Frankfurter Quality Characteristics and Rheological Properties of Mechanically Separated Chicken and Chicken Breast Meat

Danika K. Miller[1], Laura E. Yoder[1], Nuria C. Acevedo[2], Steven M. Lonergan[1], Joseph G. Sebranek[1,2] and Rodrigo Tarté[1,2*]

[1]Department of Animal Science, Iowa State University, Ames, Iowa 50011, United States

[2]Department of Food Science and Human Nutrition, Iowa State University, Ames 50011, Iowa, United States

*Corresponding author email: rtarte@iastate.edu

I. INTRODUCTION

Addition of mechanically separated chicken (MSC) modifies the texture, flavor, and color of processed meat products [1,2]. Production practices of MSC are very diverse and it is well documented that there can be drastic differences in moisture, fat and protein content due to in-going raw material variation and equipment technology [3]. If such variation occurs in composition, is there variation in functional aspects that impact finished product quality as well? Utilizing dynamic oscillatory rheology, investigators have been able to document a characteristic increase, followed by a sharp decrease and subsequent increase in storage modulus (G', measure of solid-like characteristics) and loss modulus (G'', liquid-like characteristics) during thermal gelation. The rapid decline in G' and G'' around 50–55˚C is attributed to the denaturation of light-meromyosin (LMM) [6]. However, characterization of MSC myofibrillar protein rheological properties in relation to whole muscle has not been effectively explored. Insight into the gelation pattern of MSC myofibrillar proteins may elicit an explanation of why differences in raw material functionality have been observed. The objectives of this study were to assess differences between MSC and chicken breast trim when used as frankfurter raw materials and to identify rheological attributes of their myofibrillar proteins during gelation. An improved understanding of the properties of MSC will facilitate optimization of its processing parameters.

II. MATERIALS AND METHODS

MSC obtained from two different separation methods [MSC1 Beehive separator, aged bones (3 d), MSC2 Poss separator, fresh bones) were compared to chicken breast trim (BT) as raw materials for frankfurters. Raw materials were blast-frozen (-44.4˚C for 72 h) and stored at -20˚C for < 20 days. Frankfurters, formulated to cooked targets of 56% moisture, 23% fat, and 12% protein, were produced on 3 consecutive days, vacuum-packaged, and stored under display lights (fluorescent, 2300 lux) for 98 d. Color (CIE L*, a*, b*, illuminant D65, 10° observer angle), Texture Profile Analysis and lipid oxidation were evaluated every 2 weeks. Myofibrils were isolated from each raw material by differential centrifugation, and myofibrillar proteins were solubilized (0.6 M NaCl, 50 mM sodium phosphate, 2.8% (w/v) protein concentration, pH 6.0). Dynamic oscillatory rheology (40 mm parallel plates, 0.25% strain, 1 Hz frequency) was performed on the solubilized myofibrillar proteins of each raw material. During a temperature sweep of 20–85˚C at 1˚C/ min, storage modulus (G'), loss modulus (G'') and phase angle (δ) were measured in triplicate. Protein profile was evaluated using SDS-PAGE. Shelf-life (fixed effect: treatment, day and treatment*day, random effect: replication) and rheological data (fixed effect: treatment random effect: day*treatment) were analyzed using SAS 9.4 mixed proc. Shelf-life data was corrected with a Tukey correction and an autoregressive (1) covariate. Statistical significance is denoted by a p-value < 0.05.

III. RESULTS AND DISCUSSION

All raw materials were significantly different from each other in moisture and fat content ($P<0.05$). BT was least in fat content (2.40%), above which was MSC2 (14.83%) and MSC1 (16.17%); but was the highest in moisture content (74.41%), followed by MSC2 (71.00%) and MSC1 (68.35%). BT (23.48%) was significantly higher in protein content than both MSC raw materials (MSC1=14.40%, MSC2=14.00%) ($P<0.05$). MSC2 frankfurters were greatest in fat content (25.4%) and lowest in moisture content (55.36%) ($P<0.05$). Both MSC frankfurters had significantly darker (L*), and redder (a*) external and internal color when compared to BT frankfurters; with MSC2 being the darkest and reddest treatment ($P<0.05$). Greater hardness, cohesiveness, gumminess and chewiness values were documented in MSC2 product than in BT and MSC1 product.

Proteins from all sources exhibited gelation with increased temperature (decreased δ). A peak, decline, and subsequent increase was observed in all 3 treatments at the 50–55˚C range in both the G' and G". G' slopes on both sides of the peak (S2, S3) and following the decline (S4) were significantly different between BT and both MSCs ($P<0.05$). BT's S3 was significantly steeper indicating a greater instability of the solid-like structure in the temperature range of 50–55˚C (LMM denaturation). BT S2 and S3 were significantly different from MSC treatments in G" ($P<0.05$), but not significantly different during S4.

