Assessment of the physicochemical and textural properties of food hydrogels obtained using pea protein and gellan gum

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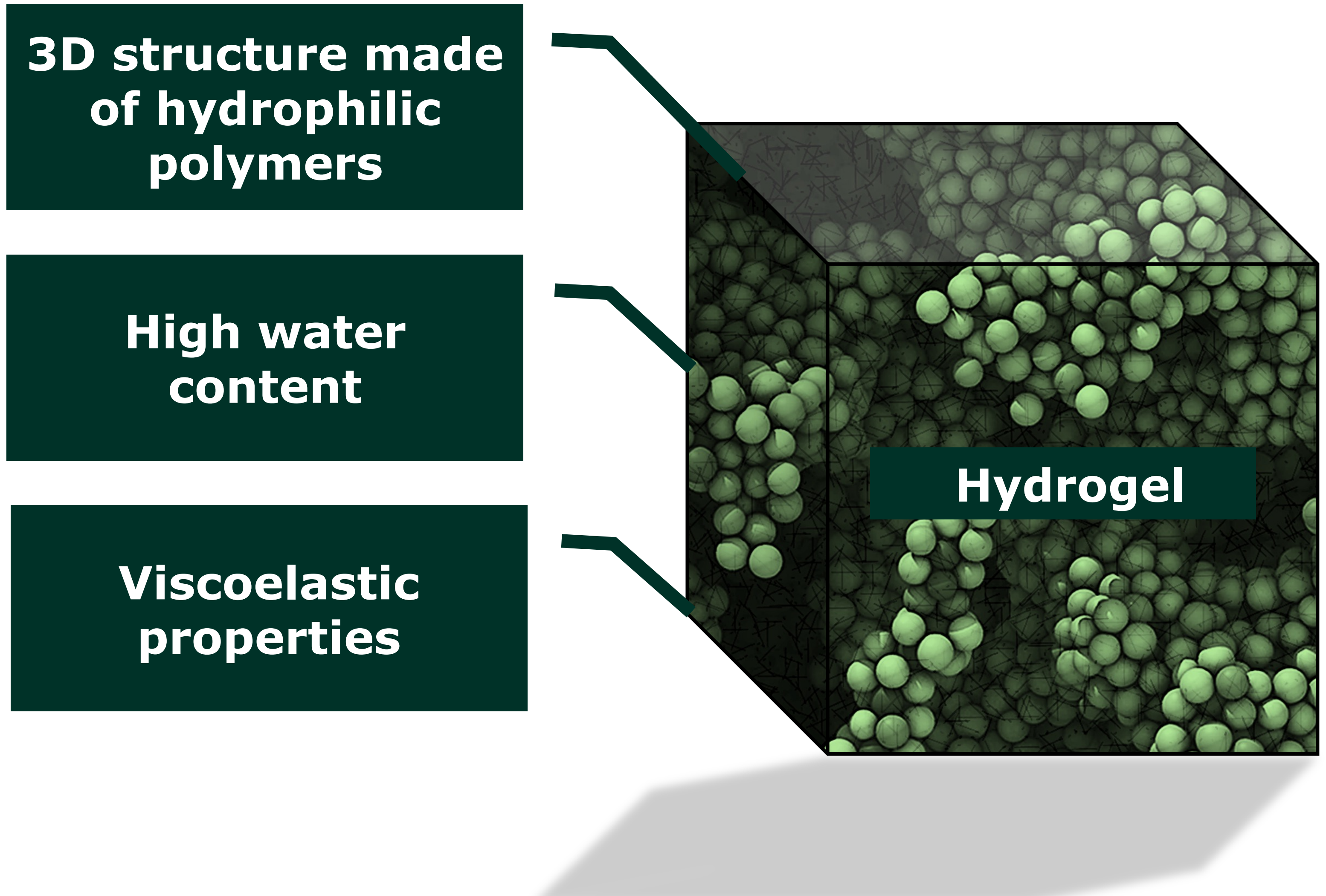
Introduction

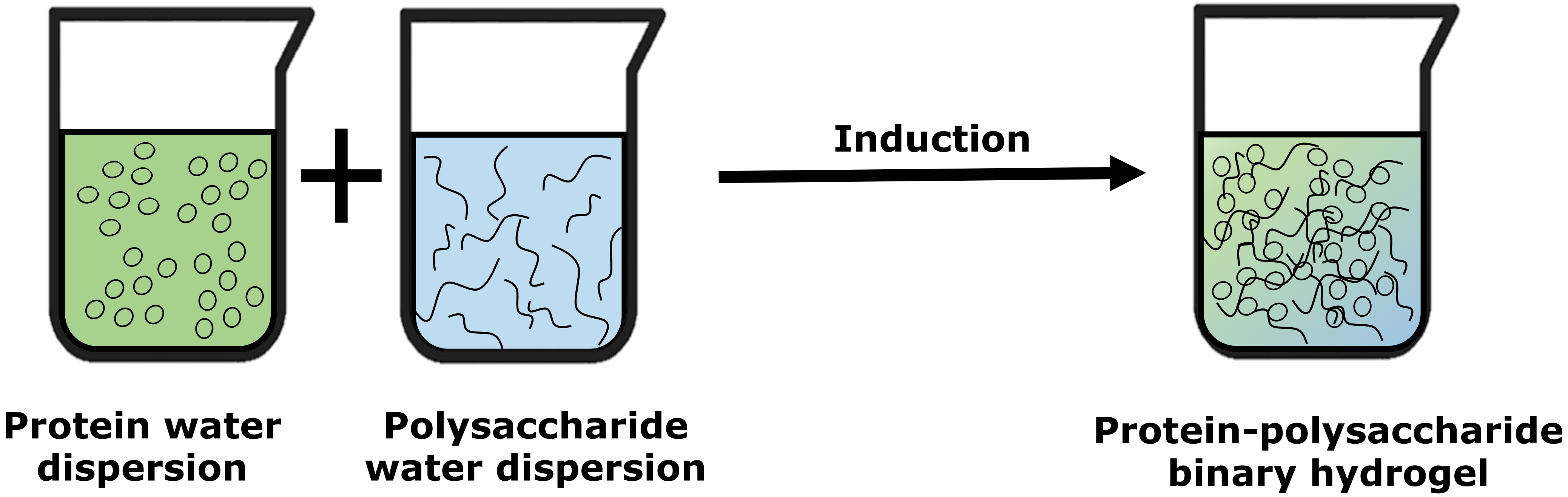
What is a hydrogel?

A material with tunable properties that can meet specific requirements for different applications in several sectors.

