COMPARATIVE EFFECTS OF MICRO vs. NANO FILLER EMULSIONS ON TEXTURAL PROPERTIES OF MYOFIBRILLAR PROTEIN COMPOSITE GELS

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I. INTRODUCTION

The interactions between protein and oil to form a composite gel matrix play an important role in textural properties [1]. Commercial comminuted and restructured meat products typically comprise a continuous protein matrix filled with emulsified fat droplets, and in the composite gel system, myofibrillar protein (MP) plays a principal structural role [2]. The aim of this research is to test the effects of nano-emulsions vs. micro-emulsions on the rheological, water-binding, and structural properties of emulsion gels. MP-stabilized O/W emulsions in nano- vs. micro-scale particles have different effects on the physical properties of emulsion gels.

II. MATERIALS AND METHODS

MP-based oil-in-water micro-emulsions and nano-emulsions were compared with each other and with lecithin-stabilized micro-emulsions and nano-emulsions. For emulsion preparation, MP (1 mg/mL) was the testing emulsifier, and lecithin (1 mg/mL) was the comparative surfactant in canola oil (10% v/v)-based water-in-oil (O/W) emulsions. High-pressure homogenization (40 MPa) was applied to produce nano-emulsions and high-speed homogenization (17,000 rpm) was used to prepare micro-emulsions. The physicochemical properties of emulsions and emulsion gels were analyzed. Emulsion particle size, ζ-potential, and morphological properties (transmission and confocal microscopies) were analyzed; dynamic rheological behaviors (storage and loss modulus), mechanical strength, water-holding capacity, water mobility, and protein secondary structures of the emulsion gels (2.5% protein, 5% oil) were measured. Statistical analyses were performed using the SPSS software. All experimental values were measured in triplicates, and the results are presented as the mean ± standard deviation. Means within groups were compared using a one-way analysis of variance followed by Duncan's multiple range test ($p < 0.05$).

III. RESULTS AND DISCUSSION

The gel strength of pure MP gel (control) was significantly lower than that of emulsion gels due to induce the interaction between protein-oil in the gel matrix [3]. The MP micro-emulsion gel (~500 nm) was slightly stronger than the MP nano-emulsion gel (~2 mm), consistent with the trend seen in moduli tests. However, emulsion gel embedded with MP-nano showed the highest water-holding capacity and water mobility, and almost no cooking loss when compared with all other composite gels. Partial structural unfolding protein suggests the improved interfacial activity of MP in nano-emulsions, and this is supported by the confocal imaging results where MP-nano displayed numerous smaller droplets distributed within the MP matrix. Moreover, depending on the emulsion type, the secondary structure was affected. Overall, emulsion gels tended to be stronger than oil-free control gels, and MP-based emulsions were more effective than lecithin-stabilized emulsions for modifying the gelling properties due to a visible interfacial protein film formed that prevented oil droplet aggregation.

Table 1 Characterization of MP solutions, micro-emulsions, and nano-emulsions

Treatments	Particle size (nm)	[-] ζ-potential (mV)	Hydrophobicity	DSC 1st peak		DSC 2nd peak	
				Enthalpy (mJ/g)	Peak (°C)	Enthalpy (mJ/g)	Peak (°C)
5% MP			776.1	569.6	57.6	12.4	67.4
Non-treated HPH			982.9	348.4	56.2	11.6	68.5
Treated HPH			1143.2	239.3	59.0	5.8	66.8
MP Micro	2090.7±587.4[a]	10.3±3.3[a]					
MP Nano	522.1±190.5[c]	10.3±3.3[a]					
Lec Micro	1330.0±229.1[b]	12.6±0.7[a]					
Lec Nano	543.5±84.7[c]	11.5±0.5[a]					

5% MP, 5% myofibrillar protein in sodium phosphate buffer (0.6 M NaCl, pH 6.25); Non-treated HPH, treated high speed homogenizer; Treated HPH, treated high speed homogenizer and high-pressure homogenizer. MP, myofibrillar protein; Lec, lecithin; micro, micro-emulsion; nano, nano-emulsion. [a-c] Different letters represent significant differences at $p < 0.05$.

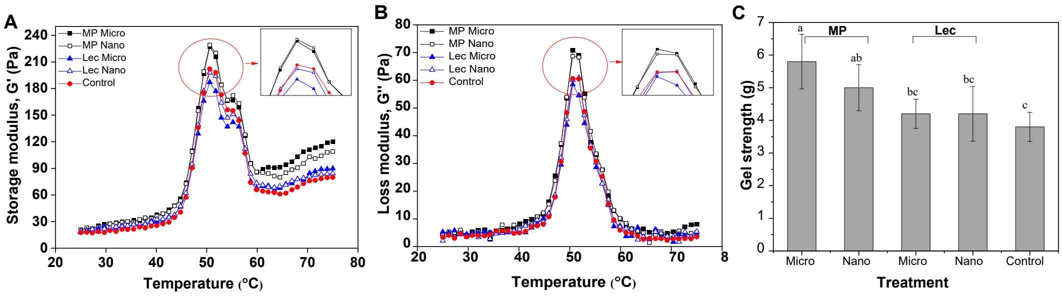

Figure 1. Storage (A), loss (B) modulus and gel strength (C) of emulsion gel. MP, myofibrillar protein; Lec, lecithin; micro, micro-emulsion; nano, nano-emulsion; control, 2.5% MP gel. [a-c] Different letters represent significant differences at $p < 0.05$.

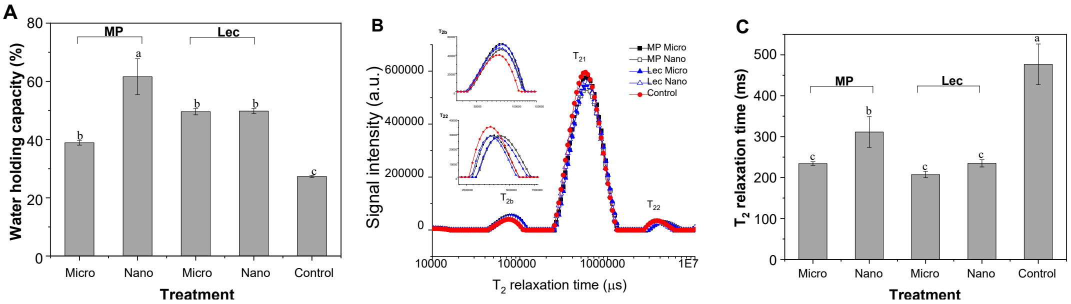

Figure 2. Water-holding capacity (A), transverse relaxation curves (B), and T_2 relaxation time (C) of emulsion gel. MP, myofibrillar protein; Lec, lecithin; micro, micro-emulsion; nano, nano-emulsion; control, 2.5% MP gel. T_{2b}, T_{21}, and T_{22} indicate bound, immobilized, and free water, respectively. [a-c] Different letters represent significant differences at $p < 0.05$.

IV. CONCLUSION

Based on the results, protein-based emulsions were preferred over lecithin-based emulsions, and MP nano-emulsions improved moisture retention in cooked MP gels.

ACKNOWLEDGEMENTS

This research has been supported by the OTTOGI HAM TAIHO Foundation.

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