm 5.19	3.98
Edible organs (Gizzard, liver and heart)	127.25 \pm 20.82	6.56
Inedible organs	198.75 \pm 21.35	10.25
Legs	85.00 \pm 4.08	4.38
Live weight	1940.00 \pm 49.98	100

N=4

Surface pH values of potassium sorbate samples without vacuum packaging were higher than those of other samples during the storage time (Fig. 1) The pH values slightly decreased during the storage time. However, vacuum packaged sample had lower pH values than other samples during storage, but its pH was slight increased on the day 24. *Sutherland et al., (1975)* noticed that when vacuum packaged beef spoiled, the product was accompanied by a slight increased in pH. No effect of sodium lactate on pH for all samples after 6 days of storage. *Brewer et al., 1995* reported that addition of sodium lactate has not significant effects on initial pH of ground pork meat. However, with time in refrigerated storage, sodium lactate sometimes reduced pH decline probably by limiting growth of acid producing bacteria particularly in vacuum packaging. *Sofos 1989* reported that sorbate is more effective in low pH foods (below 6.0) and the maximum pH for activity of sorbate ranged from 6.0 to 6.5, while it is relatively ineffective at pH values of 7.0 and above.

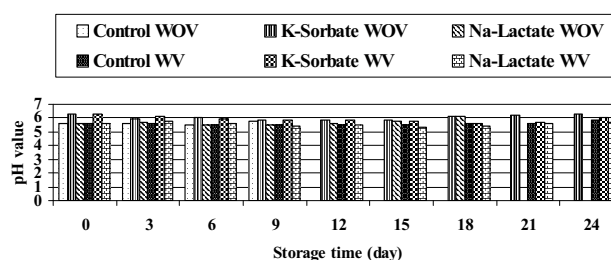


Figure 1. Effect of potassium sorbate and sodium lactate treatments and packaging materials on the pH value of chicken breast meat stored at 4 °C

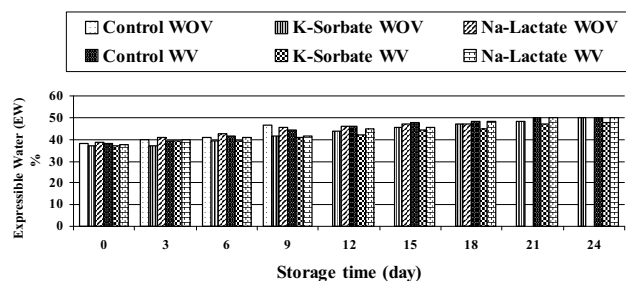


Figure 2. Effect of potassium sorbate and sodium lactate treatments and packaging materials on the expressible water content of chicken breast meat stored at 4 °C.

Figure 2 illustrates the effect of potassium sorbate and sodium lactate treatments, storage time and packaging materials on the expressible water % (EW) of chicken breast. EW % values were increased during the storage time. Vacuum packaged samples had lower EW than other samples. Sodium lactate treated sample had higher EW% than potassium sorbate treated samples, this may be due to its pH was lower. Kondaiah et al., (1985) reported that food grade phosphate treatment increased meat pH, water holding capacity (WHC), and decreased the EW % and cooking loss of ground meat. Cornforth, (1994) also stated that meat with high pH has a high water binding capacity.

Slight changes in water holding capacity (WHC) of all samples were found during the first 6 days of storage. However, water holding capacity (WHO) of all samples gradually decreased along with storage time at 4°C (Fig. 3). Potassium sorbate treated sample with or without vacuum packaging had the highest values of WHC%. This may be attributed to its high pH values. When the pH of the meat is above the isoelectric point of the myofibrillar proteins in the meat water molecules are tightly bound (Kauffman and Marsh, 1987).