Food-grade hydrogel’s building blocks are naturally sourced biopolymers:

- ✦ **Proteins**
- ✦ **Polysaccharides**





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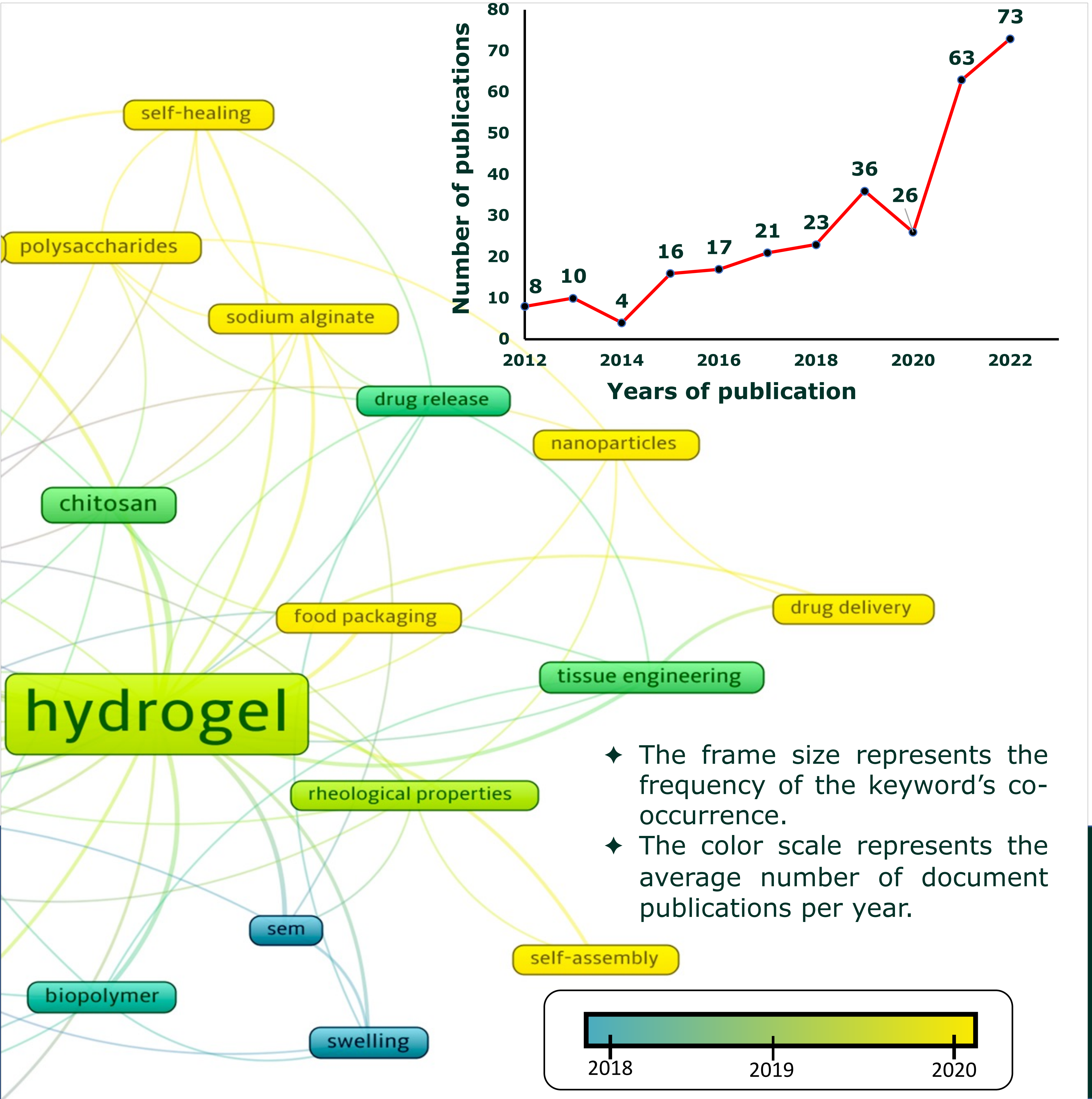
Introduction

The recent state of knowledge on the topic of food hydrogels



- ✦ The frame size represents the frequency of the keyword’s co-occurrence.
- ✦ The color scale represents the average number of document publications per year.

Importance of food hydrogels in food development

The main reasons

Due to COVID-19, people are now more concerned about their health and the environment surrounding them.

Plant-based and hybrid foods offer a new way to ensure healthy nutrition for all while protecting our natural resources.

Plant-based ingredients might not provide all the necessary nutrients - increasing interest in fortifying the end-products.

Focus on achieving the desired appearance, texture (mouthfeel), and flavor.

References

- ✦ Hilal, A.; Florowska, A.; Wroniak, M. Binary Hydrogels: Induction Methods and Recent Application Progress as Food Matrices for Bioactive Compounds Delivery—A Bibliometric Review. Gels 2023, 9, 68. https://doi.org/10.3390/gels9010068
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Research objective and scope

The aim of this research was to evaluate the physicochemical and textural properties of food hydrogels produced using pea protein and gellan gum.

The scope of this research included

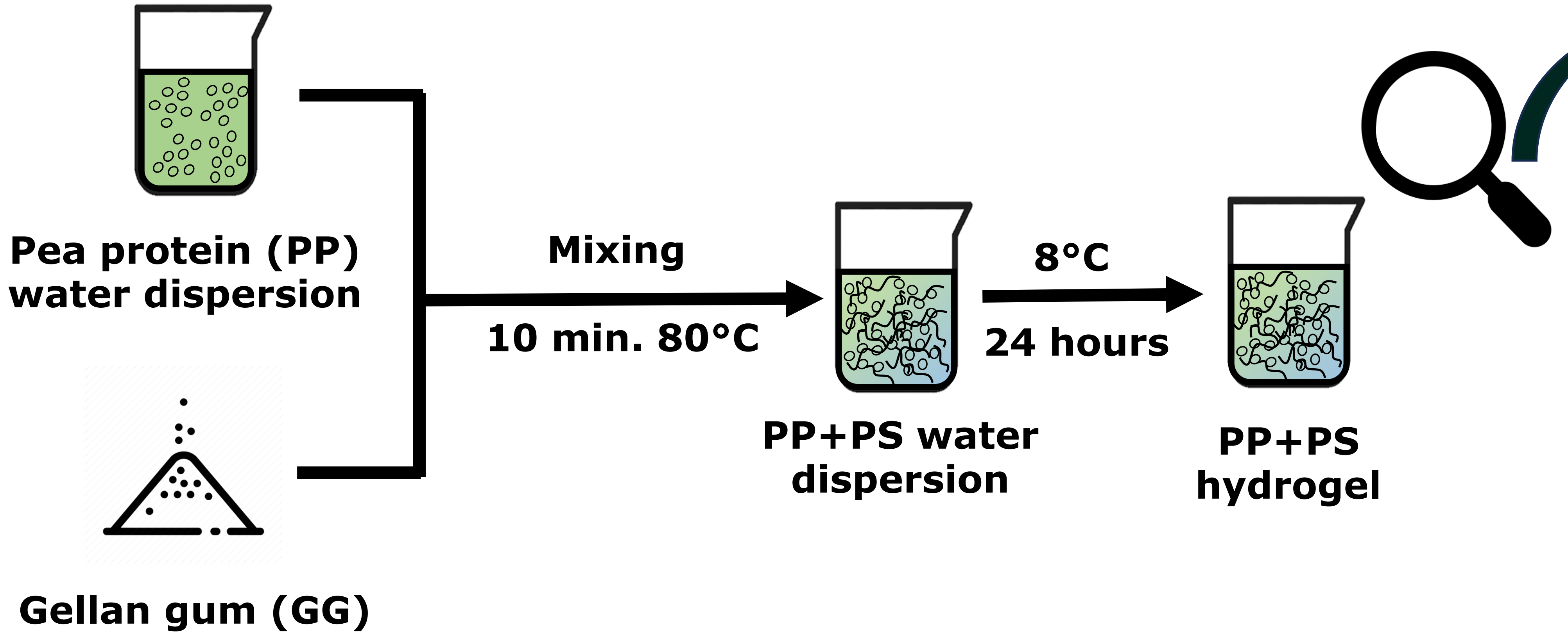
- Obtaining pea protein-gellan hydrogels (containing pea protein (PP) concentration 0, 10, and 12.5% and gellan gum (GG) concentration 0, 0.5 and 0.75%) using a thermo-mechanical induction technique.

