Effect of sugarcane dietary fiber on the microstructure of myofibrillar protein gel

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Abstract - The effects of sugarcane dietary fiber (SDF) on the microstructure of porcine myofibrillar proteins (MP) gel. Light microscopy suggested that SDF had negative effect on the gel by drawing water capability and formed large cavities in gelation. While the SEM and lacunarity showed that the protein gel had more compact and homogenous three-dimensioned network with SDF added. So it suggested that SDF affected moisture distribution in the gel and concentrated MP, promoted the unfolding of MP chains in heating process, leading to a better three-dimensioned network.

Keywords - sugarcane dietary fiber, myofibrillar protein, gelation, microstructure

I. INTRODUCTION

As consumers become more conscious of the health, the food processing industry is constantly striving to reduce fat content and fat type. One method is the replacement with various types of dietary plant fibers. The dietary fiber incorporated was able to make the blending system decrease cooking loss and modify textural quality [1]. While, it is was still unclear that how dietary fiber improved the properties of gelled protein matrix. The objective of this study was to explain the mechanism through microstructure.

II. MATERIALS AND METHODS

SDF with 80 mesh was added at 3 concentrations: 1, 2 and 3 g/100 g of myofibrillar protein (T1, T2 and T3) which was diluted to a final protein concentration of 60 mg/mL (in 0.6 mol/L NaCl, 50 mmol/L Na_2HPO_4/NaH_2PO_4 solution, pH 7.0). The samples were stored at 4°C overnight until required for use.

Sections of blended gels (8 μm thick) were cut using a microtome (CM1900, Leica, German) and then fixed and stained with hematoxylin-eosin following the procedure outlined by M. Wu, Xiong, and Chen (2011) [2].

Protein gels were examined with a Hitachi S-3000 N scanning electron microscope (Tokyo, Japan) at an accelerating voltage of 20 kV. Lacunarity, which describes the heterogeneity of the pores in protein network, was calculated as the variation in the number of pixels at each grid box placed in SEM image which treated with threshold process [3].

The data of treatment with SDF were evaluated using a one-way ANOVA. Significant differences between means were identified using Duncan's multiple range tests. The significance level was set at $P < 0.05$.

III. RESULTS AND DISCUSSION

These paraffin sections of gels (Fig.1.A) showed that the MP gels were composed of dense and homogeneous structures and the images of blended gels contained large cavities, presumably of SDF-absorbed water. Also the SDF did not have direct contact with MP gel. Fig.1.B shows representative SEM micrographs of gels. The MP of the control was not well-exposed and made good links between neighbor protein in heating process, so gel framework was inhomogeneous and clustered. And the gel with SDF could form more compact and porous microstructure. To precisely analyze the difference between gel networks, we study the lacunarity of cavities formed by gel aggregation [4]. The smaller lacunarity was, the more homogeneous the gel microstructure was. The maximum value shown in Fig.4 was also significantly reduced by the content of SDF addition ($P<0.05$).

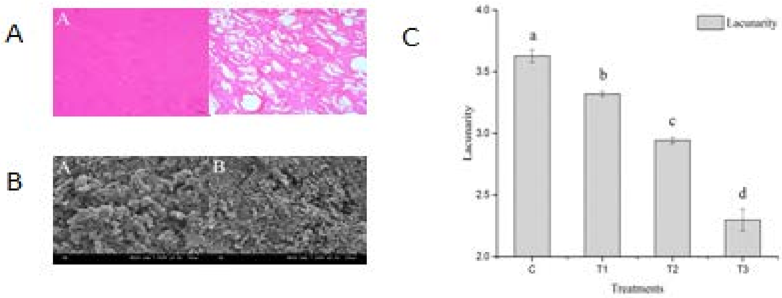

Figure. 1. (A) Light micrographs of blended gels with SDF; (B)Scanning electron micrographs of gel network; (C) Lacunarity (Max) calculated from SEM thresholded images. (n=3) A: the control B: T2

3.6 Mechanistic explanation

In Fig. 1.A the images proved that the blended gels contained large cavities, presumably of SDF-absorbed water. Unlike hydrocolloids (carrageen and so on) could self-aggregation through hydrogen bonding and hydration, act as good fillers to improve the gel properties. Also the MP gel did not have direct contact with SDF. From the result above, the SDF should have negative effect on the gel functionality of MP. On the contrary, many study reported that the gel with dietary fiber had better WHC and gel strength. So we further study the MP gel network which may result in the phenomenon above. The results indicate that SDF, acts as active dehydrating agent, could change the water distribution and concentrate MP in sol system, accelerate the hydrophobic contact in heating process, and finally lead to aggregate well gel network with homogenous cavities (Fig.1.C smaller lacunarity).

IV. CONCLUSION

The plant fiber SDF, as an active dehydrating agent, affects the moisture distribution in MP-blended products, by removing water from the MP and homogenously embedded in gelation. During the heating process, the more concentrated MP resulted in a compact and homogenous three-dimensioned network. And this enhanced gelation may strengthen the binding of SDF, forming a synergistic interactive system.

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