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Incorporation of thermo-reversible and thermo-irreversible curdlan gels for improving thermal gelling properties and rheological behaviors of myofibrillar protein (#291)

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Introduction

Myofibrillar protein (MP) is a dominant structural and functional component in fresh meat and is crucial in affecting quality profiles of processed meat products [1]. Moreover, water holding capacity (WHC) is an invaluable functional property of MP gels, which can directly influence the amount of water entrapped within the gel network [2]. Consequently, from a more practical view, the selection of emerging technologies or the addition of natural polymers should be applied in the meat industry to obtain meat products with improved quality. In our previous work, we found that the addition of thermo-reversible curdlan gels (TRC) and thermo-irreversible curdlan gels (TIRC) significantly enhanced the textural characteristics and gel properties of frankfurters (not published). Therefore, the purpose of this study was to evaluate the influence of the two types of curdlan gels (TRC and TIRC) on the thermal gelling properties and rheological behaviors of heat-induced MP gels.

Methods

Extraction of MP

MP was extracted according to the procedure described by Xia et al. [3]. All steps were conducted in a 4 °C cold room. The final MP concentration was evaluated via the Biuret method [4].

Preparation of two types of curdlan gels

Two types of curdlan gels were prepared according to the method of Wu et al. with some modifications [5].

Preparation of MP-TRC or MP-TIRC sols

Pre-determined amount of MP was suspended in 50 mM PIPES buffer containing 0.6 M NaCl (pH 6.25) to give a final protein concentration of 40 mg/mL. Then, different levels of TRC or TIRC were mixed into MP solutions to obtain final curdlan concentrations at 0.1, 0.2, 0.3, 0.4, and 0.5% (w/w, based on the total weight of MP) to make MP-TRC or MP-TIRC sols.

Preparation of MP-TRC or MP-TIRC gels

The MP-TRC or MP-TIRC sols prepared as described above were transferred to 30 × 50 mm (length × diameter) glass vials, and heated in a water bath at 75 °C for 20 min. Then, the vials were immediately chilled in an ice slurry and the obtained gels were stored at 4 °C for 24 h.

Gel strength

Before the gel strength measurement, the gels were equilibrated at room temperature for at least 1 h. Gel strength was analyzed with a Model TA-XT2 texture analyzer (Stable Micro Systems Ltd., Godalming, UK) with an attached 5 kg load cell.

Water holding capacity (WHC)

The WHC of the gels was measured using the method of Hu et al. with some modifications [6].

Dynamic rheological measurements

The rheological behaviors during thermal gelation of MP sols with or without TRC and TIRC were determined using a rheometer (DHR-1, TA Instruments Inc., New Castle, DE, USA) equipped with two parallel plates (diameter 40 mm) set 1 mm apart.

Results

Gel strength

Results are presented in Table 1 and show the gel strength of MP composite gels with and without various concentrations of TRC or TIRC. Compared with the control group (MP alone), the addition of TRC or TIRC significantly enhanced the gel strength of MP composite gels ($P < 0.05$). However, the gel strength of MP composite gels containing 0.4% to 0.5% TRC, or those containing 0.3% to 0.5% TIRC showed no significant differences within each range, respectively ($P > 0.05$). Moreover, when compared to TIRC, TRC inclusion resulted in a higher gel strength among equal concentrations ($P < 0.05$), which indicates that the MP-TRC gels had stronger textural characteristics.

Water holding capacity

As shown in Table 1, when compared with the control group, the addition of TRC noticeably enhances the WHC of MP composite gels ($P < 0.05$), but between 0.4% and 0.5% addition amounts no significant difference was observed ($P > 0.05$). However, only higher addition amounts of TIRC (0.3% to 0.5%) significantly increased the WHC of MP composite gels over the control group ($P < 0.05$). Moreover, when compared to TIRC, TRC incorporation resulted in higher WHC at the same inclusion level ($P < 0.05$), which indicates that MP-TRC composite gels possess a stronger ability to entrap water. The maximum WHC (68.37%) of a MP composite gel was obtained with a TRC concentration of 0.4%.