- Analyzing the obtained hydrogels in terms of their volumetric gelling index, microrheology, texture, physical stability, and color parameters.

Materials and methods

Materials

- ✦ Pea protein NUTRALYS® F85F (**PP**, protein content 84%) provided by Roquette Frères (Lestrem, France),
- ✦ Gellan gum (**GG**, high acyl Type 900, particle size: min. 95% mesh through 80 mesh) provided by C.E. Roeper GmbH (Hamburg, Germany).



The explanation of the samples coding

Samples code	Pea protein (PP) [%]	Gellan gum (GG) [%]
C1	10	0
C2	12.5	0
C3	0	0.5
C4	0	0.75
H1	10	0.5
H2	10	0.75
H3	12.5	0.5
H4	12.5	0.75

Methods

1) Volumetric gelling index (VGI)
2) Microrheological properties - Rheolaser Master device (Formulaction, L'Union, France)
3) Textural Properties - texture analyzer (TA.XT Plus, Stable Micro Mixtures, Surrey, UK)
4) Physical stability - LUMiSizer 6120-75 (L.U.M. GmbH, Berlin, Germany)
5) Color parameters in the CIE system (L*, a*, b*) – Minolta CR-200 colorimeter (Minolta, Japan)
6) statistical analysis – one-way ANOVA, PCA and HCA (Statistica 13.3, TIBCO Software Inc., Palo Alto, CA, USA)

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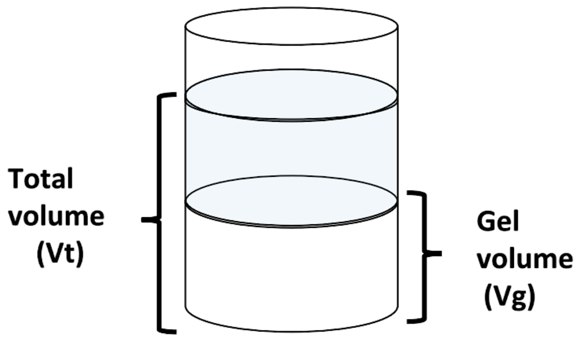
Results

1) Volumetric gelling index (VGI)

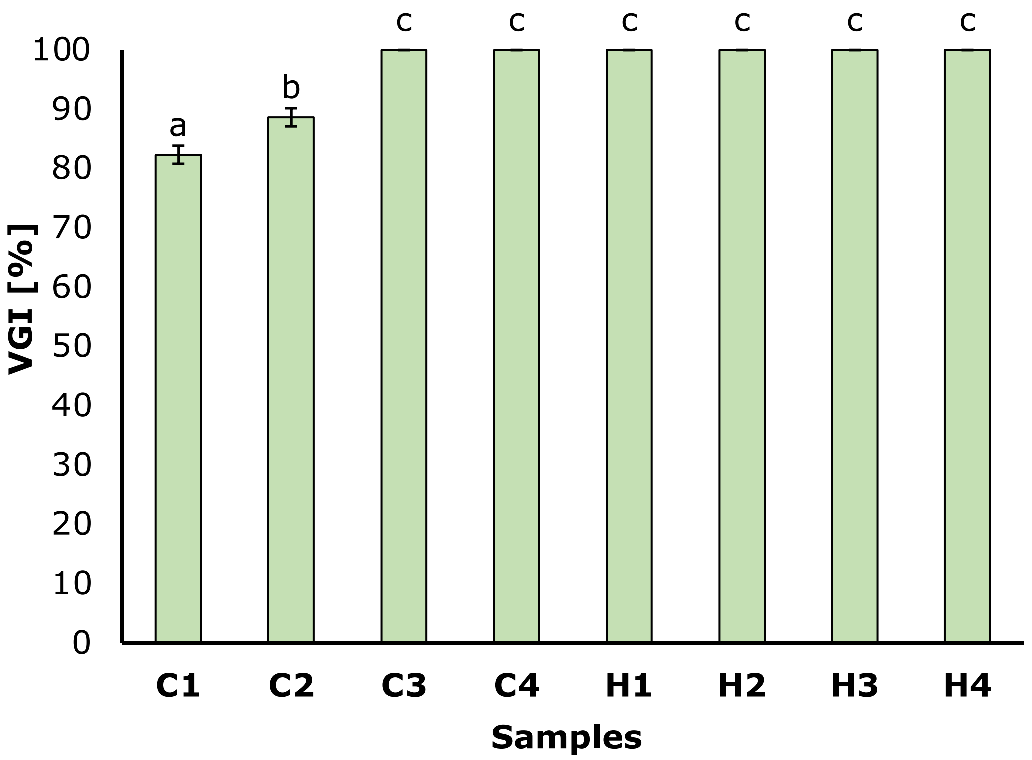


✦ VGI is a parameter that expresses a gel structure capacity to develop. VGI is equivalent to 0% when the gel structure is not formed, and it is equal to 100% when the sample is entirely gelled.

