EFFECT OF ENCAPSULATED PHOSPHATES ON LIPID OXIDATION IN GROUND BEEF AND POULTRY MEAT DURING STORAGE

Birol KILIÇ[1], Azim ŞİMŞEK[2], James R. CLAUS[3] and Esra ATILGAN[1]

[1]Suleyman Demirel University, Faculty of Engineering, Department of Food Engineering, Isparta, TURKEY

[2]Suleyman Demirel University, Egirdir Vocational School, Department of Food Processing, Isparta, TURKEY

[3]University of Wisconsin-Madison, Department of Animal Sciences, Muscle Biology Laboratory, Madison, WI, U.S.A.

Abstract – Effects of sodium tripolyphosphate (STP), sodium hexametaphosphate (HMP) and sodium pyrophosphate (SPP) on lipid oxidation in uncooked and cooked ground beef and chicken meat during storage were determined. A control (no phosphate), three treatments (0.5% unencapsulated phosphate, u; 0.5% encapsulated phosphate, e; at two coating levels (low, high) and two heating rates (slow, fast) were investigated. Cooking loss (CL), pH, color, soluble orthophosphate (SO), TBARS and lipid hydroperoxides (LPO) were determined. The use of chicken meat, a fast heating rate and uSTP resulted in lower CL ($p<0.05$). SO increased with phosphate incorporation, using chicken meat and slow heating rate ($p<0.05$). Encapsulated phosphate and coating level reduced SO ($p<0.05$). uSTP increased CIE a* and pH, whereas uSPP decreased CIE a* and pH ($p<0.05$). Encapsulated phosphate and coating level had no effect on the final pH of the cooked samples. CL, color and pH were not affected by uHMP or eHMP. Not coating level but encapsulated phosphate significantly decreased lipid oxidation in cooked samples during storage ($p<0.05$).

Key Words – Encapsulated phosphate, Lipid oxidation, Meat

I. INTRODUCTION

Lipid oxidation is one of the main factors limiting the quality and acceptability of ready-to-eat-meat products [1]. The use of food-grade phosphates is very common in the meat industry because they provide a number of beneficial effects on meat products [2]. Phosphates have strong antioxidant effects by binding metal ions that act as catalysts for oxidation [3]. However, antioxidant effects of added phosphates is reduced by phosphatases that hydrolyze phosphates into small chain length phosphates in raw meat [4]. Therefore, the inhibition of phosphatases is desirable for food processing and preservation. The most of the added phosphates are lost by the time meat is cooked due to phosphatase activity [5]. Phosphatase activity is greatly reduced by cooking [6]. Therefore, this research aim was to test the hypothesis that more effective lipid oxidation inhibition in muscle foods can be accomplished by the use of encapsulated phosphates since phosphates can be protected from phosphatase activity until adequate thermal inactivation has been achieved.

II. MATERIALS AND METHODS

Fresh skinless, boneless chicken breast meat (*Musculus superficiolis*) and beef (*Musculus longissimus dorsi*) were used. The meat was ground (9.5 mm), mixed and then reground (3.2 mm). After the first grind and initial mixing the test ingredients was incorporated. The ground meat was cooked in capped plastic tubes in a water bath. Samples were cooked to 74 °C. Uncooked and cooked samples were stored at 4 °C. The experimental design for statistical purposes was 2 species (beef, chicken) x 3 types of phosphates (STP, HMP, SPP) x four treatments (control; unencapsulated phosphate; encapsulated phosphates at two coating levels, low and high) x 2 heating rates (slow, fast) x 3 uncooked storage times (0, 2, 24 h) x 3 cooked storage (0, 1 and 7 d) as a factorial arrangement.

