Effects of processing conditions of high hydrostatic pressure (HHP) on gelling abilities and properties of inulin - soy protein hydrogels

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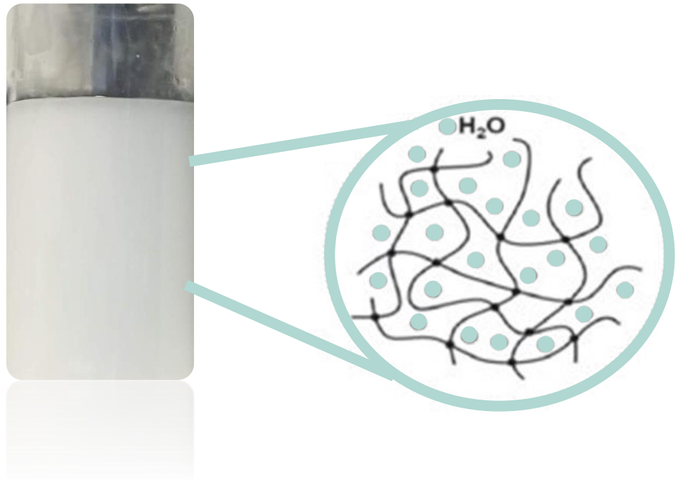
Introduction

- Hydrogels are materials with a three-dimensional hydrophilic network formed by polymer chains, and a large amount of water is bound inside this structure [1].
- They can consist of synthetic or natural polymers, of which hydrogels based on natural polymers are preferred for safety in the medicine and food industry [2].
- Currently, polysaccharide-protein hydrogels are very popular, most often consisting of polysaccharides such as starch, pectin or guar gum, and of plant or animal proteins [3].



Introduction

- It has been proven that the induction method can affect the properties of hydrogels, giving new possibilities for their use [4].
- In the literature, the high hydrostatic pressures (HHP) induction is mentioned among the most prospective methods of obtaining one – polimer gels [4;5].
- **That is why the aim of the research was to determine the effect of processing conditions of high hydrostatic pressure (HHP) on gelling abilities and properties of inulin - soy protein hydrogels.**

Materials and Method

Materials

- The induced gels consisted of 20% inulin (INU; Inulin HPX Beneo, ORAFTI) and 1% or 6% soy protein isolate (SPI; MyProtein).

Preparations

- The pressure treatments were 150, 300 and 500 MPa for 5, 10 and 20 minutes.

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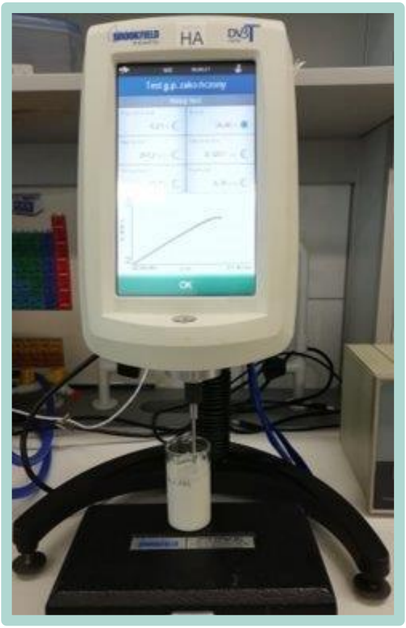
Methods



Volumetric gel index (VGI)

Yield stress – rheometer (DV3T, Brookfield, Middleboro, MA, USA)

Textural Properties – texture analyzer (TA.XT Plus, Stable Micro Mixtures, Surrey, UK)

Multi-speckle diffusing-wave spectroscopy method (MS-DWS) - Rheolaser Master device (Formulaction, Toulouse, France)

Centrifugal stability analysis method (CSA) – LUMiSizer 6120-75 (L.U.M. GmbH, Berlin, Germany)

Color parameters – Minolta CR-400 colorimeter (Minolta, Japan)

Materials and Method

Methods

- **Volumetric gel index (VGI)**, express the degree of gel formation as the volume of over the total volume. If there was no gel formed, VGI of the system would be 0; VGI would be between 0 and 100% for partial gel formation.
- **Yield stress [Pa]**, rheometer (DV3T, Brookfield, Middleboro, MA, USA) vane spindle V74 with a torque range HA; parameters: the rotation speed was adjusted to rise by 0.10 RMP continuously until the gel structure reached its flow limit.

Materials and Method

Methods

- **Textural Properties**, texture analyzer (TA.XT Plus, Stable Micro Mixtures, Surrey, UK), equipped with a 0.5 cm diameter cylindrical flat probe (P/0.5R) to measure the hydrogels **firmness** (N) (parametres: speed 1.0 mm/s, penetration depth - 8 mm); equipped with the TTC Spreadability Rig measure the hydrogels **spreadability** (Ns).
- **Color parameters**, Minolta CR-400 colorimeter (Minolta, Japan; light source D65, and a measuring head hole of 8 mm). The color components in the CIEL*a*b* system.

