EFFECTS OF SODIUM LACTATE, ENCAPSULATED OR UNENCAPSULATED POLYPHOSPHATES AND THEIR COMBINATIONS ON GROWTH OF *Listeria monocytogenes* IN COOKED GROUND BEEF

Burcu Tenderis[1], Birol Kılıç[1*], Halil Yalçın[2] and Azim Şimşek[3]

[1]Department of Food Engineering, Suleyman Demirel University, Isparta, Turkey;

[2]Department of Food Hygiene and Technology, Mehmet Akif Ersoy University, Burdur, Turkey;

[3]Department of Food Processing, Egirdir Vocational School, Suleyman Demirel University, Isparta, Turkey.

*Corresponding author email: birolkilic@sdu.edu.tr

Abstract – This study evaluated the effects of sodium lactate (2.5%), encapsulated (e) and unencapsulated (u) polyphosphates (PP; sodium tripolyphosphate, STP; sodium acid pyrophosphate, SPP), and their combinations on *Listeria monocytogenes* inhibition in cooked ground beef during storage (0, 15, 30 days). pH, water activity (a_w), oxidation-reduction potential (ORP) and *L. monocytogenes* counts were determined during storage. Results indicated that there was no difference among the groups in terms of *L. monocytogenes* counts at the beginning of storage, whereas the lowest *L. monocytogenes* counts were determined in the samples containing a combination of sodium lactate with uSPP or eSPP ($P<0.05$). The lower ($P<0.05$) ORP values were determined in all PP added groups during storage. ORP values increased with storage in all groups ($P<0.05$), whereas there was no significant changes in pH and a_w levels during storage. The use of ePP did not create any significant changes on pH, a_w, ORP and *L. monocytogenes* counts compared to that of uPP.

Key Words – *Listeria monocytogenes*, polyphosphates, encapsulated, sodium lactate

I. INTRODUCTION

Sodium lactate has been used in the meat industry for quite some time as an antimicrobial agent and shown to help to improve color stability and shelf life of muscle foods. Polyphosphates are also widely used as food additives in the meat industry to improve functional properties such as increasing water binding capacity, reducing the cooking loss, protecting flavor, accelerating cured meat color formation, delaying oxidative rancidity due to their chelating capacity, and enhancing the textural and emulsification properties [1]. In addition, PP have an inhibitory effect on the growth of microorganisms. Previous studies revealed that PP particularly effective on Gram-positive bacteria such as *Staphylococcus aureus*, *Listeria monocytogenes* and *Bacillus cereus*. However, PP were found to be have lower inhibitory effect on growth of Gram-negative bacteria and fungi. Polyphosphates exhibit antimicrobial effects by binding metal ions (Ca^{2+}, Mg^{2+}) which are essential for maintaining the integrity of cell walls in Gram-positive bacteria [2, 3]. The inhibitory effect on Gram-positive bacteria is dependent on the chain length of PP. The antimicrobial effect of PP on Gram-positive bacteria is increasing with the increasing chain length of PP [2]. Polyphosphates are hydrolyzed by phosphatases to short chain length phosphates, hence the ability to inhibit microbial growth may decreases. Encapsulation technology can be applied to PP to protect them from phosphatases in order to achieve more effective inhibition of microbial growth in cooked meat products [4]. The objective of this research was to examine the efficiency of sodium lactate, encapsulated and unencapsulated polyphosphates, and their combinations with sodium lactate on *Listeria monocytogenes* inhibition in cooked ground beef.

II. MATERIALS AND METHODS

The ground beef used in the study were purchased from a local slaughterhouse (Isparta, Turkey). All experimental groups contained 2.0% sodium chloride (meat weight basis, 106404; Merck, Germany) and 10% distilled water (meat weight basis). Thirteen experimental groups were formulated with incorporation of only sodium lactate (2.5%) or uPP (0.5%) or ePP (0.5%) or combination of uPP (0.25%) and ePP (0.25%) or combinations of uPP or ePP with sodium lactate or combinations of uPP, ePP and sodium lactate. Experimental groups were cooked in capped plastic centrifuge tubes (50 mL). Ground meat (approximately 45 g) was placed into each tube and heat processed (74 °C endpoint temperature) in a water bath [4, 5]. Cooked samples were cooled to room temperature, then *L. monocytogenes* contamination was carried out. Two strains of *L. monocytogenes* (RSKK 02028 and RSKK 472)

were used. The *L. monocytogenes* strains were stored at -80 °C before use. After thawing, strains were grown in 10 mL Tryptic Soy Broth (TSB) at 30 °C overnight. The cultures were passaged in TSB three times. The final cultures were centrifuged at 5000 rpm for 5 min. The supernatant were removed and the pellets were resuspended and washed with 10 ml sterile 0.9 % NaCl before recentrifuging to remove organic residues. The resulting pellets were resuspended using sterile peptone water and strains were combined in a single tube [6]. A contamination solution containing 10^6 CFU/mL *L. monocytogenes* strain (1 mL) was added into the plastic centrifuge tubes. Surface contamination was provided by rotating the meat block around its axis in the tube. Cooked and cooled samples were stored in tubes at 4 °C during 30 days. pH, a_w, ORP and *L. monocytogenes* counts [6] were evaluated.

III. RESULTS AND DISCUSSION

Results showed that the lowest ORP were determined in all STP containing groups on day 0 ($P<0.05$). On the other days of storage, lower ORP values were obtained in all PP containing groups ($P<0.05$). ORP values increased with storage in all groups ($P<0.05$). According to results, the lowest ($P<0.05$) a_w levels were detected in all sodium lactate containing groups. There was no significant changes in pH and a_w levels during storage. Results indicated that pH values of control (no sodium lactate, uPP and ePP) and samples with STP were higher than those of the samples with SPP ($P<0.05$). The study results showed that *L. monocytogenes* counts varied between 4.38- 4.66 $\log_{10}$ among groups on day 0. A gradual increase in *L. monocytogenes* counts during storage was determined in control and the samples incorporated with STP ($P<0.05$) whereas there was a significant decrease in *L. monocytogenes* counts with storage in groups produced with SPP and sodium lactate combination ($P<0.05$). The higher *L. monocytogenes* counts were determined in both control and STP incorporated groups on day 15 and 30 compared to those determined in groups with SPP or SPP and sodium lactate combination ($P<0.05$). SPP and sodium lactate combination caused 1-2 log reduction in *L. monocytogenes* counts. pH, a_w, ORP and *L. monocytogenes* counts were not affected by the use of ePP.

IV. CONCLUSION

The results indicated that the use of STP has no inhibitory effect on *L. monocytogenes* growth. However, both uSPP and eSPP had the inhibitory effect on growth of *L. monocytogenes* and this effect was enhanced when uSPP or eSPP was used in combination with sodium lactate. Using encapsulated form of SPP did not contribute more in advancing inhibition level. According to results, a combination of sodium lactate with uSPP or eSPP or combination of sodium lactate, uSPP and eSPP were suggested for controlling the growth of *L. monocytogenes* in the processing of ready to eat meat products.

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