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# IMPACT OF SOLID-TO-LIQUID LIPID RATIO ON THE GELATION AND EMULSION PROPERTIES OF LAMB MYOFIBRILLAR PROTEIN GELS

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## I. INTRODUCTION

Myofibrillar protein (MP), a salt-soluble protein from muscle, plays a vital role in the texture and structure of meat products due to its ability to form heat-induced gel networks. Its functional properties, such as water-holding capacity and gel strength, also make it important in emulsion gel systems, especially in functional foods. Lamb MP, known for its high myosin content, shows better gel-forming ability than pork or beef MP [1].

Emulsion gels combine emulsions and gels into one system, providing enhanced stability, viscoelasticity, and structural strength. Embedding oil droplets in a structured aqueous network improves emulsion stability, which is essential for consistent gel network formation. The type of oil used strongly influences emulsion and gel behavior because fatty acid chain length and saturation level affect interfacial tension, viscosity, and droplet size. Solid fat content especially affects gel strength by promoting a compact structure and stabilizing bioactive components [2].

Vegetable oils distinctly affect the quality and nutritional value of meat products [3]. In contrast to the more frequently studied vegetable oils, this study aimed to investigate the effects of blending olive oil containing long-chain fatty acids with coconut oil containing medium-chain fatty acids on the texture, microstructure, and physicochemical and rheological properties of lamb MP-based emulsion gels. By analyzing various oil ratios, this study explored the potential of plant-based oils as sustainable alternatives to animal fats. Furthermore, these findings could lead to the development of healthier meat products and vegetarian or hybrid formulations, broadening their application and aligning with current trends in sustainable food systems.

## II. MATERIALS AND METHODS

Lamb myofibrillar protein (MP)-based oil-in-water emulsions were prepared using a 10% (w/w) oil phase of coconut and olive oil mixtures (10:0 to 0:10). Emulsions were stabilized with MP (25 mg/mL) and homogenized at 8,000 rpm. Solid fat index was measured by differential scanning calorimetry, and droplet size, ζ-potential, and apparent viscosity were evaluated. Emulsion gels were formed by heating MP-emulsion mixtures (1:1, w/w), and gel strength, protein structure, water-holding capacity, water mobility, rheology, and morphology were analyzed using appropriate techniques. All values were measured in triplicate and analyzed by one-way ANOVA with Duncan's test ($p < 0.05$).

## III. RESULTS AND DISCUSSION

Medium-chain triglycerides of coconut oil contribute to increased viscosity at lower temperatures, whereas excessive amounts (>60% of total lipid) disrupt the protein matrix and weaken the gel strength. Fourier-transform infrared spectroscopy analysis showed that moderate coconut oil levels promoted α-helix formation, improving protein stability and water-holding capacity, whereas excessive incorporation led to random coil formation and lower water retention. Rheological analysis confirmed the highest storage modulus at 40%–60% coconut oil, supporting the strongest gel network. The morphological analysis revealed smaller and more uniformly distributed pores at optimal ratios, corresponding to superior mechanical strength and stability.

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

| Treatments | Particle size (μm) | Span | [−] ζ-potential (mV) | Viscosity (Pa·s) at 10 $s^{-1}$ | | |
|---|---|---|---|---|---|---|
| | | | | 10˚C | 30˚C | 45˚C |
| 10:0 | 20.51 ± 0.30$^{e}$ | 2.19 ± 0.22$^{b}$ | 20.03 ± 0.15$^{ab}$ | 1612.7 | 2003.7 | 1628.5 |
| 8:2 | 21.48 ± 0.50$^{d}$ | 2.97 ± 0.36$^{a}$ | 19.50 ± 0.00$^{bc}$ | 2254.9 | 1837.9 | 1762.9 |
| 6:4 | 25.31 ± 0.93$^{a}$ | 1.62 ± 0.09$^{c}$ | 20.46 ± 0.75$^{a}$ | 2441.9 | 2172.5 | 1667.4 |
| 4:6 | 22.14 ± 0.23$^{c}$ | 1.76 ± 0.07$^{c}$ | 19.43 ± 0.06$^{bc}$ | 3353.2 | 2999.4 | 2373.2 |
| 2:8 | 22.19 ± 0.26$^{c}$ | 1.75 ± 0.03$^{c}$ | 20.06 ± 0.25$^{ab}$ | 2694.1 | 2848.7 | 2471.6 |
| 0:10 | 23.34 ± 0.90$^{b}$ | 1.78 ± 0.09$^{c}$ | 18.96 ± 0.15$^{c}$ | 2717.9 | 5256.9 | 3878.9 |

Values shown are mean ± SD.

Different letters (a–e) represent significant differences at $p < 0.05$.
The ratio indicated the proportion of olive and coconut oils relative to the total lipid content of the emulsion gel.

