EMULSION AND GELLING PROPERTIES OF PORK MYOFIBRILLAR PROTEIN EMULSIFIED GELS AS AFFECTED BY DIFFERENT SALT LEVELS AND PH VALUES

Ho S. Jang and Koo B. Chin

[1]Department of Animal Science, Chonnam National University, Gwangju 500-757, South Korea

[*]Corresponding author (phone: +82-62-530-2121; fax: +82-62-530-2129; e-mail: kbchin@chonnam.ac.kr)

***Abstract*—the emulsion stability, emulsifying activity, and gelling properties of pork myofibrillar protein were affected by many factors. Especially, the interaction of protein and fat is important to affect the desirable texture or flavor in meat products. Thus, this study was to determine the effects of salt level (NaCl, 0M, 0.3M, 0.6M) and pH values (pH 5.0, 5.5, 6.0, 6.5) on emulsion and gelling properties of pork myofibrillar protein (MP) with the addition of corn oil. Emulsion stability index (ESI), emulsifying activity index (EAI), creaming index (CI), cooking yield (CY, %) and gel strength (GS, gf) were measured to determine the emulsion and gelling properties of MP system. The ratio of MP and corn oil was 1:20 for ESI, EAI and CI, and 1:2 for gelling properties. EAI and ESI of pork MP system showed higher at pH 6.0 and pH 6.5 than at pH 5.0 and pH 5.5 in 0.3 M salt ($P<0.05$). Thus, the optimum condition to have better emulsion properties was pH 6.5 in 0.3 M salt. GS increased with increased salt level, and decreased with increased pH from 5.5 to 6.5 in higher salt level (0.6 M salt). CY increased with increased pH in 0 M and 0.3 M. CYs were higher in 0.6 M salt as compared to 0.3 M salt, regardless of pH ranges from 5.5 to 6.5. Gelling properties were best at pH 5.5 in 0.6 M salt. These results indicated that the salt level and pH value in MP emulsion system were highly interacted and significantly affected the MP emulsion system. Further research is required to determine how these factors affected the MP emulsion system and actual emulsified meat products.**

***Index Terms*—emulsion, myofibrillar protein, salt level and pH value, gelling properties**

I. INTRODUCTION

Myofibrillar proteins (MPs) contribute to the characteristics of muscle protein. Especially, MPs formed a firm texture of heat–induced gel and played an important part of processing meat (Ionescu 2008). In addition, hydrophobic myosin head combined with fat and hydrophilic tail combined with water. Thus, MPs improved functional properties of emulsifying activity and emulsion stability. Emulsion is an important processing condition, and it affected product quality, flavor, and texture (Ramirez-Suarez 2003). In these days, consumers prefer to take low-fat meat products, however, fat should take it to maintain body metabolism. However, emulsion is an unstable systems which tend to be destabilized physical mechanisms, such as creaming, sedimentation, flocculation, coalescence, and phase inversion. (McClements 1994). Thus, the pH change and the addition of ingredient might affect emulsion stability and emulsifying activity (Manoi 2009). Thus, pH changes affected gelling properties as well as emulsion properties, due to changes of water holding capacity (Bertram, 2004). Moreover, addition of salt improved the solubility, resulting in improved gelling and emulsion properties. Thus, this study was performed to determine the effects of salt levels (NaCl, 0M, 0.3M and 0.6M) and pH values (pH 5.0, 5.5, 6.0 and 6.5) on emulsion and gelling properties of pork myofibrillar protein (MP) with the addition of corn oil.

II. MATERIALS AND METHODS

1. Extraction of myofibrillar protein (MP)

Myofibrillar protein isolate (MPI) was prepared from pork loin by washing three times with 4 volumes (v/w) of 0.1M NaCl, 50 mM NaH_2PO_4 buffer (pH 6.25), followed by washing with eight volume (v/w) of 0.1M NaCl (pH 6.25) and adjusted to targeted pH values (5.0, 5.5, 6.0, 6.5) using 1N HCl or NaOH (Hong, 2010) and centrifuged at 3000 x g for 15 min at 4℃ (Beckman, Palo Alto, CA, USA). Protein concentration was determined by the biuret method.

2. Emulsion preparation and properties

The combinations of various pH values (5.0, 5.5, 6.0, 6.5) and ionic strength (0, 0.3, 0.6M) were mixed with 1% MP and 20% corn oil. The dilutes were homogenized using an Ultra-Turrax(T25 basic, Ika Works Inc., Wilmington, NC) at 13,000 rpm for 2 min.