III. RESULTS AND DISCUSSION

Results of pH analysis illustrated that raw samples formulated with uSTP and uSPP, in general, had higher and lower pH values compared to other groups, respectively ($p< 0.05$). Effect of uSTP and uSPP on pH was reduced by the encapsulation. Hovewer, coating level was not a significant factor for controlling pH changes. In general, raw and

cooked chicken meat samples had higher pH values than beef samples ($p< 0.05$). The lowest pH values were determined in the samples produced with SPP regardless of encapsulated or not and coating level for both meat types ($p<0.05$). The results showed that the encapsulation did not reduce the effect of uSTP and uSPP on pH during storage. This may suggest that the encapsulated phosphates and coating levels have no significant effect on the final pH of the cooked meat samples at the end of storage.

The results showed that CL was affected by type of meat and phosphate and heating rate. Beef samples had comparatively higher CL than chicken samples ($p<0.05$). Heating rate affected CL, a higher CL was determined in samples underwent slow heating rate ($p<0.05$). The results indicated that samples manufactured with uSTP had the lowest CL among all treatment groups ($p<0.05$). Encapsulation process showed tendency to reduce this beneficial effect of STP, however, CL was still lower in samples containing eSTP than other groups ($p<0.05$). It was determined that the addition of uSPP, eSPP, uHMP and eHMP had no observable effect on CL ($p>0.05$). Concerning coating levels, there was no significant differences for CL between low and high coating levels ($p>0.05$).

The results of CIE L*a*b* values showed that meat type affected all raw and cooked ground meat color values ($p<0.05$). Higher L* and lower a* and b* values were determined in chicken meat samples than beef samples ($p<0.05$). Using phosphates in sample formulation generally resulted in an increase in L*a*b* color values. There was also a gradual decrease in L*a*b* color values in all treatment groups during 24 h storage period in our study. In general, the use of encapsulated phosphate and coating level did not have significant effect on color values of both meat types. On the other hand, cooking significantly increased L* and decreased a* values of the samples ($p<0.05$). Higher L* and b* and lower a* values were observed for chicken samples compared to beef. Seven days of storage time increased b* and decreased a* values in cooked samples regardless of meat type, hovewer, L* values were generaly constant during storage. The highest L* and b* and the lowest a* values were determined ($p<0.05$) for treatments containing uSPP. Encapsulation of SPP slightly prevented this effect on color and there was no significant difference between coating levels. The presence of uSTP and eSTP produced higher ($p<0.05$) CIE a* values at the end of storage than in the samples containing uSPP and eSPP. Heating rates was not a significant factor affecting color values in cooked samples during storage period except day 0 where higher L* values were determined in samples cooked with fast heating rate.

Regardless of treatments, higher SO levels were observed in chicken samples compared to beef ($p<0.05$). As expected, SO content of uncooked samples increased with phosphate incorporation ($p<0.05$). In general, the samples to which uSTP and uSPP were added had the highest SO levels for both beef and chicken meat ($p<0.05$). The lowest SO level was determined in control group ($p<0.05$). Encapsulation and coating level enhanced reduction in SO level during 24 h storage ($p<0.05$), indicating that encapsulation of polyphosphates provided enhanced protection for polyphosphates against hydrolysis induced by phosphatase activity. With regard to cooking, cooking did not have important effect on SO level. Hovewer, fast heating rate resulted in a decrease in SO compared with low heating rate ($p<0.05$). This indicated that the higher heating rate accelerated thermal inactivation of phosphatases. SO levels were also higher in cooked chicken samples than beef ($p<0.05$). Similar to uncooked samples, SO content increased in all treatment groups during 7 d storage period and the highest SO levels were observed in the samples formulated with uSTP and uSPP for both beef and chicken meat ($p<0.05$). Encapsulated STP and uSPP had lower SO levels compared with unencapsulated counterparts ($p<0.05$). Study results indicated that the higher encapsulation level resulted in lower SO due to better protection of phosphates from phosphatase activity.