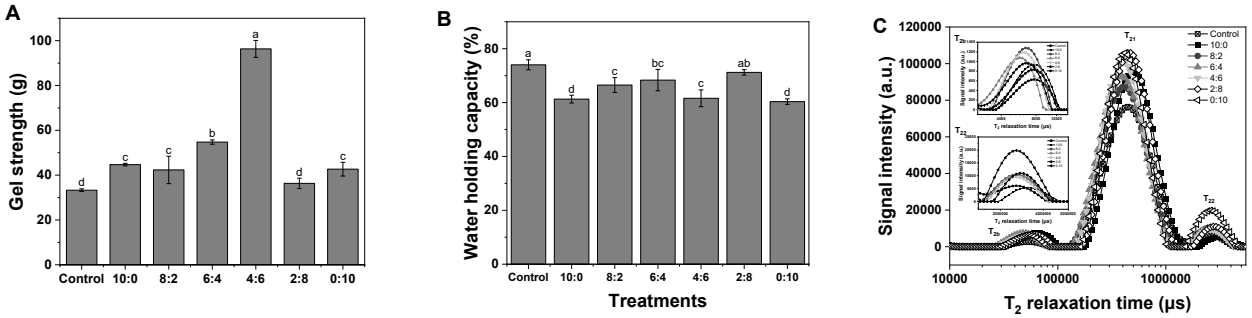



Figure 1. Water-holding capacity (A) and transverse relaxation curves (B) of emulsion gels. The Control was 2.5% MP gel without oil. The ratio indicated the proportion of olive and coconut oils relative to the total lipid content of the emulsion gel. $T_{2b}$, $T_{21}$, and $T_{22}$ represent bound, immobilized, and free water, respectively. Different letters (a–d) indicate significant differences at $p < 0.05$.

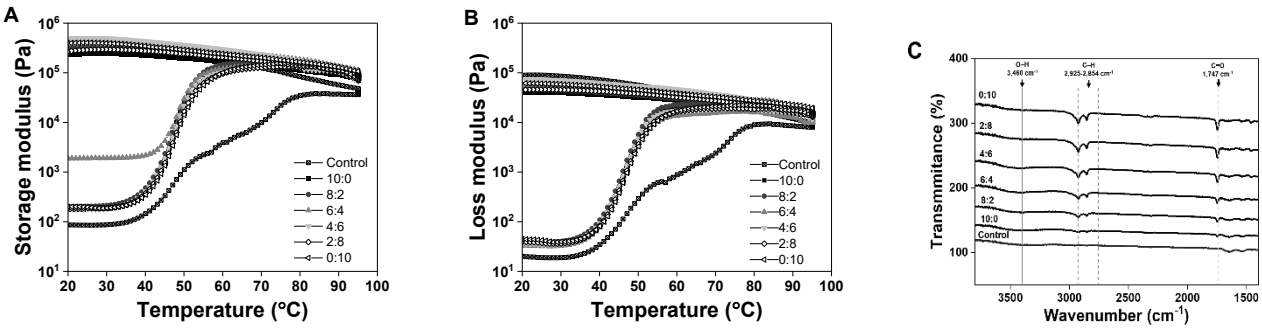



Figure 2. The storage (A) and loss modulus (B), and FT-IR spectra (C) of MP emulsion gels. The Control was 2.5% MP gel without oil. The ratio indicated the proportion of olive and coconut oils relative to the total lipid content of the emulsion gel.

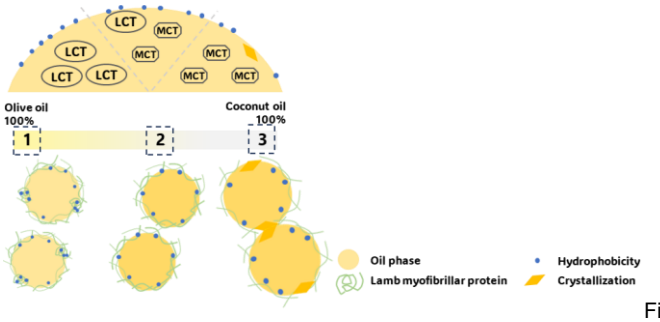



Figure 3. The structural mechanisms of MP emulsion gels.

## CONCLUSION

Increasing the solid fat content altered the emulsion droplet size, increased the viscosity, and improved the WHC of the gel. The optimal oil ratio facilitated the formation of a uniform and dense gel network, enhancing both stability and mechanical properties. Emulsion gels containing 60% solid fat in total lipids exhibited superior physical properties compared to other ratios. These results suggest that optimizing the solid fat content is key to developing emulsion gels with improved texture and stability, potentially broadening their application in meat product formulations.

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