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

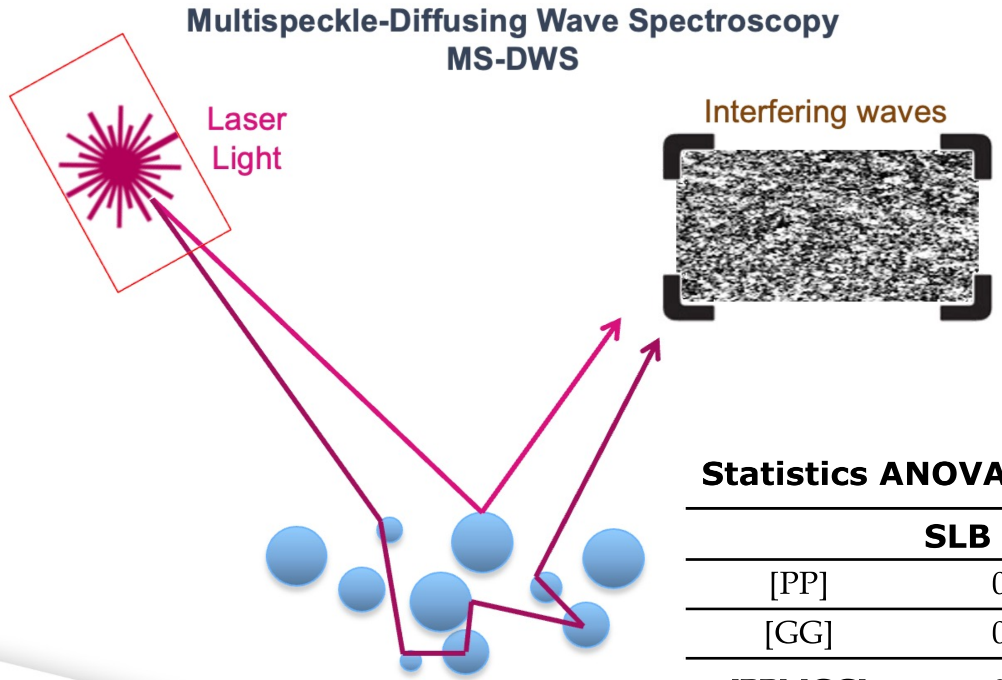
Statistics ANOVA, η2 [-]

	VGI [%]
[PP]	0.682
[GG]	ns
[PP]·[GG]	0.811



Example of an inverted vial containing the experimental combination H4 (12.5% PP and 0.75% GG)

2) Microrheological properties - Rheolaser Master device

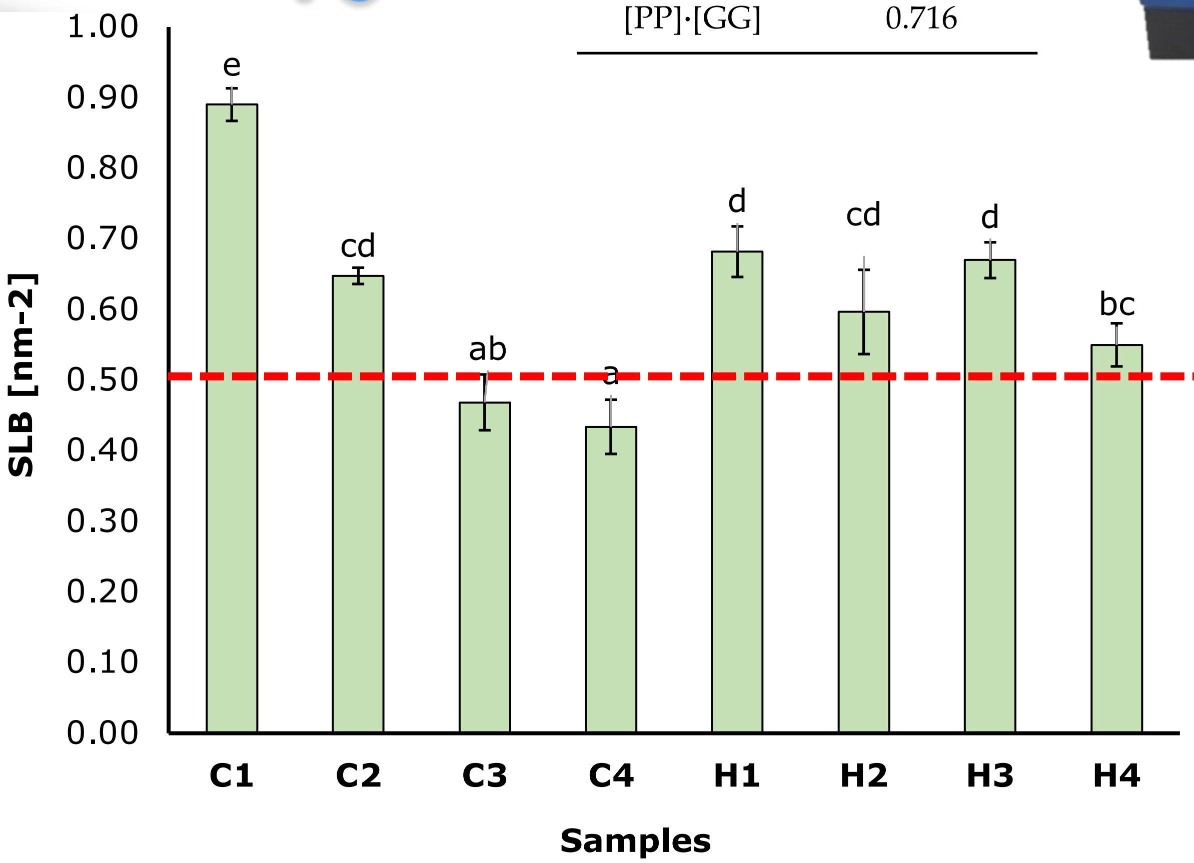


Solid-liquid balance (SLB)

✦ SLB is proportional to the viscoelastic properties of the studied sample. SLB is related to the following functional characteristics: adhesion, shape stability, texture, spreadability, and physical stability.

Statistics ANOVA, η2 [-]

	SLB [nm-2]
[PP]	0.692
[GG]	0.587
[PP]·[GG]	0.716



SLB > 0.5 → G' < G"
The samples exhibited typical liquid-like (viscous) behavior

SLB = 0.5 → G'=G"

SLB < 0.5 → G' > G"
The samples exhibited typical solid-like (elastic) behavior

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✦ Florowska, A., Hilal, A., Florowski, T., Mrozek, P., & Wroniak, M. (2022). Sodium Alginate and Chitosan as Components Modifying the Properties of Inulin Hydrogels. *Gels*, *8*(1), 63. https://doi.org/10.3390/gels8010063