TBARS values increased gradually during storage period in all uncooked beef and chicken samples regardless of phosphate incorporated or degree of encapsulation. However, TBARS values were significantly lowered by uSTP and uSPP in beef, uSTP, uSPP and uHMP in chicken meat at end of 24 h storage compared to other groups ($p<0.05$). As expected, the higher TBARS values were observed in the samples incorporated with

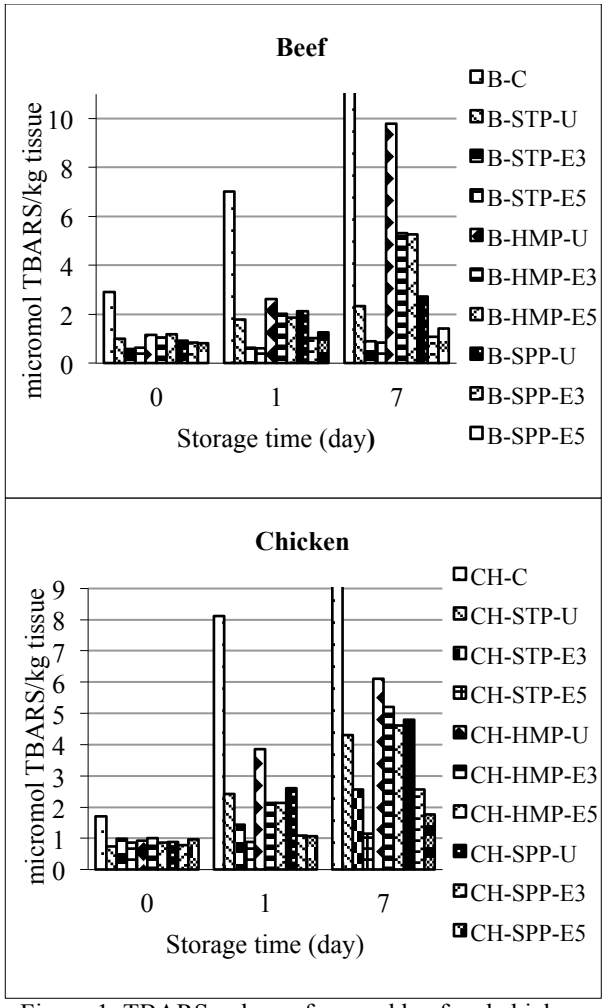

Figure 1. TBARS values of ground beef and chicken meat cooked with slow heating rate.

CH: chicken, B: beef, C: control, STP: sodium tripolyphosphate, HMP: sodium hexameta phosphate, SPP: sodium pyrophosphate, U: unencapsulated, E3: 30% coating and E5: 50% coating.

encapsulated phosphates than the samples with unencapsulated counterparts ($p<0.05$). This result showed that encapsulation prevented antioxidant effect of phosphates in uncooked samples. Furthermore, the higher TBARS were determined in beef than chicken in both uncooked and cooked samples ($p<0.05$). This may be the result of higher iron level in beef. In the present study, regardless of the phosphate incorporated or degree of encapsulation, phosphates resulted in lower ($p<0.05$) TBARS values (Fig.1.) in comparison to the control samples on all days of 7 d storage in cooked beef and chicken samples ($p<0.05$). In an effort to determine differences in the oxidative stability between cooked samples formulated with and without encapsulated phosphates, encapsulation significantly enhanced the oxidative stability of cooked samples during storage period ($p<0.05$). The highest oxidative stability was accomplished in the samples contained eSTP and eSPP ($p<0.05$) followed by uSTP and uSPP. Hovewer, there was no observable differences between 30% and 50% coating levels as far as TBARS concerned. The highest TBARS values were determined in control samples ($p<0.05$). The slightly higher TBARS were obtained from chicken samples underwent slow heating rate, dissimilar to beef samples, where heating rate did not affect the level of TBARS.