The EAI and ESI were measured by the turbidometic methods (Pearce & Kinsella, 1978). The pH and ionic strength combinations of 2.7 ml were mixed with 0.3 ml at 0.1% SDS. The dispersion (30 ㎕) from the mixture was diluted up to 3 ml. The absorbance of 500ηm was measured (A_0) and then samples were kept for 3hr at 20℃ (A_3).

$$EAI(m^2/g) = \frac{2 \times 2.303}{\Phi \times C \times 10.000} \times A_{500} \times D$$

Φ is the volume of oil, and C is the protein concentration (g/ml), and D is dilution factor

$$ESI(\%) = \frac{A_t}{A_0} \times 100$$

A_0 and A_t mean absorbance at 500ηm at time 0 and 3h, respectively.

3. Creaming index

Emulsion dispersions were filled with a tube and stored at room temperature for 24 h. The creaming index was determined as ;

$$\text{Creaming index}(\%) = \frac{H_s}{H_t} \times 100$$

Ht is the total height and Hs is the height of separated emulsion

4. Cooking yields and gel strength

The pH 5.0, 5.5, 6.0, 6.5 and ionic strength 0, 0.3, 0.6M condition mixed respectively 3% MP and the ratio of MP and corn oil was 1:2 for gelling properties. Cooking yield was determined after cooking in water bath from 5℃ to 80℃. $(W_a/W_I)\times100$; W_a is the weight of the remaining gels. W_I is the weight of the initial gels. A puncture test determine to the gel strength. The sample were using an Instron model (3340, Instron Corporation, Canton, MA, USA). The probe diameter was 9 mm and head speed was at 50 mm/min.

III. RESULTS AND DISCUSSION

1. Emulsion properties

The results of salt level and pH value on EAI, ESI and creaming index of emulsion properties made with myofibrillar protein and corn oil mixtures are presented in Tables 1~ 3. EAI of pork emulsified MP produced at low pH (5.0) increased with increased salt levels, however, those at 0.3 M salt level became highest pH at either 6.0 or 6.5. These results showed that the various EAI values were observed, depending on various pH and salt combinations. The higher salt level (0.6M salt) may prevent protein electrostatic interaction (Ramirez-Suarez 2003). EAI of pork emulsified MP did not differ among various pH values in 0 M salt level ($p>0.05$). EAI of pork emulsified MP increased from pH 6.0 in 0.3 M salt, whereas decreased from pH at 6.0 in 0.3 M (Table 1). ESI values were not different at lower pH less than pH 6.0 in other salt levels (Table 2), however, those increased at pH 6.0 and 6.5 in 0.3 M salt. Thus, the better condition would be higher pH (> 6.0) in 0.3 M salt level. Creaming index tended to be higher with increased pH and salt level, resulting in best creaming index at both pH 6.0 and 6.5 in 0.6M salt level. These results indicated that optimum condition of EAI and ESI were at pH 6.0 and 6.5 in 0.3 M, however higher pH and salt combination was better for the creaming index.

2. Cooking yield and gel strength

CYs of pork emulsified MP were acceptable at pH 6.0 and 6.5 in either 0.3 or 0.6 M salt level. In addition, the CYs at lower pH (5.5) were also acceptable in higher salt level (0.6 M). Although WHC was lowest at isoelectric point, the increased salt level improved WHC (Westphalen, 2005). The gel strength of pork emulsified MP was acceptable at most pH levels in higher salt level (0.6M salt), except for pH 5.0. Thus, the increased salt level improved the gelling properties of pork emulsified MP. These result indicated that the best combination of CYs was at pH 5.5 in 0.6 M salt or pH 6.0 and 6.5 in salt level higher than 0.3 M salt. The acceptable gel strength was met in higher salt levels, regardless of pH values (pH > 5.5).

Table 1. Emulsifying activity index (EAI) of emulsified pork MP as affected by various pH and salt levels

Parameters	pH5.0	pH5.5	pH6.0	pH6.5
0M	5.5 ± 0.8^{xB}	6.0 ± 0.3^{xA}	6.1 ± 0.6^{xB}	6.7 ± 0.6^{xB}
0.3M	5.5 ± 0.5^{yB}	7.8 ± 0.5^{yA}	12.4 ± 0.2^{xA}	10.8 ± 2.4^{xA}
0.6M	7.9 ± 0.9^{xA}	6.5 ± 2.5^{xyA}	3.7 ± 0.3^{yC}	4.4 ± 1.3^{yB}

$^{A-C}$ Means with same superscript in a column are not different ($P>0.05$). $^{x-y}$ Means with same superscript in a raw are not different ($P>0.05$).

Table 2. Emulsion stability index (ESI) of emulsified pork MP as affected by various pH and salt levels

Parameters	pH5.0	pH5.5	pH6.0	pH6.5
0M	39.2±2.6^{xA}	38.6±1.5^{xA}	37.6±2.6^{xB}	41.0±2.7^{xB}
0.3M	34.4±2.8^{zA}	44.8±2.2^{yA}	56.3±0.6^{xA}	53.9±7.5^{xA}
0.6M	40.6±4.9^{xA}	42.0±8.4^{xA}	34.7±6.3^{xB}	43.1±2.4^{xB}

$^{A-B}$ Means with same superscript in a column are not different (P>0.05). $^{x-z}$ Means with same superscript in a row are not different (P>0.05).