Materials and Method

Methods

- **Centrifugal stability analysis method (CSA)**, LUMiSizer 6120-75 (L.U.M. GmbH, Berlin, Germany), parameters: wavelength 870 nm, volume 1,8 mL of the dispersion; light factor: 1; 1500 rpm; experiment time: 15 h 10 min; interval time 210 s; temperature 20 °C.
- **Multi-speckle diffusing-wave spectroscopy method (MS-DWS)**, Rheolaser Master device (Formulaction, Toulouse, France), parameters: samples, placed in glass vials 20 ml, wavelength 650 nm, time 23h, temperature 22 ± 1 ℃.

Materials and Method

Statistical Analysis

- The gathered data from three independent, experimental repetitions were statistically evaluated using the Statistica 13.3 (TIBCO Software Inc. Palo Alto, CA, USA) software. A one-way analysis of variance was performed to assess the significance of differences in the average values of measured parameters of inulin – soy protein hydrogels. Tukey's test at a significant level $\alpha = 0.05$ revealed significant differences between hydrogels obtained in different induction parameters and soy protein concentration.

Funding

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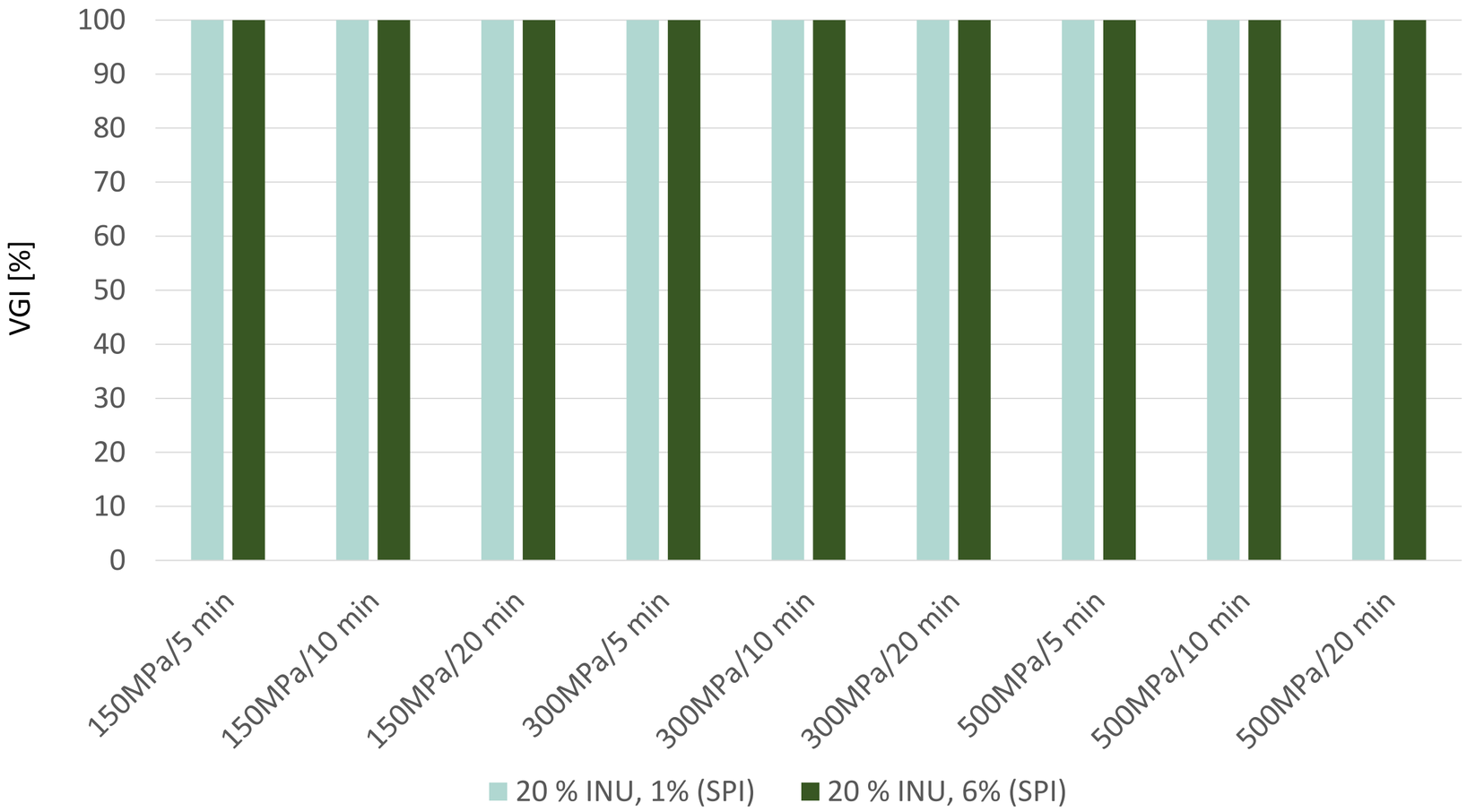
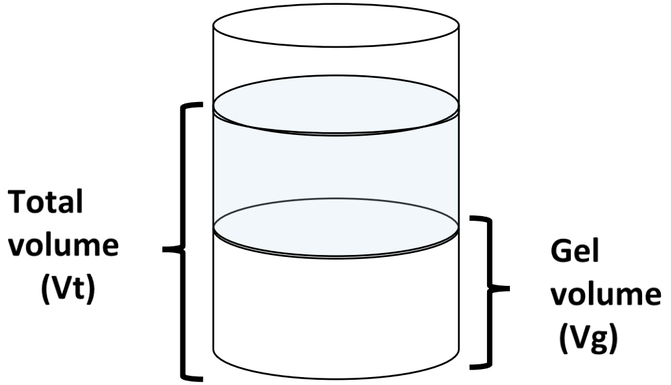
Results