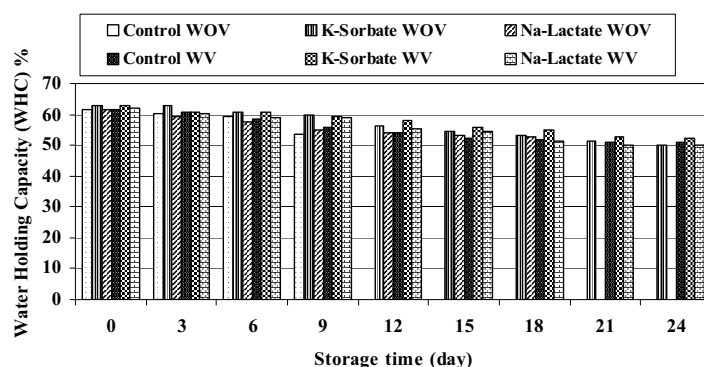


Figure 3. Effect of potassium sorbate and sodium lactate and packaging materials on the water holding capacity content of chicken breast meat stored at 4 °C.

The total volatile basic nitrogen (TVBN) could be used as a quality indicator for fish products (Jay, 1992) and is associated with the amino acid decarboxylase activity of microorganisms during storage. Changes in TVBN value during storage are shown in Fig. 4. Total volatile basic nitrogen (TVBN) values of all samples increased with increasing the storage time and the greatest change occurring between eighteen and twenty-four days of storage. Samples treated with potassium sorbate had the lowest levels of TVBN compared to the other samples. The chicken parts dipped in 10%potassium sorbate had a 20-day shelf life at 4°C, based on off-odor development and time for total counts to reach 10^7 (Cunningham, 1979). Total volatile basic nitrogen content of control packaged without vacuum in LDPE rapidly increased after 6 and 9 days of

storage. While control sample packaged under vacuum had low TVBN values in the same period of storage. Treated and untreated samples packaged under vacuum had lower values of TVBN than the other samples. Modified atmosphere packaging inhibits the growth of aerobic spoilage microorganisms, such as *pseudomonas* species, but allows facultative anaerobes such as lactic acid bacteria to grow (Marth, 1998). Samples packaged in LDPE without vacuum remained at higher TVBN level suggesting greater bacterial populations and activity, which are in agreement with its microbial counts.

Aerobic plate counts (APC) were increased with increasing the storage time except samples treated with potassium sorbate its APC decreased on the day 3 and starting increased on the day 6 (Fig. 5). The increment was rapid for control sample packaged in LDPE without vacuum and the greatest changed occurring between the ninth and twelfth days. Samples treated with potassium sorbate with or without vacuum packaging had the lower APC than other samples. McMeekin *et al.*, (1984) reported that a 30 second dip of poultry pieces and fillets in 5% potassium sorbate and vacuum packaging delayed microbial growth and extended shelf life to 35 days at 2°C. The combination of modified atmosphere packaging and potassium sorbate treatment provided the most effective inhibitory system against the poultry spoilage organisms (Elliott, *et al.*, 1985). Vacuum packaging with potassium sorbate and sodium lactate treatments retarded microbial growth on chicken breast and prolong the shelf life compared to without vacuum packaging.

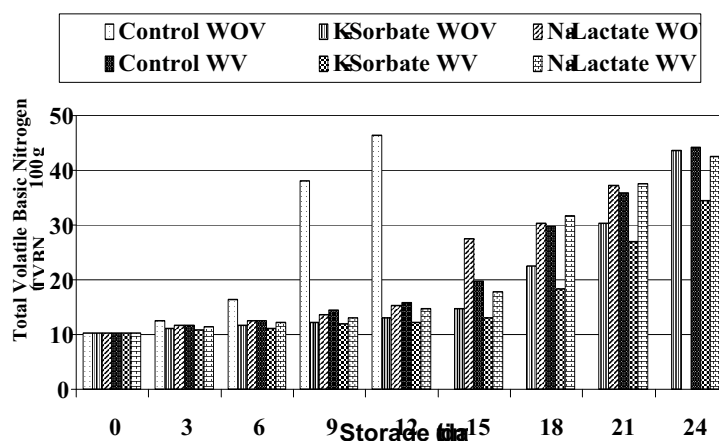


Figure 4. Effect of potassium sorbate and sodium lactate treatments and packaging materials on the total volatile basic nitrogen (TVBN) content of chicken breast meat stored at 4 °C.