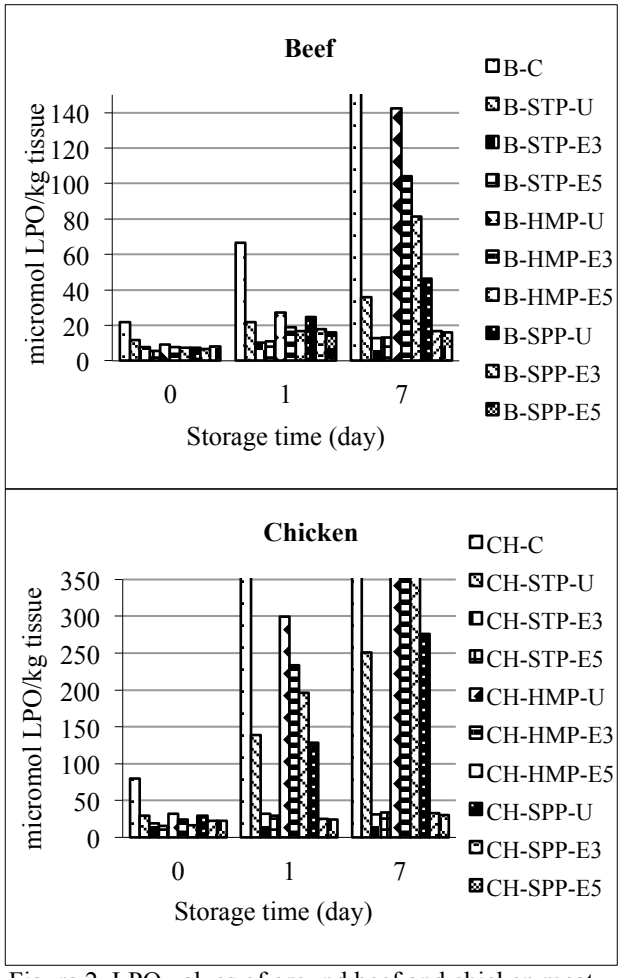

Figure 2. LPO values of ground beef and chicken meat cooked with slow heating rate.

CH: chicken, B: beef, C: control, STP: sodium tripolyphosphate, HMP: sodium hexameta phosphate, SPP: sodium pyrophosphate, U: unencapsulated, E3: 30% coating and E5: 50% coating.

There was a gradual increase in LPO in uncooked samples during 24 h storage ($p<0.05$). Although there were non-significant differences between control of beef and chicken on day 0 and 2 h, higher LPO were determined for beef samples compared to chicken after 24 h storage ($p<0.05$). LPO were lower ($p<0.05$) in both beef and chicken samples containing unencapsulated phosphates at the end of storage, where the lowest LPO were obtained the samples formulated with uSTP ($p<0.05$). As expected, antioxidant effect of three phosphates used in this study was reduced by encapsulation ($p<0.05$). While coating level generally did not affect LPO values in chicken samples, 50% coating level resulted in higher LPO formation in beef samples compared to 30%. Encapsulated STP inhibited LPO formation in beef samples more effectively than eSPP and eHMP ($p<0.05$). However, this effect was not observed in chicken samples where there were no significant differences among encapsulated phosphates. It was observed that cooking increased LPO formation especially in chicken meat samples on processing day (day 0). LPO were higher ($p<0.05$) in cooked chicken samples compared to beef. LPO were slightly higher and lower in chicken and beef samples respectively under fast heating rate and these differences were statistically significant ($p<0.05$). LPO in beef and chicken samples formulated with uSTP and uSPP were significantly lower than that of the samples containing uHMP which was still significantly lower from the controls ($p<0.05$). As far as encapsulated phosphates concerned, the lowest LPO formation among all treatments was also determined in beef and chicken samples produced with eSTP and eSPP ($p<0.05$). However, higher coating level (50%) had no extra significant impact on enhanced inhibition of LPO formation compared to the inhibition level accomplished with 30% coating.

IV. CONCLUSION

It is suggested that the use of encapsulated phosphates can be an effective strategy to inhibit lipid oxidation in pre-cooked ready-to-meat products indicating potential prolonged shelf life. Based on this study, foodservice operators and consumers can enhance food safety and achieve convenience and economic benefits at the same time.

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