Volumetric gel index



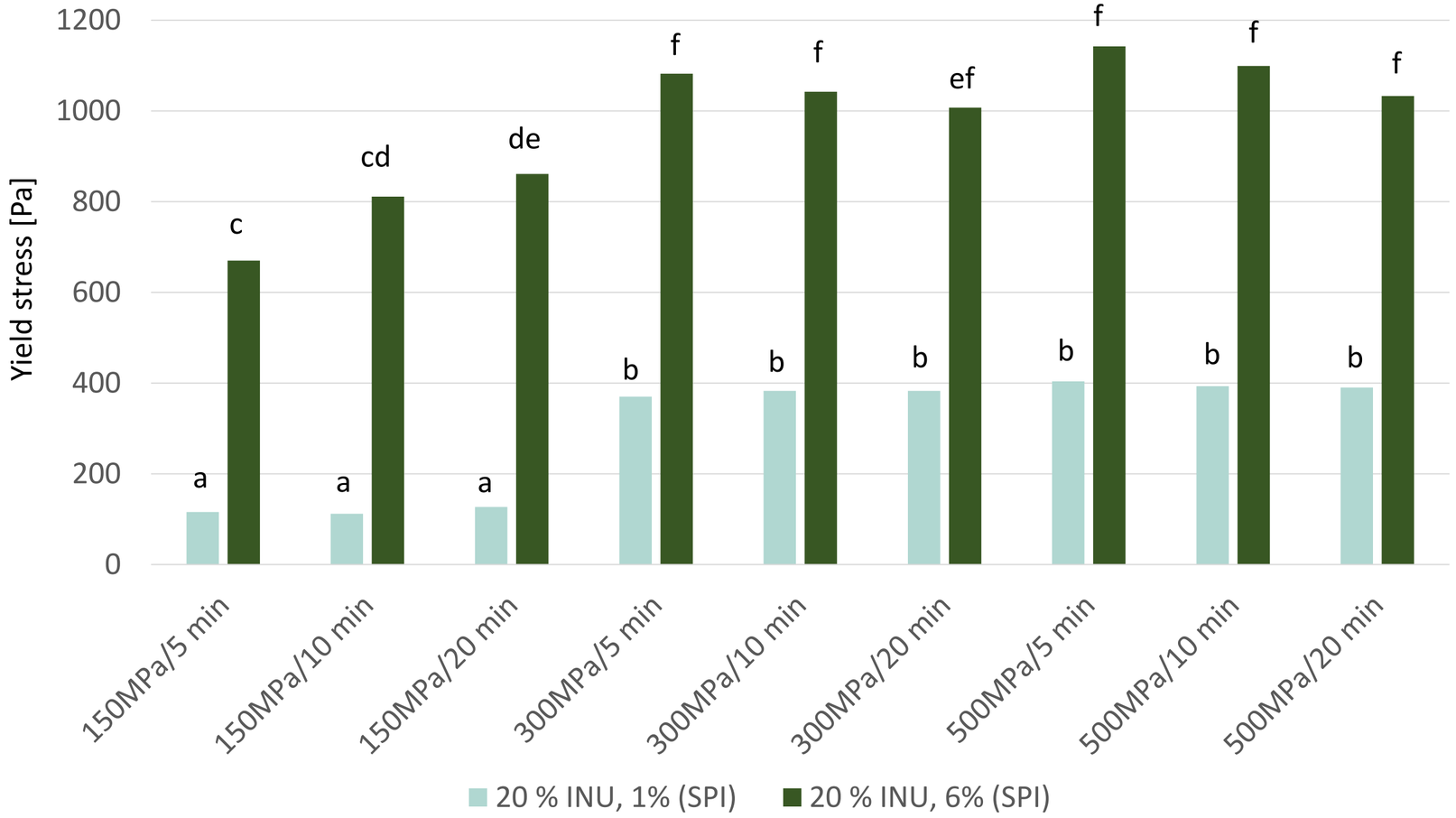


$$\mathbf{VGI} = \frac{\boldsymbol{Vg}}{\boldsymbol{Vt}}$$

Inulin-soy protein hydrogels can be formed by the high hydrostatic pressures (HHP) induction, regardless of the pressure applied (150, 300, 500 MPa) and time of induction (5, 10, 20 min.).

Results