Potassium sorbate treatment with vacuum packaging increased the time to reach aerobic count 6.5 log CFU/cm² for beef slices stored at 4°C (Zamora and Zaritzky, 1987). According to the guidelines from the Meat Hygiene Manual (Canadian Food Inspection Agency) these maximum values are 7 and 3 log CFU/g for total aerobic mesophilic and coliform count (Saucier *et al.*, 2000). Aerobic plate count of control sample WOV packaging was over the accepted limit on the day 12 but exhibited off-odor on the day 9. However, control sample WV packaging exhibit off-odor on the day 12 of storage. Van Laack, (1994) reported that off-odors become noticeable in chilled meat and poultry when bacterial numbers are between 7.0 and 7.5 log₁₀ CFU/cm². Aerobic plate count remained under the maximum value (7 log CFU/g) after 15 day of storage for all samples except the control sample packaged without vacuum. The shelf life of sodium lactate or potassium sorbate with vacuum packaging treated chicken breast meat (populations of microorganisms and sensory quality) could be extended to 18 and 21 days, respectively.

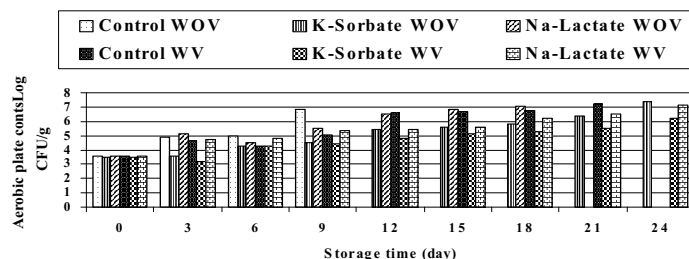


Figure 5. Effect of potassium sorbate and sodium lactate treatments and packaging materials on the aerobic plate counts in chicken breast meat stored at 4 °C.

Psychrophilic count increased with increasing the storage time. Potassium sorbate treated sample with vacuum packaging had the lowest psychrophilic counts during storage time (Fig. 6). Control sample without vacuum packaging had low psychrophilic count with acceptable color and odor scores, by day nine of refrigerated storage the counts was rapidly increased with moderate discoloration and off odor, indicating complete spoilage Fig. 6. Chicken spoilage off-odors can be attributed to the growth of psychrotrophic bacteria degrading amino acids found in the muscle (Pooni and Mead, 1984).

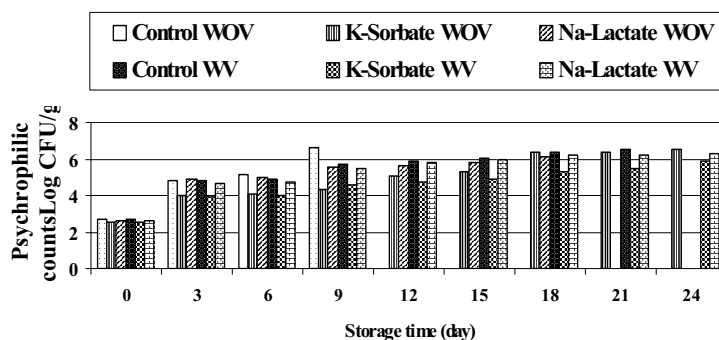


Figure 6. Effect of potassium sorbate and sodium lactate treatments and packaging materials on the psychrophilic counts in chicken breast meat stored at 4 °C.

