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Thermal gelation of whey protein at different pH values

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Gelation is an important functional property of whey proteins. Their ability to form heat induced gels and provide appropriate texture is determined by its molecular structure (primary, secondary, tertiary, quaternary), interactions with other components (salts, acids, urea) and processing conditions (pH, ionic strength, heating temperature, heating and cooling rate).
The objective of this work was to define gel texture changes of whey protein isolates (WPI) at various pH values in function of following processing operations: tribomechanical activation and enzymatic hydrolysis.
Whey protein gels were prepared by heating dispersions of two commercial powdered whey protein isolates before and after tribomechanical activation and enzymatic hydrolysis, respectively. The results obtained showed that tribomechanical activation as well as enzymatic hydrolysis influenced the gelation ability. Texture of gels was affected by pH. Gels prepared at pH 3 showed higher hardness than gels at pH 7.
This work suggests that desired modification of gel texture can be achieved in order to enhance the suitability of WPI for incorporation into various processed and formulated food products.

1. Introduction

Whey is liquid by-product of the cheese making process which can be further processed into spray dried products like for instance whey protein concentrates (WPC), whey protein isolates (WPI) or whey protein hydrolysates (WPH)). Characteristics of different types of whey protein powder available on the market are related to the chemical composition and processing technique. Whey proteins are widely used as important ingredients in different foods (dairy, meat and bakery products) due to their unique nutritional and functional properties. Processing steps can alter the characteristics of whey protein products which can result in the modification of whey protein structure and functionality (i.e. foaming, emulsification, gelation).
The two major whey proteins are β-lactoglobulin (β-lg) and α-lactalbumin (α-lac). β-lactoglobulin is primary gelling agent while α-lactalbumin has got good emulsifying properties. (Gezimati et al., 1997; Rojas et al., 1997).The gelling properties of thermally induced gels are influenced by concentration, heating rate, extent of denaturation, ionic strength, pH and the presence of specific ions.

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Gelation is generated by the action of heat, pressure and by divalent cations (Schmidt, 1984.). Most protein gels are prepared by heating. Thermal gelation of whey proteins is a two step mechanism. First step involves an initial denaturation-unfolding of whey protein molecules, followed by rearrangements and aggregation of functional groups which become available for intermolecular interactions under appropriate conditions, resulting in a three-dimensional gel network (Krešić et al., 2008). This phenomenon is important in food industry due to strong effect on rheological and textural properties of food.

2. Materials and methods

In this work research was conducted with whey protein isolate BiPRO (Manufacturer: Davisco Foods International, Le Suer, SAD), whey protein isolate RT-90 (Manufacturer: Main Street Ingredients, La Crosse, SAD), commercial whey protein hydrolysate BioZate 5 (Manufacturer: Davisco Foods International, Le Suer, SAD) and commercial whey protein hydrolysate RT-80 as well (Manufacturer: Main Street Ingredients, La Crosse, SAD). Chemical composition of each sample was declared by manufacturer and is presented in table 1.

Table 1: Chemical composition of whey protein isolates and whey protein hydrolysates

Sample	Protein (%)	Lactose (%)	Fat (%)	Water (%)	Ash (%)
Whey protein isolate BiPRO	92,0	1,0	0,3	5,0	2,0
Whey protein isolate RT-90	90,0	0,8	0,5	4,2	2,5
Whey protein hydrolysate Biozate 5	90,0	0,1	0,5	5,0	4,5
Whey protein hydrolysate RT-80	81,0	5,0	6,0	4,0	4,0

Tribomechanical activation

Samples were treated in the laboratory using the equipment devised for tribomechanical activation (figure 1).The treatment was carried out at rotor speed 44 000 r.p.m. and at ambient temperature. TMA equipment is made up of housing and two rotor disks.The disks rotate in opposite directions at the same angular rate. The particles are accelerated and, because of the repeated change of direction of motion, are in constant collision, which causes friction in short time intervals (less than 0.001 s).

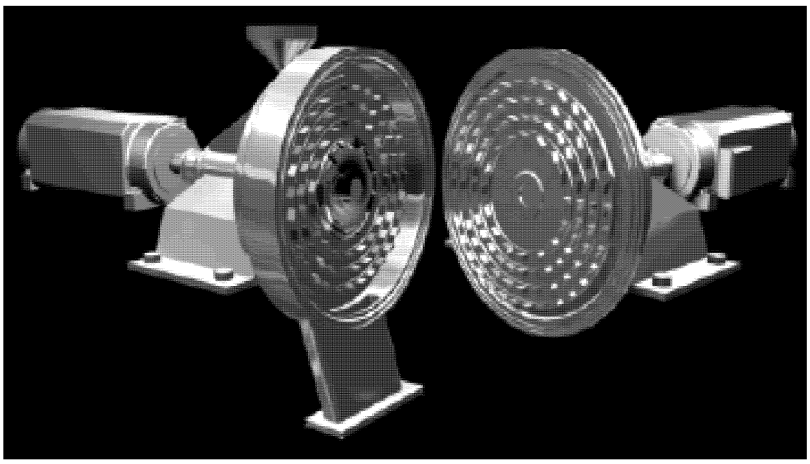

Figure 1. Laboratory equipment for tribomechanical activation (Herceg et al., 2004a)