Yield stress [Pa]

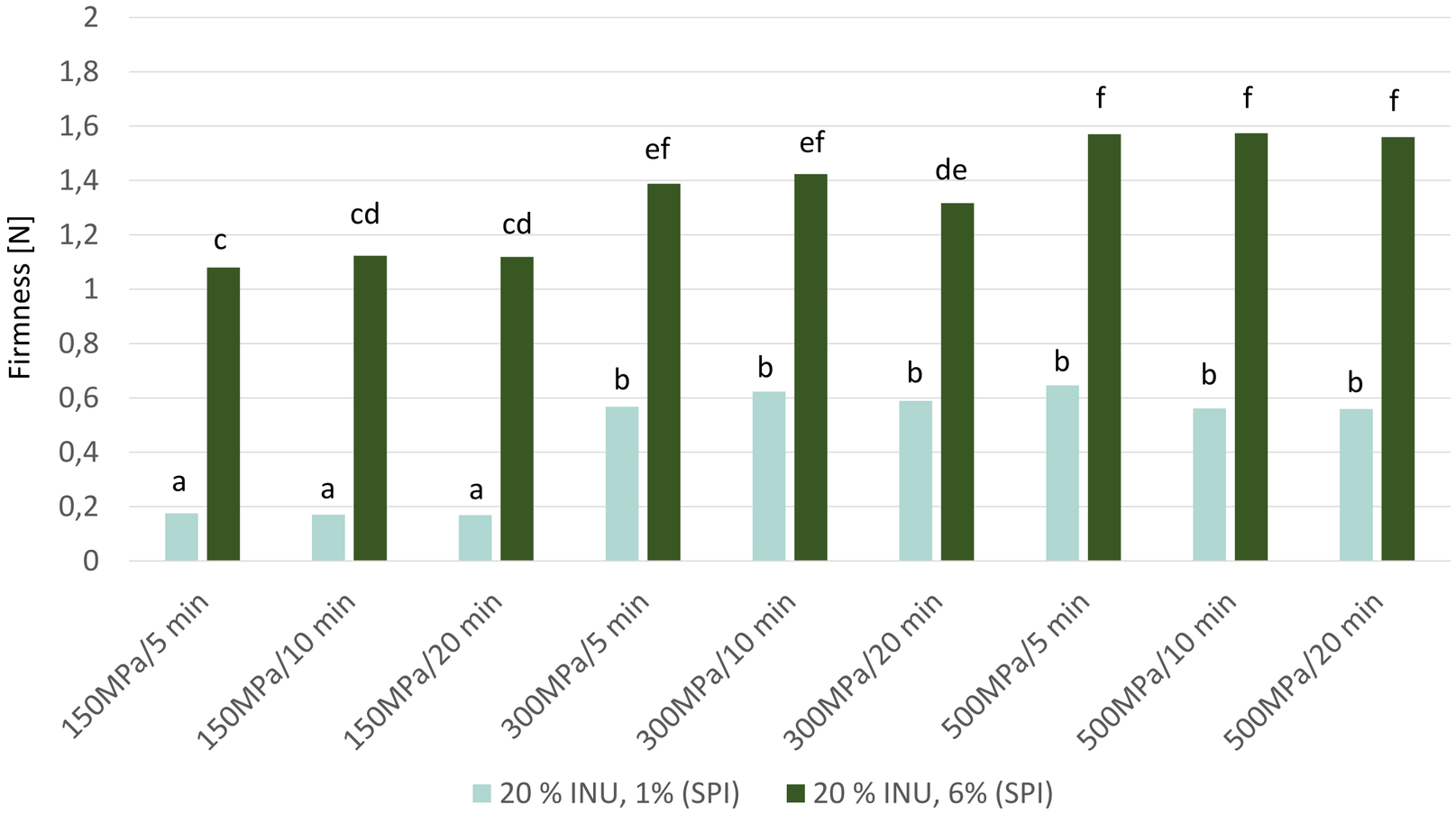


The induction of high pressure gelation had an effect on the yield stress regardless of the protein concentration used. This influence is visible especially in the case of higher values of applied pressures - 300 and 500 MPa, where the yield stress of inulin hydrogels increases.