Anaerobic counts of all samples increased along with the storage time. The increment rate was lower in the vacuum packaged and potassium sorbate treated samples than other samples (Fig.7). Saucier et al., 2000 reported that modified or controlled atmosphere packaging extends shelf life of poultry, meat and seafood, and inhibits the growth of gram-negative bacteria and other related psychrotrophs which produce off odors and flavors. Sodium lactate treated sample packaged in LDPE without vacuum had the highest number of anaerobic counts. Anaerobic plate counts increased rapidly for control sample packaged in LDPE without vacuum. Saucier et al., (2000) reported that modified atmosphere packaging can maintain a desirable color in ground poultry meat but offers no guarantees with respect to the microbial profile of meat.

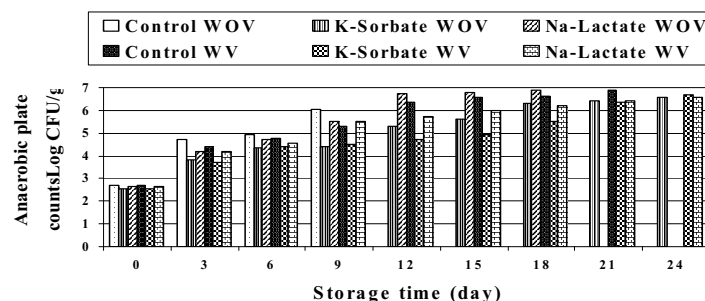


Figure 7. Effect of potassium sorbate and sodium lactate treatments and packaging materials on the anaerobic plate counts in chicken breast meat stored at 4 °C.

Potassium sorbate and sodium lactate with vacuum packaging reduced the growth of coliform bacteria compared to control (Fig. 8). 2% lactic acid spray was effective in reducing numbers of *E. coli* and could be useful as pathogen intervention steps in lamb slaughter processing (Ramirez *et al.*, 2001). However, coliform counts for all samples were over the accepted limit (3 log CFU/g) Saucier *et al.*, (2000) at day 12 except the sample treated with potassium sorbate with vacuum packaging. Control samples without vacuum packaging had higher coliform count than other samples during the first week of storage and its count was greater than the accepted limit (3 log CFU/g) at the day 9. Potassium sorbate was effective in controlling growth of pathogens and natural microflora on fresh poultry (Robach and Sofos, 1982).

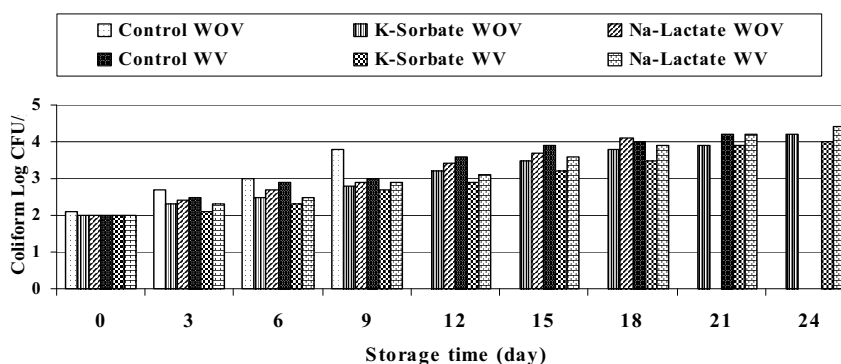


Figure 8. Effect of potassium sorbate and sodium lactate treatments and packaging materials on the coliform counts in chicken breast meat stored at 4 °C.

The Hunter color values L^* , a^* and b^* of potassium sorbate or sodium lactate treatment and packaging with or without vacuum were presented in (Table 2). Little differences were found in the Hunter color L^* , a^* , and b^* among samples at zero time. Qiao *et al.*, (2002) found that the variation in breast chicken color may be due to long term genetic factors as well as short term antemortem stress. L^* (Lightness) b^* (yellowness) values for all samples sharply decreased after 3 days of storage and then gradually decreased with increasing the storage time. The a^* (redness) values for all samples slightly changes in the first 12 days of storage and decreased at the end of storage period. Huang and Huang (1994) reported that neither lactates treatment nor packaging system had no effect on hunter color values of tilapia fillets stored at 4°C for 16 days. Darker broiler breast meat fillets stored at 3°C have a shorter shelf life than lighter breast fillets; the shorter shelf life may be attributed to the differences in pH (Allen *et al.*, 1997).