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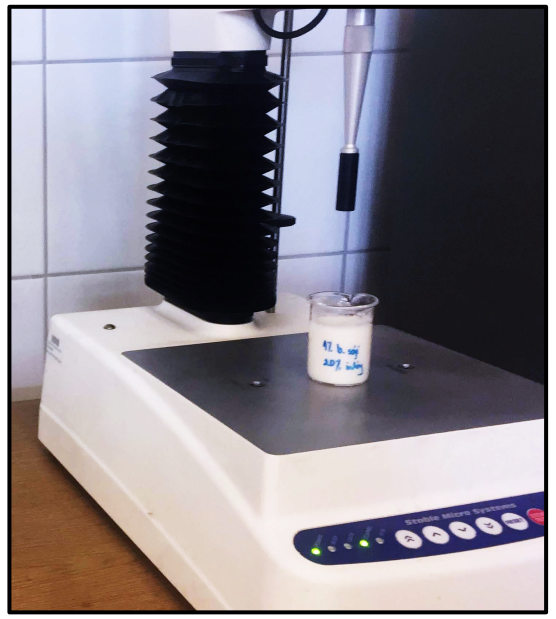
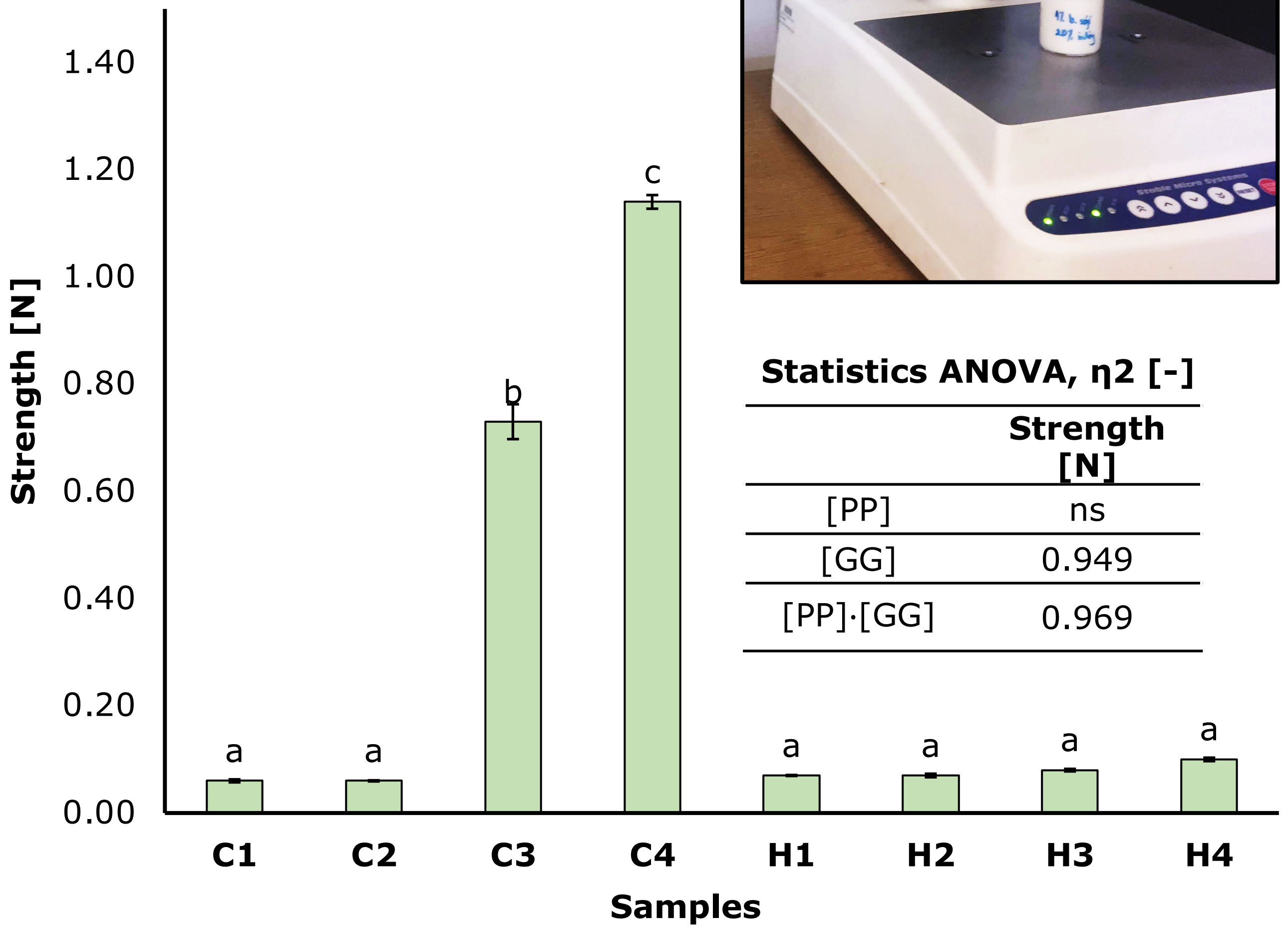
3) Textural Properties - texture analyzer

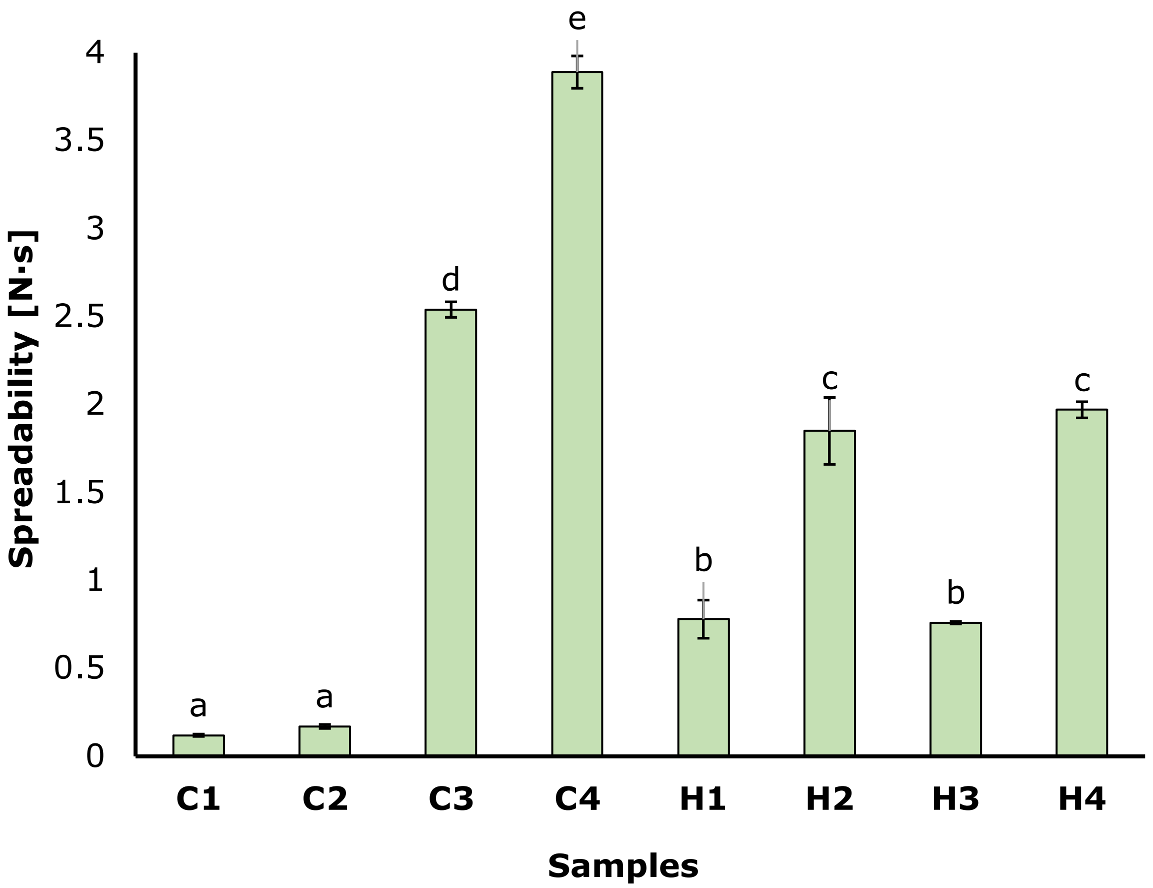
✦ The strength parameter represents the amount of force required to penetrate the structure of the studied hydrogel. A high strength value suggest that the structure of the hydrogel is compact.