Gel preparation

Whey protein solutions were prepared by dissolution of the powder in deionised distilled water and stirring with a magnetic stirrer for 90 min at room temperature in beakers at a concentration of 10wt%. The pH of the solutions was adjusted using 1 N HCl and 1 N NaOH. Beakers were placed in a water bath heated at 80˚C for 30 minutes. After the heat treatment, the solutions were rapidly cooled to 10˚C in an ice bath and stored in a refrigerator overnight. Gels were placed at room temperature 2h before texture analysis.

Gel texture properties

Gel texture parameters were determined by a Texture analyzer HD+ (Stable Micro System, UK). The gels were penetrated with a xx-mm diameter cylinder probe. A force-time curve was obtained at a crosshead speed of 0.5 mm/s. Hardness at fracture was determined from the texture analysis of the gels.

3. Results and discussion

The whey proteins are compact globular proteins with a relatively uniform distribution of a chain of polar (hydrophobic), non-polar (neutral) and uncharged and charged remains of amino acids. The wrinkled intramolecular structure of these proteins is a result of the disulfide bonds (S–S) between the remains of cisteine inside the molecules, mainly covered with hydrophobic remains (Tratnik, 1998). During tribomechanical treatment of the whey proteins, the protein globules were mechanically divided, producing a larger number of protein fragments and peptides (Herceg et al., 2004b).

During hydrolysis proteins are broken down into peptides of different sizes and free amino acids, Consequently, the extent of the interactions amongst the exposed functional groups of whey proteins after tribomechanical treatment and enzymatic hydrolysis increases. This interactions are responsible for the network strength.
Also, an important factor in the gelation process of whey proteins and characteristics of the obtained gels is pH. Namely, pH affects the net charge carried by the protein.
Textural properties of gels obtained by heating (80˚C/30 min) of 10% solutions of whey protein isolates with different pH values (3,0; 7,0 i 9,0) are presented in figures 2-5. At pH value 3 the harder gels were formed in compliance with gels at pH 7. However, at pH values 7 harder gels were formed by hydrolisates, and with pH value 3 substantially greater hardness of the gels were prove to be from untreated proteins. No gels formation was established at pH 9.

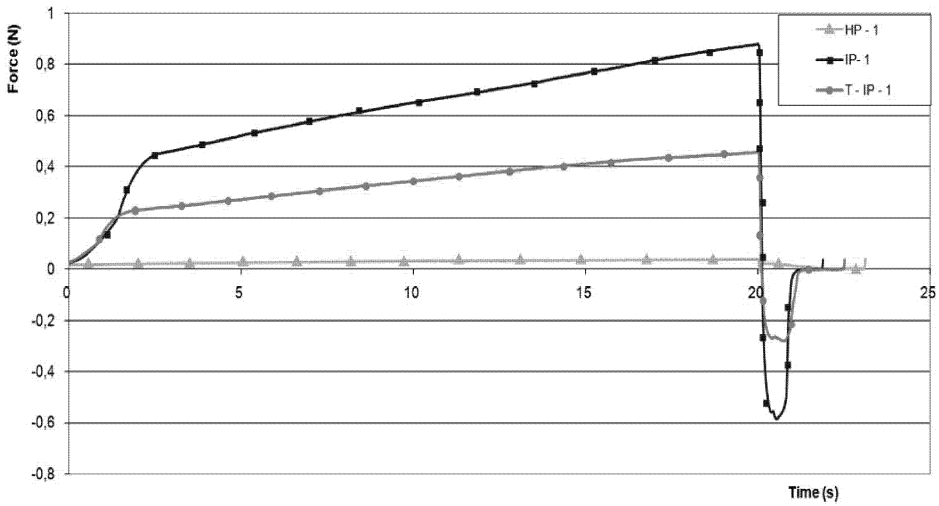

Figure 2. Hardness of treated and untreated whey isolate protein gels Bipro at pH 3

