Testing Potential Chitosan Hydrogels for 3D Printing

Sara Cardoso[1]*, Francisco Narciso[1,2], Nuno Monge[3], Ana Bettencourt[1], Isabel A.C. Ribeiro[1]

1 Research Institute for Medicines (iMed.ULisboa), Faculty of Pharmacy, Universidade de Lisboa, Avenida Prof. Gama Pinto, 1649-003 Lisboa, Portugal;
2 Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica, Portugal;
3 Centro Interdisciplinar de Estudos Educacionais (CIED), Escola Superior de Educação de Lisboa, Instituto Politécnico de Lisboa, Campus de Benfica do IPL, 1549-003 Lisboa, Portugal

Introduction

- 3D printing technology presents high demand due to its diversity, high customization, and the ability to adapt to different needs;
- Hydrogels are a common type of ink that can be used in a 3D printing methodology, for allowing the incorporation of different types of components, and producing simple and easy formulations;
- Chitosan hydrogels might present characteristics with the features necessary for a 3D extrusion process.

The aim of this study was to understand if it is possible to use chitosan-based hydrogels as inks for a 3D printing process and assess which parameters are needed to optimize the process.

Methods

Several chitosan hydrogels were produced by dissolving the polymer in acetic acid at 1% (wt/V). Viscosity was assessed (Brookfield Ametek®, DVEELVTJ0) and final hydrogel formulations were loaded into 3D printed extrusion syringes, and printed (Regemat 3D BIO V1) in a cube shaped configuration designated "scaffolds". All the hydrogels were subjected to different printing conditions to access which parameters were ideal to achieve the best printability.

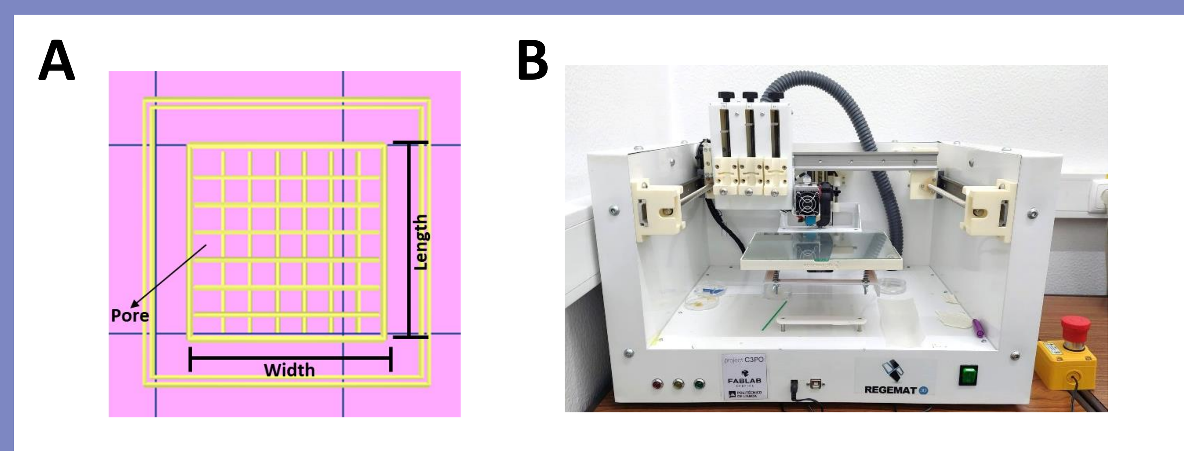

Figure 1. Scaffold CAD model (1 x 10 x 10 mm) **(A)** and Regemat 3D Bioprinter **(B)**.

Results

1. Viscosity evaluation

Chitosan hydrogels presented a suitable viscosity with shear-thining behaviour and thixotropy, ideal for an extrusion 3D printing method.