Table 2. Effect of potassium sorbate and sodium lactate and packaging on color (L, a, and b) of chicken breast meat stored at 4°C for 24 day

Samples	Color	Storage time (day) at 4°C								
		0	3	6	9	12	15	18	21	24
Control WOV	L	56.44	50.42	49.81	47.06	—	—	—	—	—
	A	4.64	4.38	4.13	4.03	—	—	—	—	—
	b	3.94	2.03	2.80	1.86	—	—	—	—	—
Potassium sorbate WOV	L	55.53	49.98	48.56	49.28	49.23	48.63	49.37	48.86	49.19
	A	5.12	6.24	6.22	6.05	5.11	5.23	4.99	4.42	4.25
	b	3.32	1.75	2.53	2.65	2.77	2.21	2.87	2.08	2.30
Sodium lactate WOV	L	55.51	49.96	49.77	47.91	47.24	47.72	46.24	—	—
	A	5.45	5.44	5.27	5.01	5.26	5.03	4.32	—	—
	b	3.76	1.35	1.99	2.21	2.33	1.73	0.73	—	—
Control WV	L	56.44	49.62	48.76	49.80	49.54	49.62	47.32	47.30	—
	A	4.64	6.24	5.32	4.89	4.66	4.75	4.53	4.23	—
	b	3.94	1.94	1.92	1.87	1.57	1.71	1.67	1.45	—
Potassium sorbate WV	L	55.53	50.82	49.97	49.66	49.85	49.19	48.23	47.06	47.12
	A	5.12	5.34	5.13	5.08	4.95	4.30	4.52	4.26	4.39
	b	3.32	1.78	2.12	1.98	2.05	2.12	2.14	1.86	1.61
Sodium lactate WV	L	55.51	50.31	49.45	49.68	49.04	48.75	48.44	47.21	47.43
	A	5.45	5.44	4.79	5.18	4.22	4.39	4.20	4.13	4.22
	b	3.76	2.12	2.35	2.16	1.89	1.81	1.73	1.62	1.70

N=4

WOV = Without vacuum packaging;

WV = With vacuum packaging

Sensory panelists were unable to detect any differences between treatments for overall color on day 0 of display (Fig. 9). However, no color discoloration was observed on the day 3, 6 and 9 of storage for potassium sorbate treated samples with vacuum packaging. On the other hand, color of control sample without vacuum became unacceptable on the day 9. Slight discoloration was detected in vacuum packaged treated samples during the 18 days of storage. Color scores of sodium lactate treated sample without vacuum packaging decreased on the day 12 and became unacceptable on the day 18.

Off odor was detected in the control samples on the day 9 of storage (Fig. 10). Van Laack (1994) reported that off-odors become noticeable when bacterial numbers are between 7.0 and 7.5 log₁₀ CFU/cm². Potassium sorbate and sodium lactate treated samples with vacuum packaging had higher odor scores than other samples.

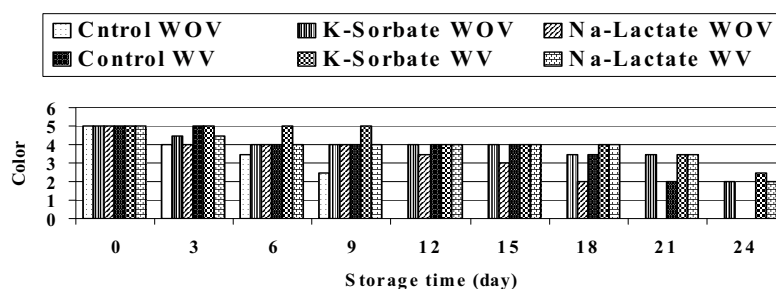


Figure 9. Effect of potassium sorbate and sodium lactate and packaging materials on the color score of chicken breast meat stored at 4 °C.