Dynamic rheological behaviour during gelation

As depicted in Fig. 1A and B, compared to the MP control, the addition of TRC or TIRC at different concentrations led to higher initial G' values before heating but lower G' values when the temperature reached the first peak

Notes

(Tp). As presented in Fig. 1 C and D, the initial and final *G″* values for the MP-TRC or MP-TIRC were significantly higher than that of the control group (MP alone) ($P < 0.05$). Moreover, TRC rendered higher *G″* values than TIRC among equal addition amounts during the final heating temperature (80 °C) ($P < 0.05$).

Conclusion

Compared with the control samples, the enhanced gel strength and WHC of the MP gels could be attributed to the interaction of TRC or TIRC with the MP gel matrix during heat-induced gelation. This was verified by dynamic rheology analysis. Therefore, these two types of curdlan gels had distinct effects on the gelling properties and rheological behaviors of MP.

Sample	Gel strength (g)	WHC (%)
Control	15.70 ± 0.44^{h}	47.33 ± 1.40^{g}
TRC-0.1%	22.23 ± 0.45^{f}	53.20 ± 1.61^{ef}
TRC-0.2%	28.43 ± 0.51^{d}	55.63 ± 1.68^{de}
TRC-0.3%	32.20 ± 0.40^{b}	61.37 ± 1.91^{bc}
TRC-0.4%	33.70 ± 0.40^{a}	68.37 ± 1.12^{a}
TRC-0.5%	34.57 ± 0.81^{a}	65.00 ± 1.20^{ab}
TIRC-0.1%	19.27 ± 0.40^{g}	49.00 ± 1.35^{fg}
TIRC-0.2%	25.53 ± 0.31^{e}	50.67 ± 1.42^{fg}
TIRC-0.3%	30.03 ± 0.50^{c}	56.37 ± 0.60^{de}
TIRC-0.4%	30.70 ± 0.30^{c}	59.33 ± 1.82^{cd}
TIRC-0.5%	30.33 ± 0.50^{c}	58.33 ± 1.92^{cd}

Table 1 Gel strength and WHC of MP gels containing different concentrations of TRC or TIRC Values are given as means ± SD from triplicate determinations; for each column letters a-e indicate significant differences between samples ($P < 0.05$).

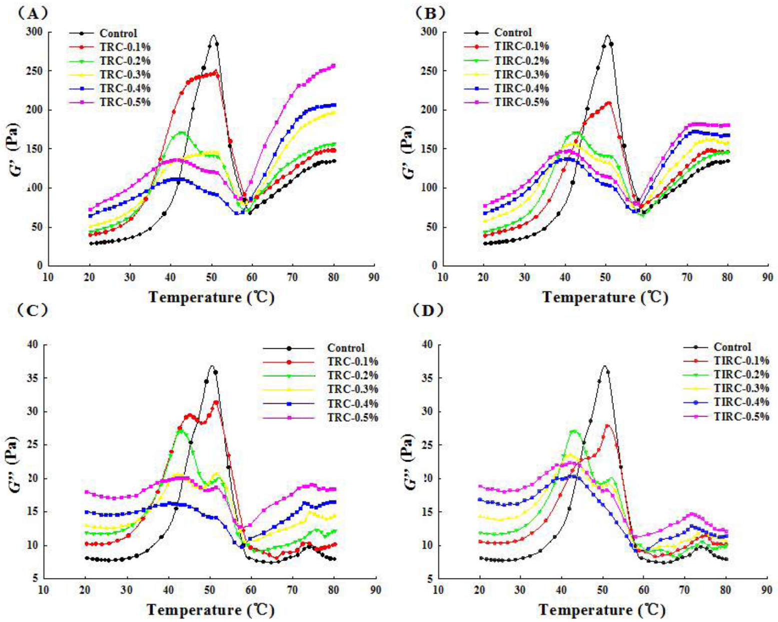

Figure 1. The dynamic rheological behaviors analysis (G’, the storage modulus; G’’, the loss modulus

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