Statistics ANOVA, η2 [-]

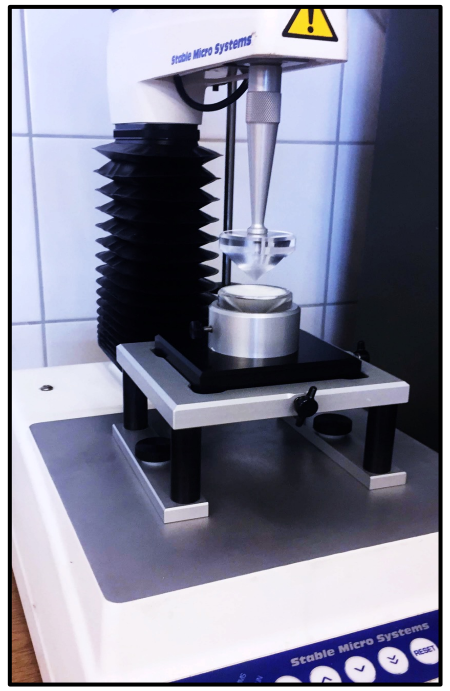
	Strength [N]
[PP]	ns
[GG]	0.949
[PP]·[GG]	0.969



Statistics ANOVA, η2 [-]

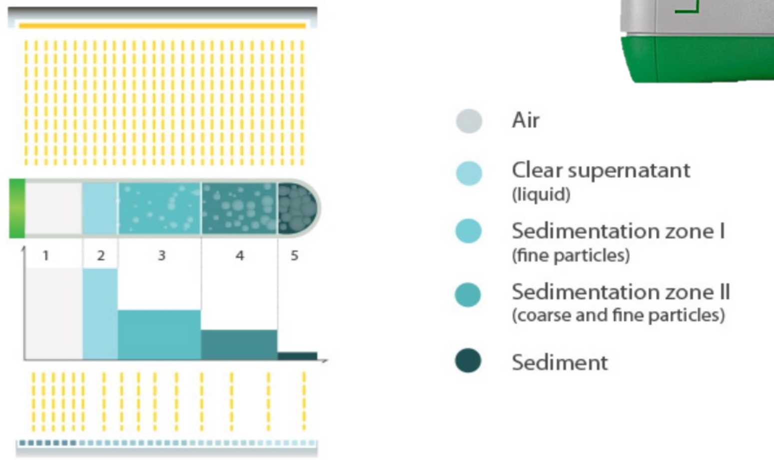
	Spreadability [N·s]
[PP]	ns
[GG]	0.983
[PP]·[GG]	ns

✦ The spreadability parameter is related to the ease with which a sample (hydrogel), can be applied in a thin, even layer. A high spreadability value indicates that the hydrogel is less spreadable.



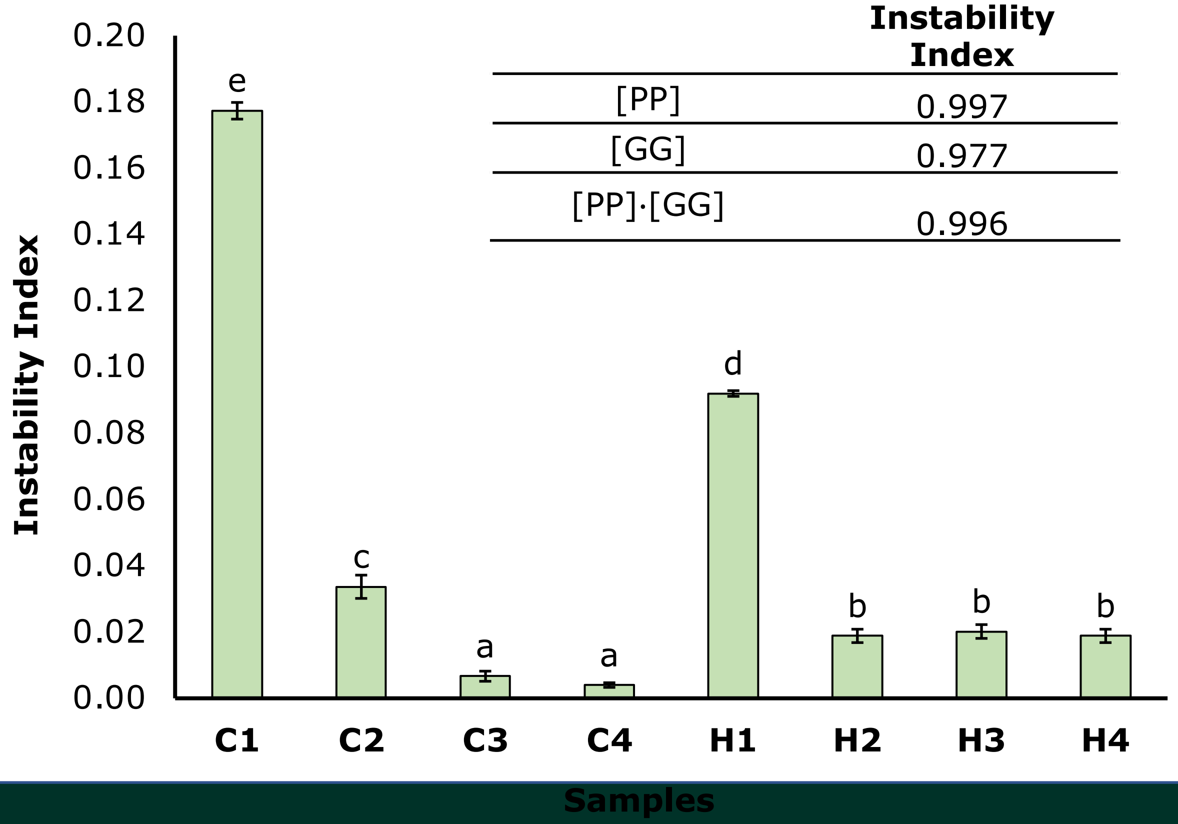
4) Physical stability - LUMiSizer

✦ **Instability index** of the analyzed hydrogels using STEP technology - space and time resolved extinction profiles.