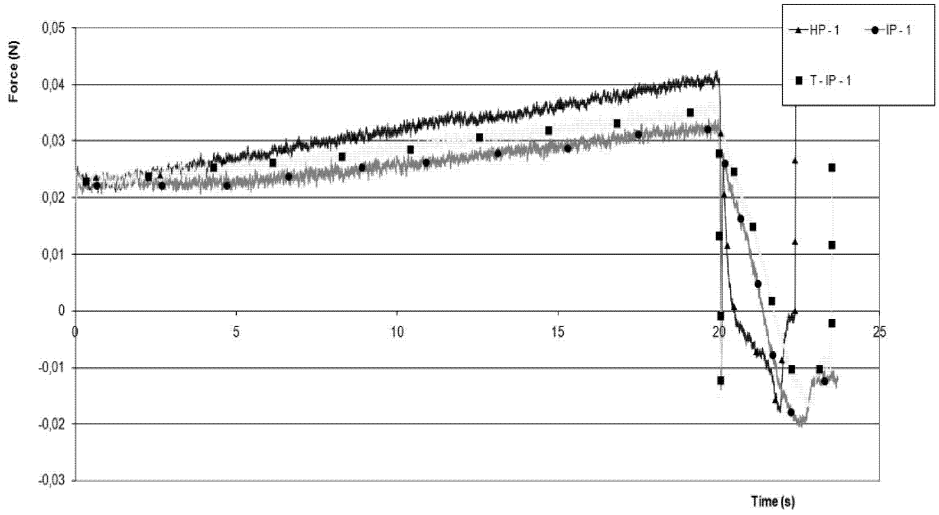

Figure 3. Hardness of treated and untreated whey isolate protein gels Bipro at pH 7

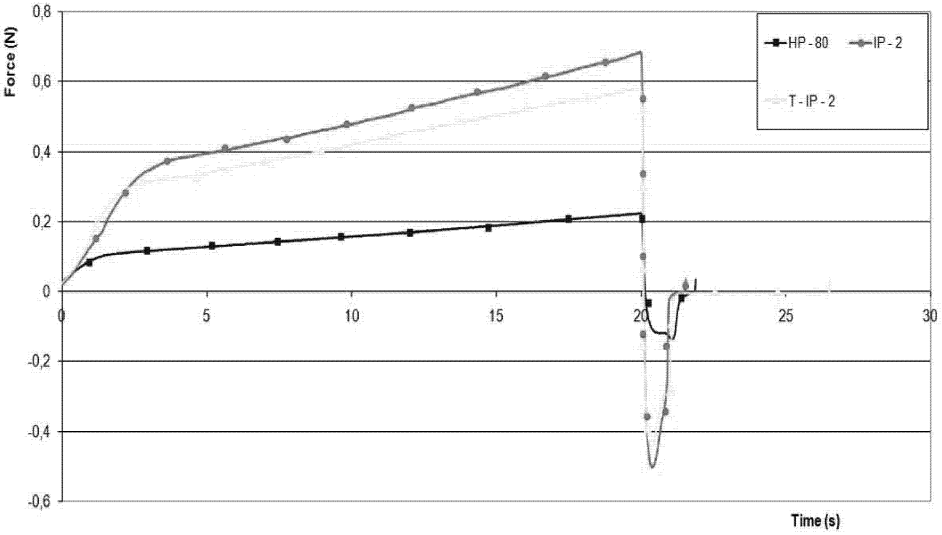

Figure 4. Hardness of treated and untreated whey isolate protein gels RT at pH 3

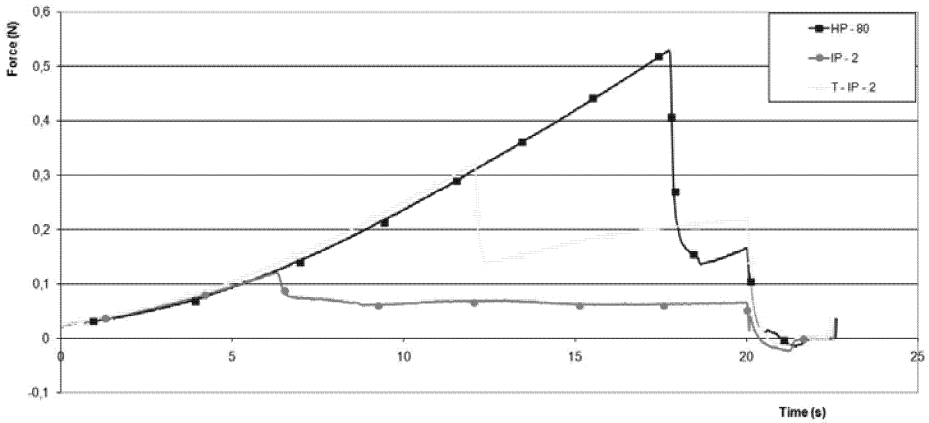

Figure 5. Hardness of treated and untreated whey isolate protein gels RT at pH 7

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