Additionally, despite the 20% INU, 6% SPI samples, the induction time had no influecne on the yield stress of the hydrogels.

Results

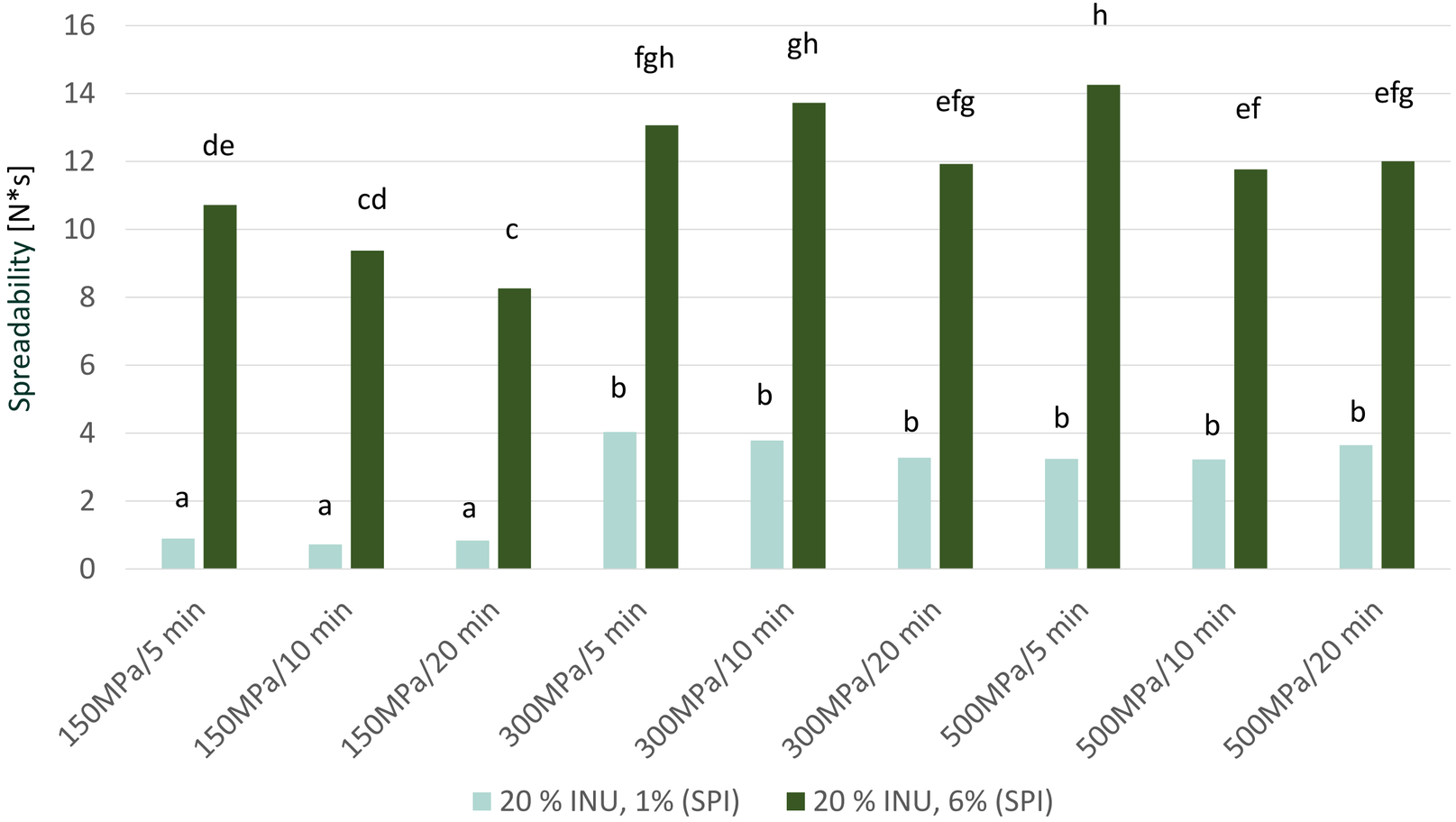
Textural Properties - firmness



The use of higher pressures for induction of inulin-soy protein gels - 300 and 500 MPa, makes the obtained gels harder, regardless of the protein concentration used. It was also found that the induction time had no effect on the firmness of the hydrogels.