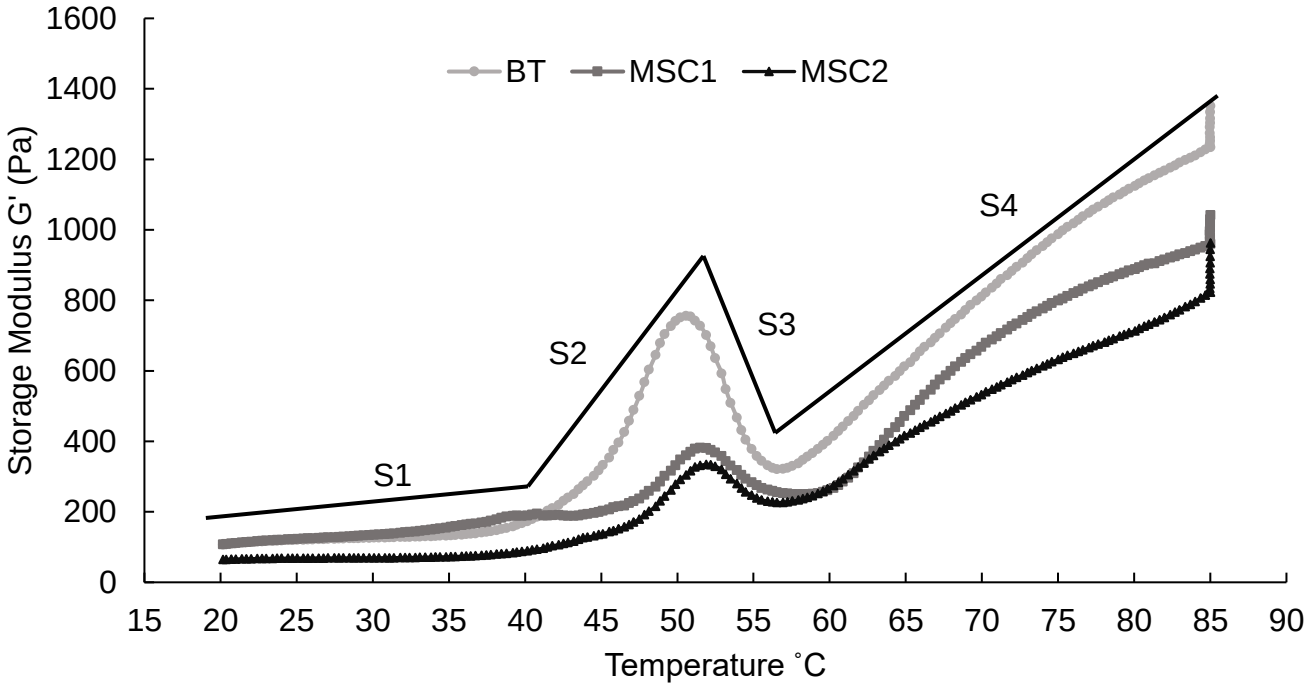

Figure 1. Storage Modulus (G') of Myofibril Solutions

IV. CONCLUSION

The data shows that physical properties of myofibrillar proteins from MSC and chicken breast meat differ during thermal gelation. Chicken breast myofibrillar proteins exhibited greater instability of solid-like structure (decrease in G') than both MSCs in the temperature range LMM denatures. The plateauing of storage modulus could indicate damage of this region during the mechanical separation process. The data also reveal that properties of different MSC can result in significant variation in finished product quality as indicated by greater hardness and redness of MSC2 frankfurters than MSC1 frankfurters. MSC2 frankfurters were also harder and more cohesive than chicken breast frankfurters, underscoring the importance of understanding the features of raw materials that will affect processing functionality. This research demonstrates MSC can produce product with equal or greater texture to whole muscle products and identifies variation within commercial MSC functionality. With further research, optimization of MSC processing will result in consumer products with firmer texture and improved overall quality.

ACKNOWLEDGEMENTS

The authors thank Elaine Larson and Dr. Edward Steadham for their technical assistance.

REFERENCES

1. Daros, F. G., Lucia Masson, M., & Amico, S. C. (2005). The influence of the addition of mechanically deboned poultry meat on the rheological properties of sausage. Journal of Food Engineering 68:185–189.
2. Froning, G. W. & Johnson, F. (1973). Improving the quality of mechanically deboned fowl meat by centrifugation. Journal of Food Science 38:279–281.
3. Froning, G. W. (1976). Mechanically-deboned poultry meat. Food Technology 30(9):50–63.
4. Froning, G. W. (1970). Poultry meat sources and their emulsifying characteristics as related to processing variables. Poultry Science 49:1625–1631.
5. Xiong, Y. L. (2001). Mechanism of rheological changes in poultry myofibrillar proteins during gelation. Avian and Poultry Biology Reviews 12:137–149.