Table 3. Creaming Index (CI) of emulsified pork MP as affected by various pH and salt levels

Parameters	pH5.0	pH5.5	pH6.0	pH6.5
0M	62.7±3.2^{xA}	62.0±1.8^{xB}	57.9±0.4^{yB}	54.9±1.9^{yB}
0.3M	69.3±4.8^{yA}	58.4±2.4^{zB}	59.7±2.0^{zB}	97.0±5.1^{xA}
0.6M	67.4±7.3^{yA}	92.9±12.1^{xA}	100±0 ^{xA}	100±0^{xA}

$^{A-B}$ Means with same superscript in a column are not different (P>0.05). $^{x-z}$ Means with same superscript in a row are not different (P>0.05).

Table 4. Cooking yield (CY) of emulsified pork MP as affected by various pH and salt levels

Parameters	pH5.0	pH5.5	pH6.0	pH6.5
0M	50.1±4.3^{zA}	61.5±4.7^{yB}	67.1±2.8^{xyC}	73.0±6.0^{xB}
0.3M	48.3±3.6^{zA}	65.4±6.3^{yB}	96.0±1.3^{xB}	100±0^{xA}
0.6M	50.5±4.2^{yA}	100±0^{xA}	100±0^{xA}	100±0^{xA}

$^{A-C}$ Means with same superscript in a column are not different (P>0.05). $^{x-z}$ Means with same superscript in a row are not different (P>0.05).

Table 5. Gel strength (GS) of emulsified pork MP as affected by various pH and salt levels

Parameters	pH5.0	pH5.5	pH6.0	pH6.5
0M	0 ^{zB}	7.9±0.9 ^{xB}	9.4±1.7 ^{xB}	4.5±1.3 ^{yB}
0.3M	9.58±6.4 ^{yA}	10.2±6.9 ^{yB}	5.0±0.9 ^{yB}	20.9±7.0 ^{xB}
0.6M	14.3±4.6 ^{zA}	141.4±30.7 ^{xA}	99.7±20.9 ^{yA}	72.3±25.7 ^{yA}

$^{A-B}$ Means with same superscript in a column are not different (P>0.05). $^{x-z}$ Means with same superscript in a row are not different (P>0.05).

IV. CONCLUSION

This study was performed to determine the effects of salt levels (NaCl, 0 ~ 0.6M) and pH values (pH 5.0 ~ 6.5) on emulsion and gelling properties of emulsified pork myofibrillar protein (MP) with the addition of corn oil. The optimum condition of EAI and ESI was pH at either 6.0 or 6.5 in 0.3M, however higher pH and salt combinations were better for the creaming index. The best combination for CYs was at pH 5.5 in 0.6M salt or pH at either 6.0 or 6.5 in salt level higher than 0.3 M salt. The acceptable gel strength was observed in higher salt levels, regardless of pH values (pH > 5.5).

ACKNOWLEDGEMENT

This study was supported by Brain Korea 21(Center for the control of animal hazards using biotechnology), Chonnam National University, Gwangju, Korea.

REFERENCES

Bertram, H. C., Kristensen, M., and Andersen, H. J. (2004). Functionality of myofibrillar proteins as affected by pH, ionic strength and heat treatment – a low-field NMR study. *Meat Science*, 68, 249-256.

Hong, G. P., and Chin, K. B. (2010). Effects of microbial transglutaminase and sodium alginate on cold-set gelation of porcine myofibrillar protein with various salt levels. Food Hydrocolloids, 24, 444-451.

Ionescu, A., Aprodu, I., Daraba, A., and Porneala, L. (2008). The effects of transglutaminase on the functional properties of the myofibrillar protein concentrate obtained from beef heart. *Meat Science*, 79, 278-284.

Manoi, K., and Rizvi, S. S. H. (2009). Emulsification mechnisms and characterizations of cold, gel-like emulsions produced from texturized whey protein concentrate. Food Hydrocolloids, 23, 1837-1847.

McClements, D. J. (1999). Food emulsions. Boca Racton, FL, USA:CRC Press.

Pearce, K. N., and Kinsella, J. E. (1978). Emulsifying properties of proteins: Evaluation of a turbidimetric technique. Journal of Agricultural and Food Chemistry, 26, 716-723.

Ramirez-Suarez, J. C., and Xiong, Y. L. (2003). Rheological properties of mixed muscle/nonmuscle protein emulsions treated with transglutaminase at two ionic strengths. International Journal of Food Science and techology, 38, 777-785.

Westphalen, A. D., briggs, J. L., and Lonergan, S. M. (2005). Influence of pH in rheological properties of porcine myofibrillar protein during heat induced gelation. *Meat Science*, 70, 293-299.