Results

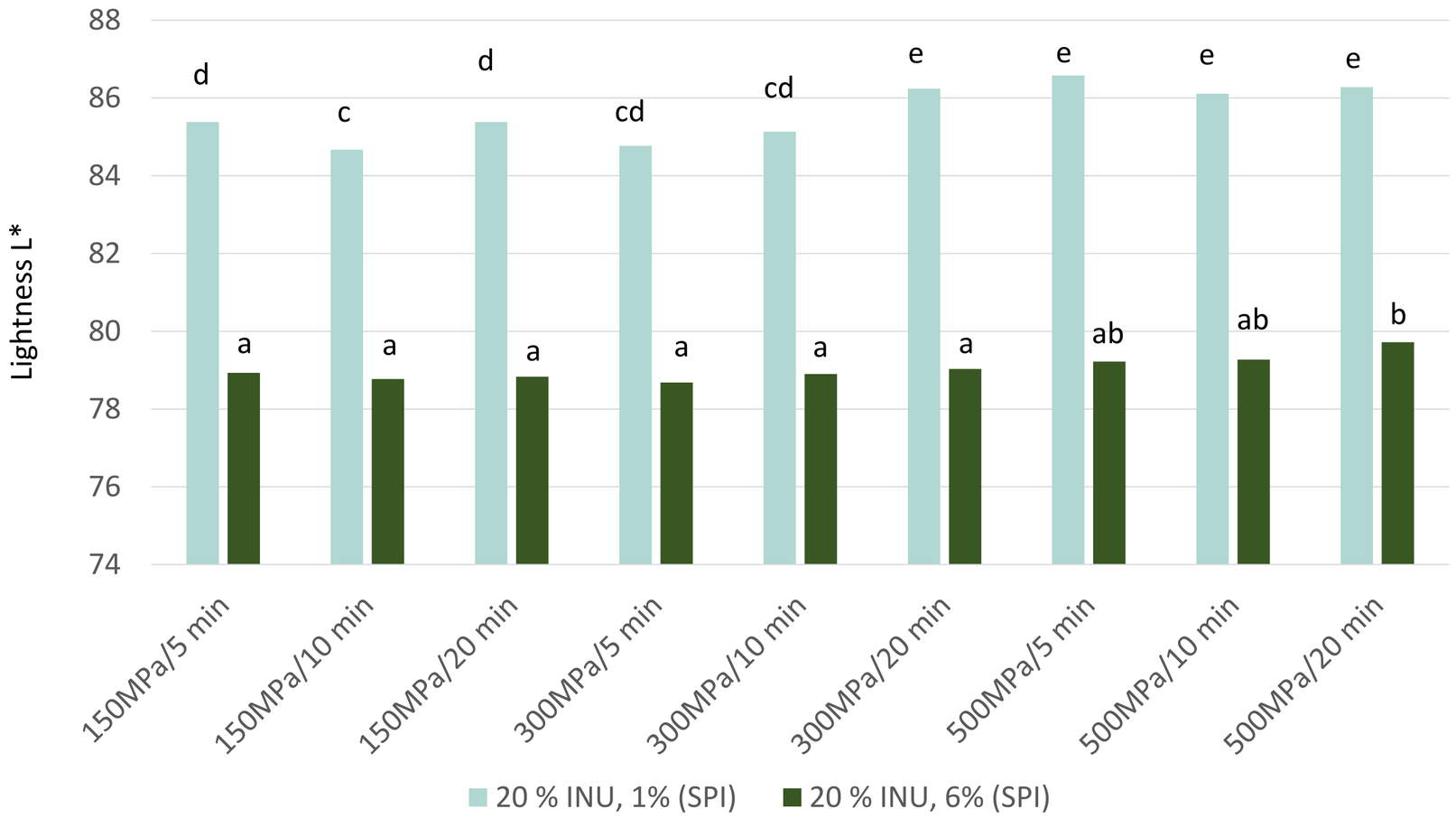
Textural Properties – spreadability [Ns]



It has been observed that higher pressures (300 MPa and above) make inulin-soy protein hydrogels more difficult to spread, regardless of the protein concentration used. Generally, at lower SPI concnetration, no influence of the HHP induction time was observed, and at higher SPI concetration (6%), extendending the induction time from 5 to 20 min results in more spreadable gels.