Statistics ANOVA, η2 [-]

	Instability Index
[PP]	0.997
[GG]	0.977
[PP]·[GG]	0.996



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5) Color parameters in the CIE system (L*, a*, b*) – Minolta CR-200 colorimeter

✦ To determine the color differences between all the samples, **the total color difference parameter ΔE** was calculated:

Samples	H4	H3	H2	H1	C4	C3	C2	C1
C1	2.13	1.57	1.06	3.98	59.14	60.18	1.81	0.00
C2	2.58	2.88	2.85	5.73	60.44	61.47	0.00	
C3	59.12	58.70	59.31	58.23	1.13	0.00		
C4	58.09	57.67	58.27	57.18	0.00			
H1	5.28	3.98	3.15	0.00				
H2	2.28	1.22	0.00					
H3	1.36	0.00						
H4	0.00							

Statistics ANOVA, η2 [-]

	WI	YI
[PP]	0.644	0.891
[GG]	ns	0.757
[PP]·[GG]	0.686	0.762

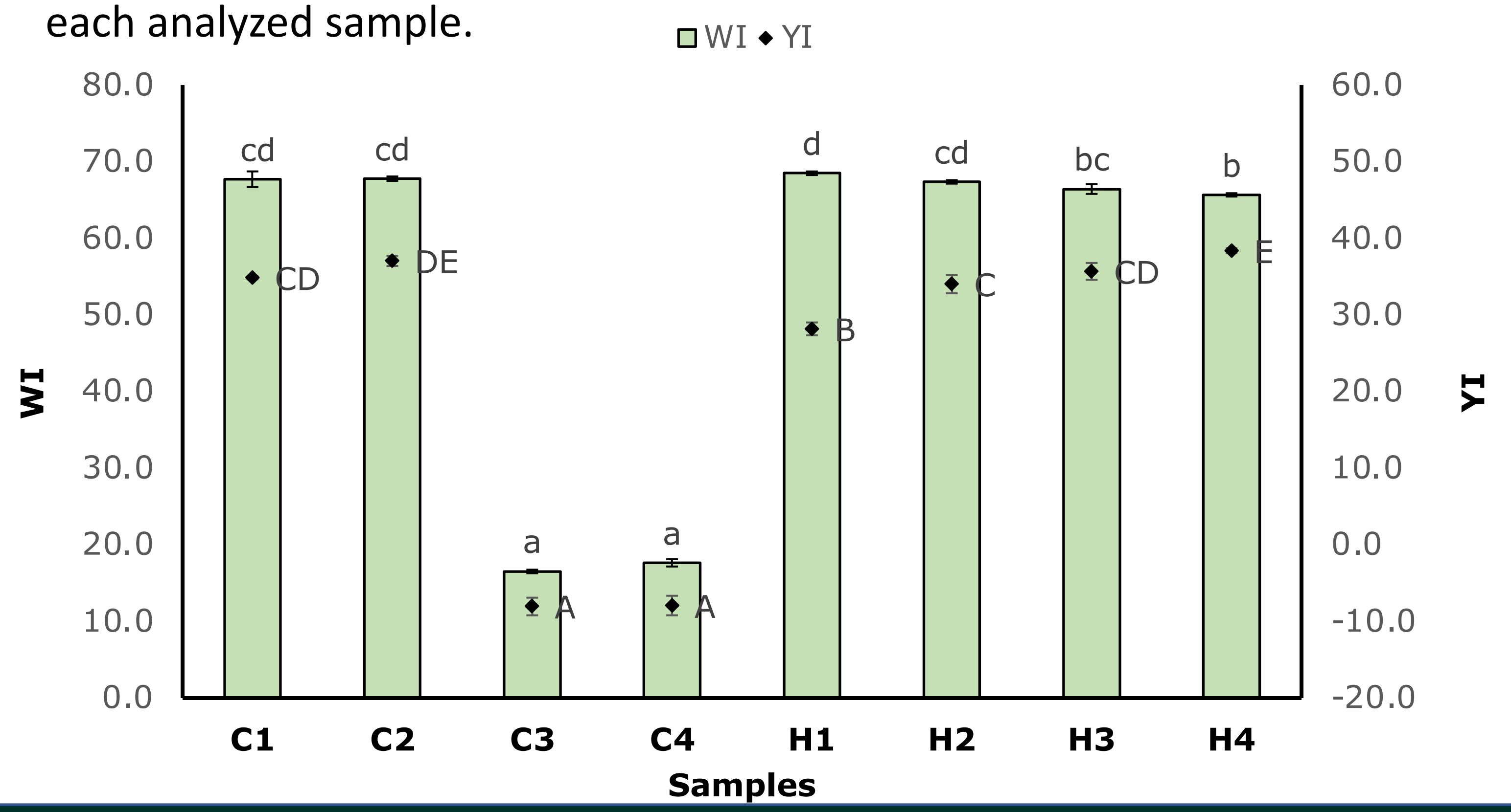
$\Delta E = \sqrt{(L^*_{s1} - L^*_{s2})^2 + (a^*_{s1} - a^*_{s2})^2 + (b^*_{s1} - b^*_{s2})^2}$, where: $L*_{S1}$; $a*_{S1}$; $b*_{S1}$ and $L*_{S2}$; $a*_{S2}$; $b*_{S2}$ refer to the color parameters of the compared samples.

0 < ΔE < 1	1 < ΔE < 2	2 < ΔE < 3.5	3.5 < ΔE < 5	5 < ΔE
Observer does not notice the difference	**Only experienced observer can notice the difference**	**Unexperienced observer also notices the difference**	**Clear difference in color is noticed**	**Observer notices two different colors**

✦ To determine the whiteness and yellowness of the obtained samples, **the whiteness index (WI) and yellowness index (YI)** of each combination was calculated:

$$WI = 100 - \sqrt{(100 - L^*)^2 + a^{*2} + b^{*2}},$$

$YI = 142.86 \times \left(\frac{b^*}{L^*}\right)$, where: L*, a*, and b* refer to the color parameters of each analyzed sample.