Robach and Sofos, (1982) reported that off odors from the sorbate treated birds were not noticed until the 19th day of storage at 3°C. From these data it could be concluded that the average shelf life of control sample without vacuum packaging was 3 to 6 days and for control with vacuum packaging was 12

to 15 days. Potassium sorbate and sodium lactate treatments with vacuum packaging extended the shelf life of breast chicken to 21 days at 4°C. However the shelf life of sodium lactate or potassium sorbate without vacuum were 12 and 18 days respectively.

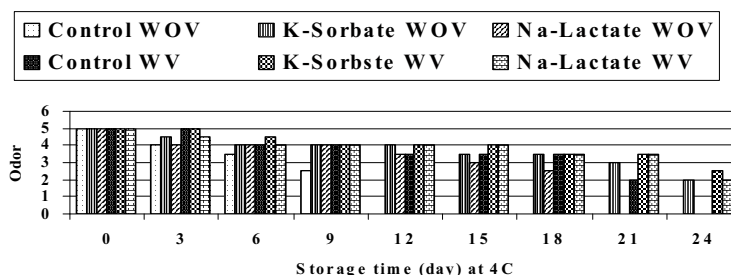


Figure 10. Effect of potassium sorbate and sodium lactate and packaging materials on the odor score of chicken breast meat stored at 4 °C.

UTICAJ KALIJUMSORBATA I NATRIJUMLAKTATA U KOMBINACIJI SA SISTEMOM PAKOVANJA PRI MODIFIKOVANOJ ATMOSFERI NA STABILNOST GRUDNIH MIŠIĆA PILETA SKLADIŠTENIH U FRIZIDERU

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Rezime

Grudno meso brojlera tretirano je sa 10% kalijumsorbata u trajanju od 5 minuta ili 8% natrijumlaktata u trajanju od 2 minuta, zapakovano sa ili bez vakuuma i skladišteno na temperaturi od 4°C 24 dana. Površinska pH, Hunterove vrednosti za boju (L*, a*, and b*), sposobnost zadržavanja vode (WHC), (TVBN), broj aerobnih (APC), anaerobnih, psihofilnih, koliformnih ćelija i senzorni kvalitet su ocenjivani tokom perioda skladištenja.

Rezultati su pokazali da je meso grudi činilo 16,68% žive mase pileta. Neznatne promene su primećene u površinskoj pH vrednosti i Hunter-ovim vrednostima za boju tokom skladištenja. Uzroci tretirani kalijumsorbatom, bez i sa vakuum pakovanjem, su imali najveće vrednosti WHC%. TVBN vrednosti za sve uzorke su se povećavali sa trajanjem perioda skladištenja. Uzroci tretirani sa kalijumsorbatom su imali najniži nivo TVBN u poređenju sa ostalim uzorcima. Vakuum pakovanje sa tretmanom uzoraka sa kalijumsorbatom i sodijumlaktatom je usporilo mikrobijalni porast na pilećim grudima i produžilo rok trajanja u poređenju sa mesom koje nije bilo vakuumirano. Uzorci tretirani kalijumsorbatom i natrijumlaktatom bez vakuumiranja su imali više ocene boje i mirisa u odnosu na ostale uzorke. Na osnovu ovih podataka može se zaključiti da je prosečno trajanje kontrolnih uzoraka bez vakuumiranja bilo 3 do 6 dana a kontrolnih sa vakuumiranjem 12 do 15 dana. Rok trajanja uzoraka tretiranih natrijumlaktatom ili kalijumsorbatom bez vakuumiranja je bio 12 do 18 dana respektivno. Međutim, tretman kalijumsorbatom i natrijumlaktatom sa vakuumiranjem je produžilo rok trajanja pilećih grudi na 21 dana na temperaturi od 4 °C.

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