Results

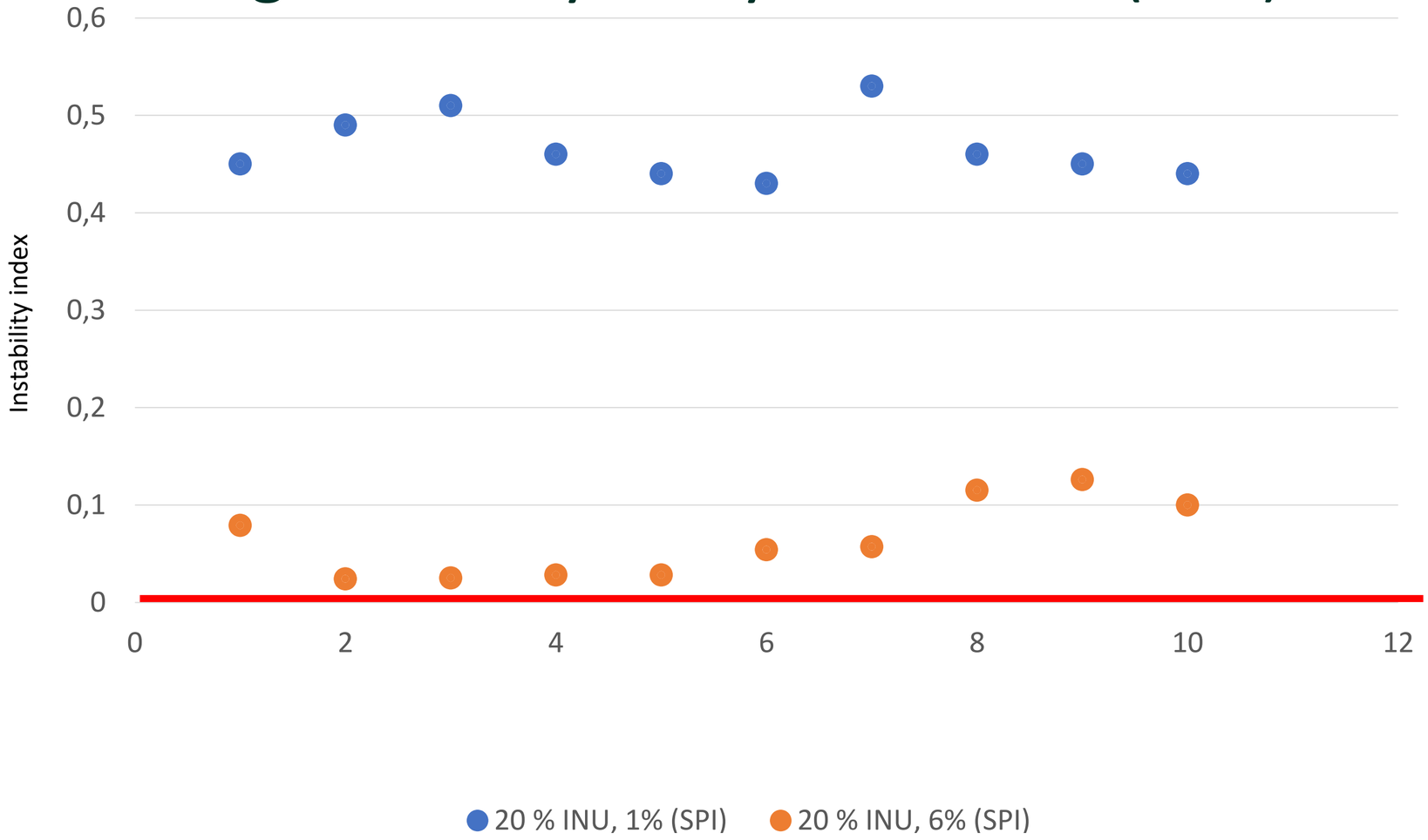
Lightness L*

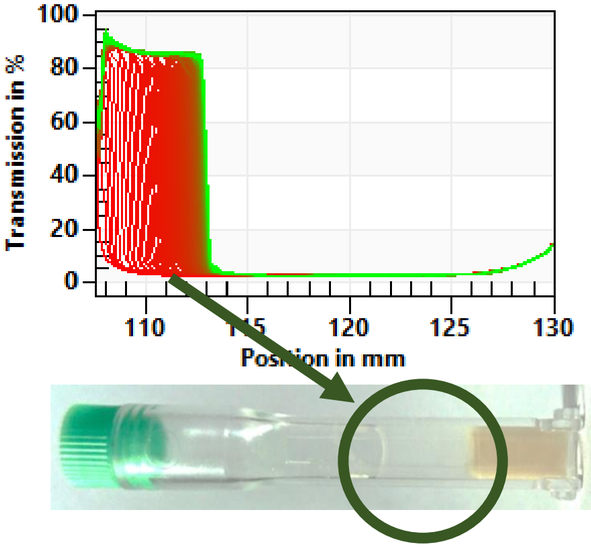


Comparing the obtained samples in terms of their lighteness, a slight brightening of the samples was found when applying the highest pressure values (500 MPa) or the longest time of induction.

