Rheological aspects of mixed gels made from protein and κ-carrageenan

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ABSTRACT

Mixed gels, made from soy or pea protein concentrates and κ-carrageenan was investigated. Pea protein concentrate (PPC) exhibited greater synergy with κ-carrageenan than soy protein concentrate (SPC) in relation to gel strength , gel stiffness and pH stability.

INTRODUCTION

A number of proteins are used in food products in order to provide increased functionality (waterbinding, gelation, emulsion stability etc.). Such functional proteins are often part of food systems, where hydrocolloids are also used, and a synergistic effect can be obtained (Marrs[1], Tokaev et al.[2], Tolstoguzov[3]).

The present investigation was undertaken in order to map the optimum physical /chemical conditions for a synergistic effect between commonly used food proteins (soya protein and pea protein) and κ-carrageenan.

Compressive measurements of finished gels with varying composition were made and compared with oscillatory measurements obtained during gel formation.

MATERIALS AND METHODS

Two different pea protein concentrates (P 2000 and P 2100 from Nutrio A/S, Haderslev, DK) were compared to a soy protein concentrate (Purina 500 E, SFK, Hvidovre, DK).

Compressive measurements were done using an Instron Universal Testing Machine (Model 4301, Instron Ltd., High Wycombe, Bucks., UK).

Gels were made in the following manner: Suspensions with varying amounts of protein (17-18% w/w) and κ-carrageenan (1-0% w/w) were made using demineralized water and the pH was regulated in the interval 6.2-7.4 using 0.1N HCl or NaOH. The suspensions were de-aerated overnight at 5°C, filled in tins, heat treated at 125°C for 1 hour, kept at 5°C for 24 hours and analyzed. Compressive measurements were made on 5 cylinders (height 21.45 mm, diameter 24 mm) from each tin, using a crosshead speed of 100 mm/min. Total solids was measured with a MA 30 Moisture Analyzer (Sartorius AG, Göttingen, D). The average total solids in the final gels was 18,51% (std. 1,25 %) (n=205). This is somewhat higher than the intended 18%, due to syneresis in the tins.

Dynamic measurements were made using a Bohlin VOR rheometer (Bohlin AB, Lund, S) provided with a cup and spindle measurement system (C25). Suspensions were made as described for the compressive measurements, but the pH was kept at 6.8 with a phosphate buffer. Gelation was followed using oscillatory measurements (frequency 5 Hz, amplitude 0.5%) during a temperature gradient from 40-90°C , followed by relaxation measurements (an amplitude of 5%, with a strain rise time of 2 s and a measurement time of 300 s) and a frequency sweep (0.1-20 Hz, 0.5% amplitude) at 40°C.

Results from the dynamic measurements were treated according to the modified Takanayagi method of Clark et al.[4], used in several recent studies on mixed systems containing food components (Ziegler and Rizvi[5], Svegmark and Hermansson[6], Chronakis and Kasapis[7], Kasapis et al.[8]).

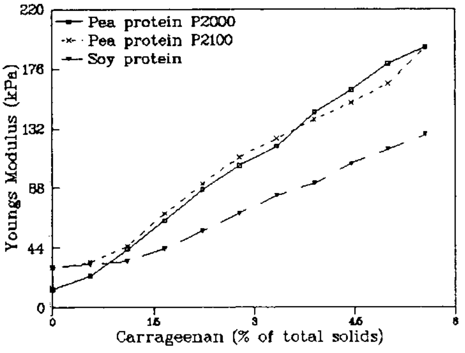

Figure 1. Youngs Modulus for gels with 18% total solids made from different proteins with varying amounts of κ-carrageenan added (n=6).

RESULTS

The compressive measurements showed that the pea protein concentrates used exhibited greater synergy with κ-carrageenan than soy protein concentrate. Figure 1 illustrates this using Youngs Modulus as an indicator of the stiffness of the gels. A similar relationship was found for the compressive force at the breakpoint (i.e. gel strength).

The highest gel strength and gel stiffness was found in the range 6.4-6.8. Mixes of PPC with κ-carrageenan were influenced less by variations in pH than equivalent gels made with SPC (Figure 2).

Data from the oscillatory measurements were treated according to Clark et al.[4], using the elastic modulus, G´, at 5 Hz from the frequency sweep on the finished gel. Results are presented in figure 3 and indicate that a change from

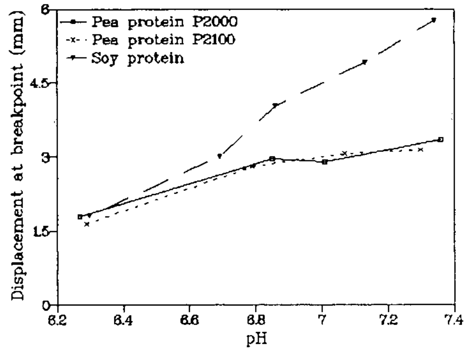

Figure 2. Displacement at breakpoint versus pH for soy and pea protein concentrates. Values are for gels with 18% total solids (3.3% from added κ-carrageenan). (n=10)

lower bound behavior (protein constituting the continuous phase) to upper bound behavior (a continuous phase constituted of κ-carrageenan) occurs in the mixed gels at concentrations where carrageenan constitutes 2.8-5.6 % of the total solids. This change occurs at lower concentrations of κ-carrageenan when PPC is used, compared to SPC.

Relaxation measurements and modelling the frequency dependence of G´ (using a 3-element gel model as described by Nakamura et al.[9]) confirms this result.

Figure 3 also illustrates that a p-value of approx. 4-5 fits reasonably well with the measured data, indicating that κ-carrageenan is 4-5 times as solvent attracting than the protein concentrates used.

CONCLUSION

Addition of κ-carrageenan to PPC for the formation of mixed gels results in gels with higher gel strength and greater stiffness than in equivalent gels made with SPC. The gels made with PPC are also less sensitive to pH than gels made with SPC. Application of modified Takanayagi models to oscillatory data indicated a shift

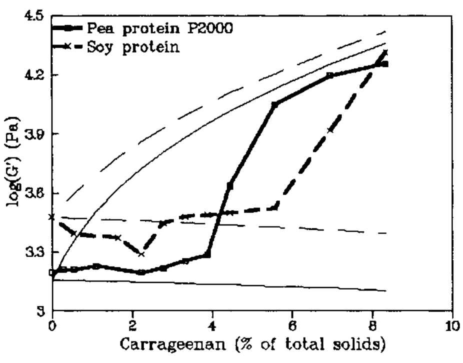

Figure 3. Elastic modulus (G´) measured at 5 Hz and 0.5% amplitude for mixed gels made from soy or pea protein concentrate and κ-carrageenan. Thin lines represent upper (isostrain) and lower (isostress) boundary for p=4 (n=3).

in the continuous phase from protein to κ-carrageenan at concentrations from 4-8% κ-carrageenan in the total solids. This shift occurs at lower concentrations when pea protein concentrate is used.

FURTHER WORK

We are at present investigating the applications of the present mixed systems in meat batters, as well as analyzing the microstructure.

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