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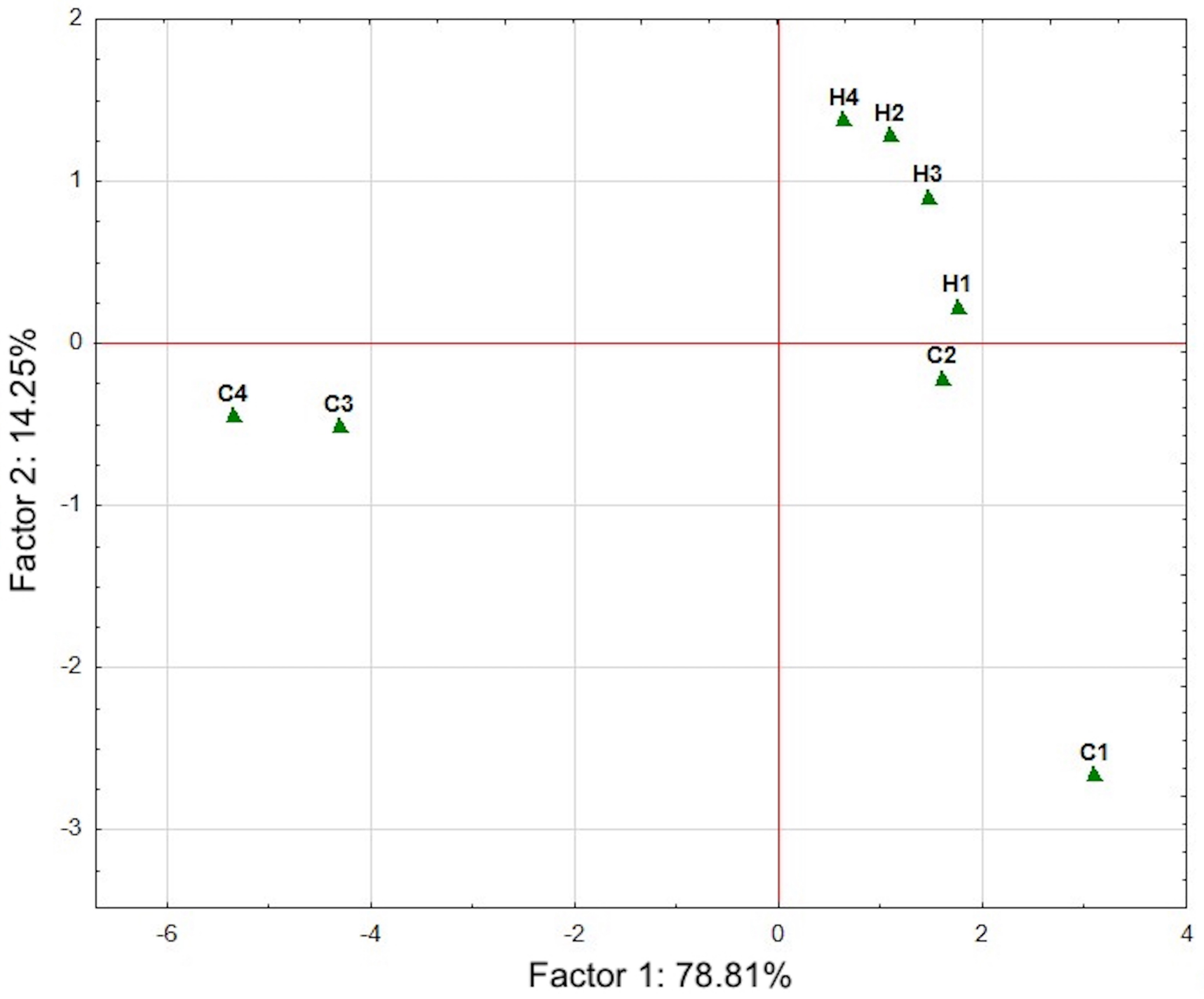
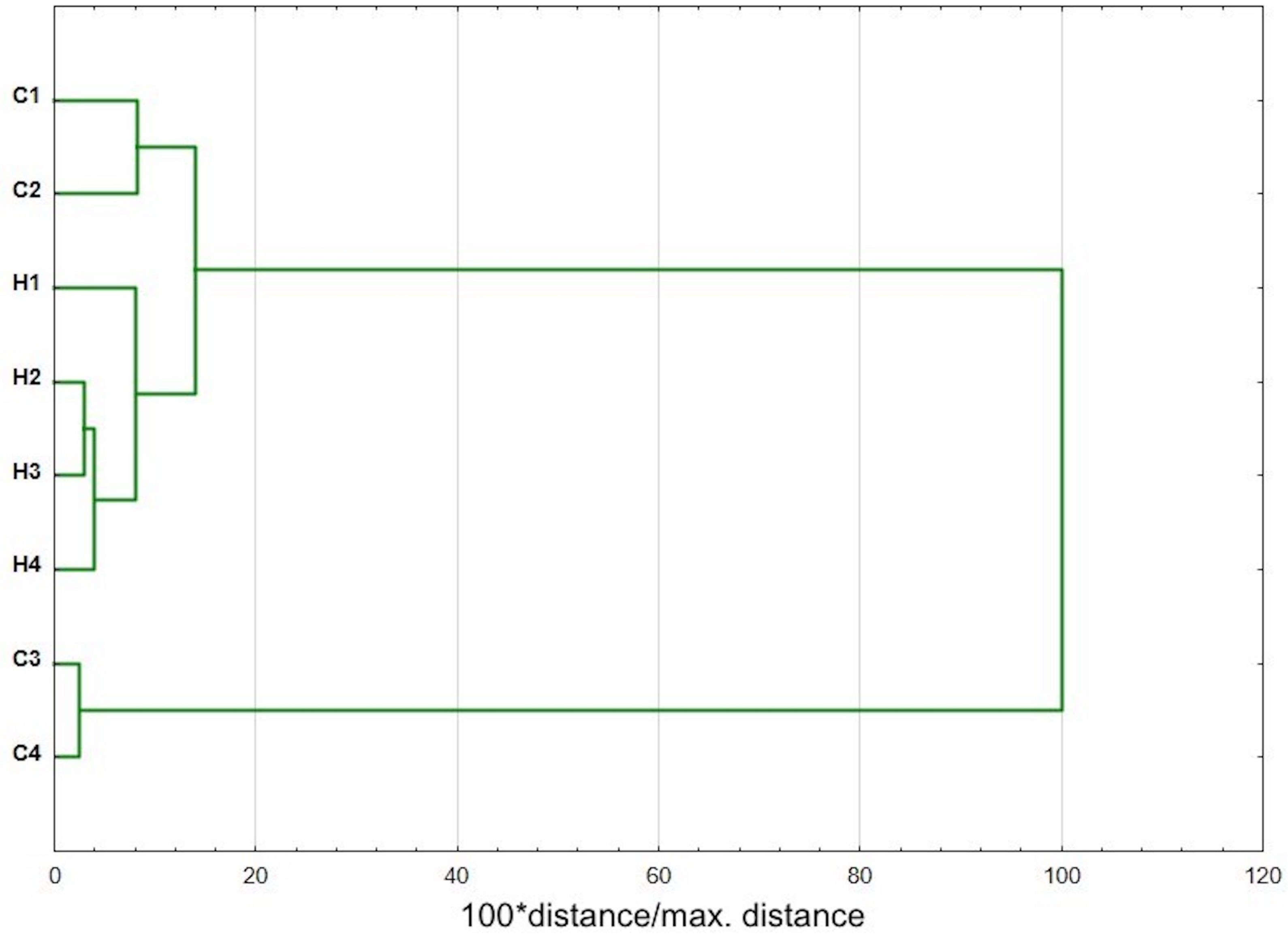
5) statistical analysis – Principal component analysis (PCA) and Hierarchal cluster analysis HCA (Statistica 13.3, TIBCO Software Inc., Palo Alto, CA, USA)

PCA



HCA



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Conclusion

The aim of this research was to evaluate the physicochemical and textural properties of food hydrogels produced using pea protein and gellan gum

- **By varying the concentrations of pea protein and gellan gum, the physicochemical and textural properties of the resulting binary hydrogels can be controlled.**
- **In terms of the analyzed properties, the most optimal variant was the one containing 12.5% pea protein and 0.75% gellan gum.**
- **Depending on the properties that the final food product must exhibit, a binary protein-polysaccharide hydrogel can be used as a matrix to contribute to that product's physicochemical and textural properties.**

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