Results

Centrifugal stability analysis method (CSA)



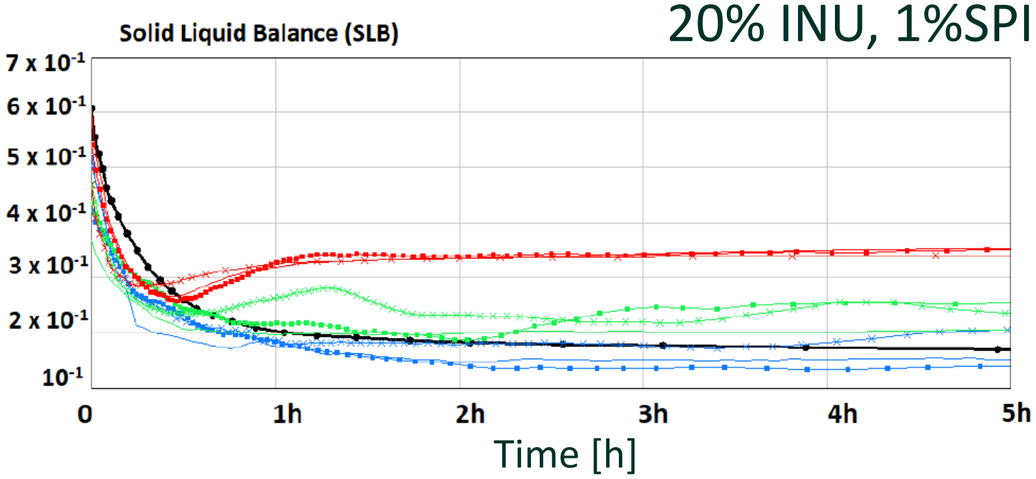


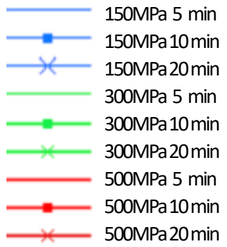
It was found that the stability of the tested inulin-soy protein hydrogels was mainly influenced by the protein concentration, while gels containing 6% of proteins were more stable, regardless of induction parameters.

Results

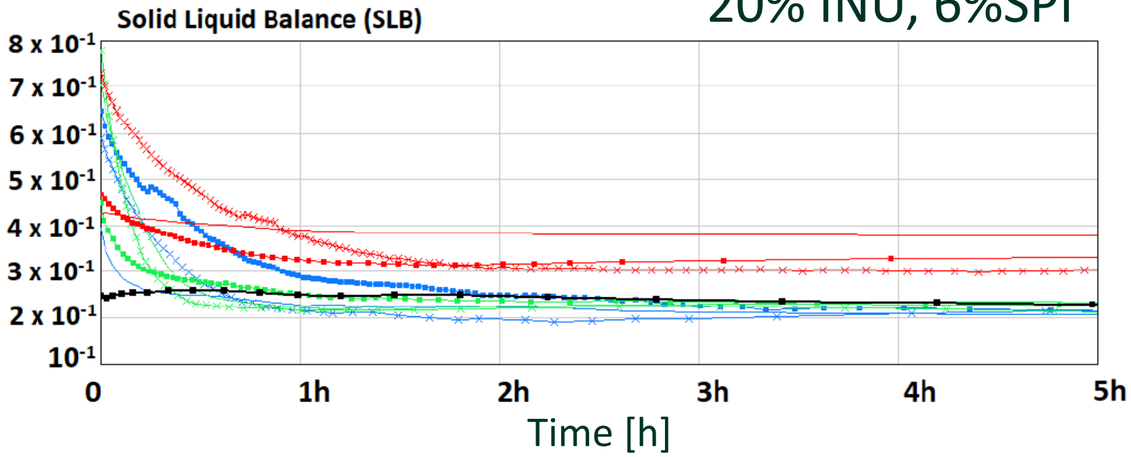
Solid Liquid Balance

20% INU, 1%SPI





20% INU, 6%SPI



Solid Liquid Balance (SLB) gives indications of how the ratio of liquid-solid behavior changes over time. As the gelling process began to take place in the chamber of the high pressure device, low SLB values are observed. However, significant changes in the structure of the samples were still observed in the first hour of the test, during which gel formation occurred (SLB <0.5) [6].

Conclusions

- Using the high pressure technique it is possible to induce inulin-soy protein hydrogels.
- By modifying the HHP induction parameters, especially the pressure applied, it is possible to obtain inulin - soy protein hydrogels with different properties. For example, by using higher pressures for the induction of hydrogels (300 and 500 MPa), gels with higher yield stress, firmness and spreadabilty values can be obtained.
- The pressurization parameters did not affect the stability of inulin-soybean protein hydrogels.

References

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