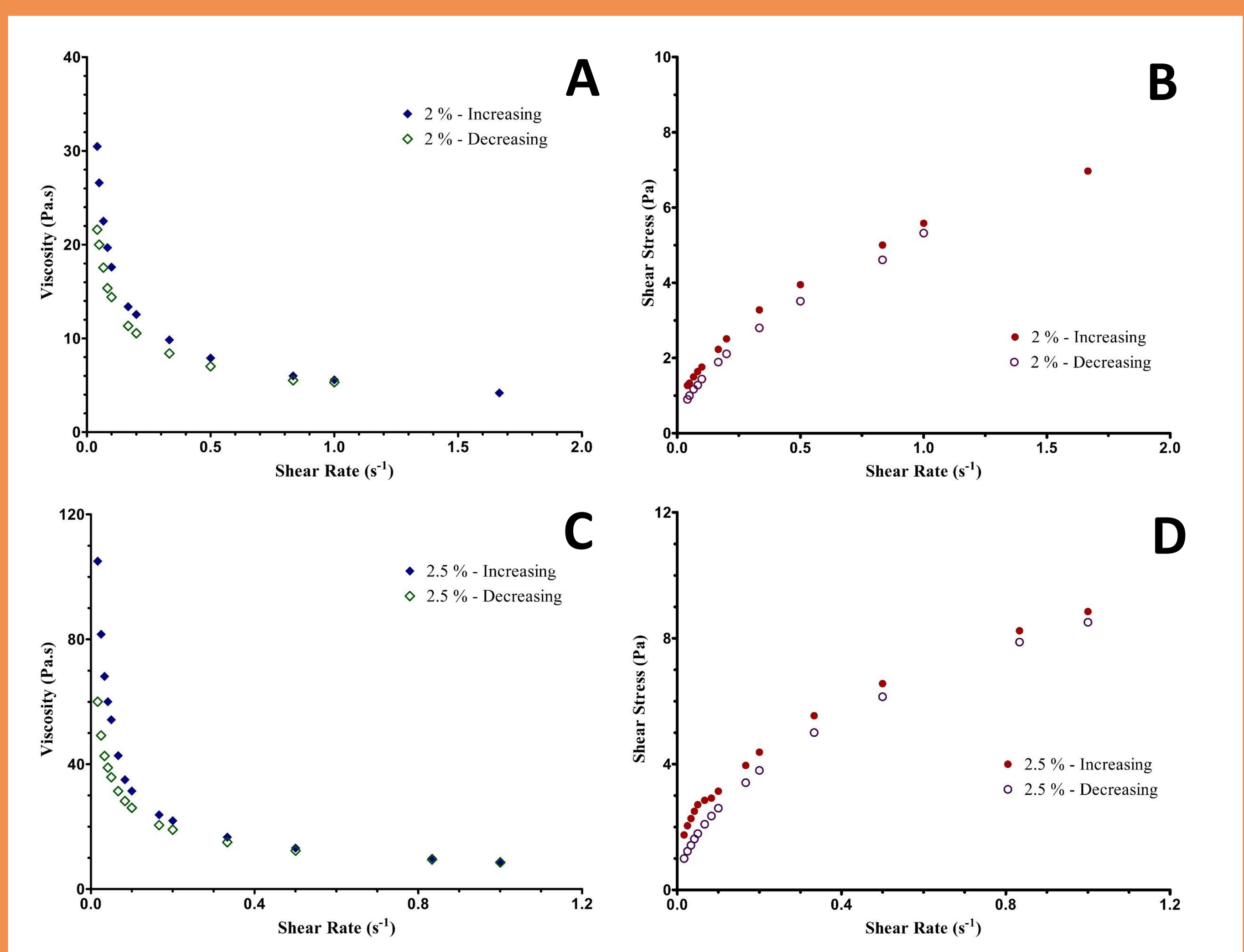

Figure 2. Viscosity as a function of shear rate for 2 wt% **(A)** and 2.5 wt% **(C)** of chitosan and Shear stress in function of shear rate for 2 wt% **(B)** and 2.5 wt% **(D)** of chitosan

2. Printing optimization study

The results obtained showed that some scaffolds present a strong structure with well-defined pores. Moreover, when applying the same printing conditions, the hydrogel with 2.5 wt% chitosan showed a better structure and matrix with defined pores when compared to the other concentrations used.

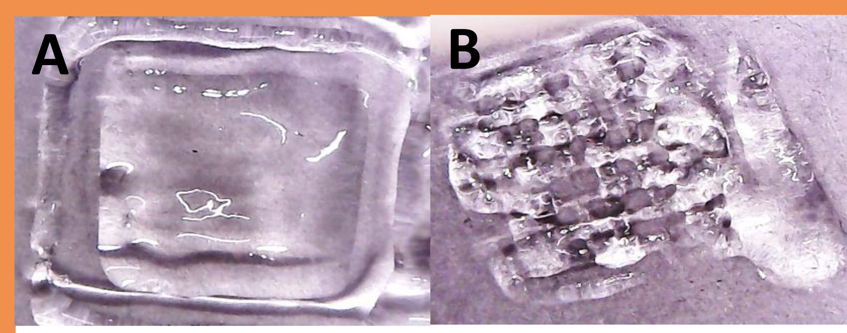

Figure 3. Scaffolds printed with 2.0 wt% **(A)** and 2.5 wt% **(B)** of chitosan.

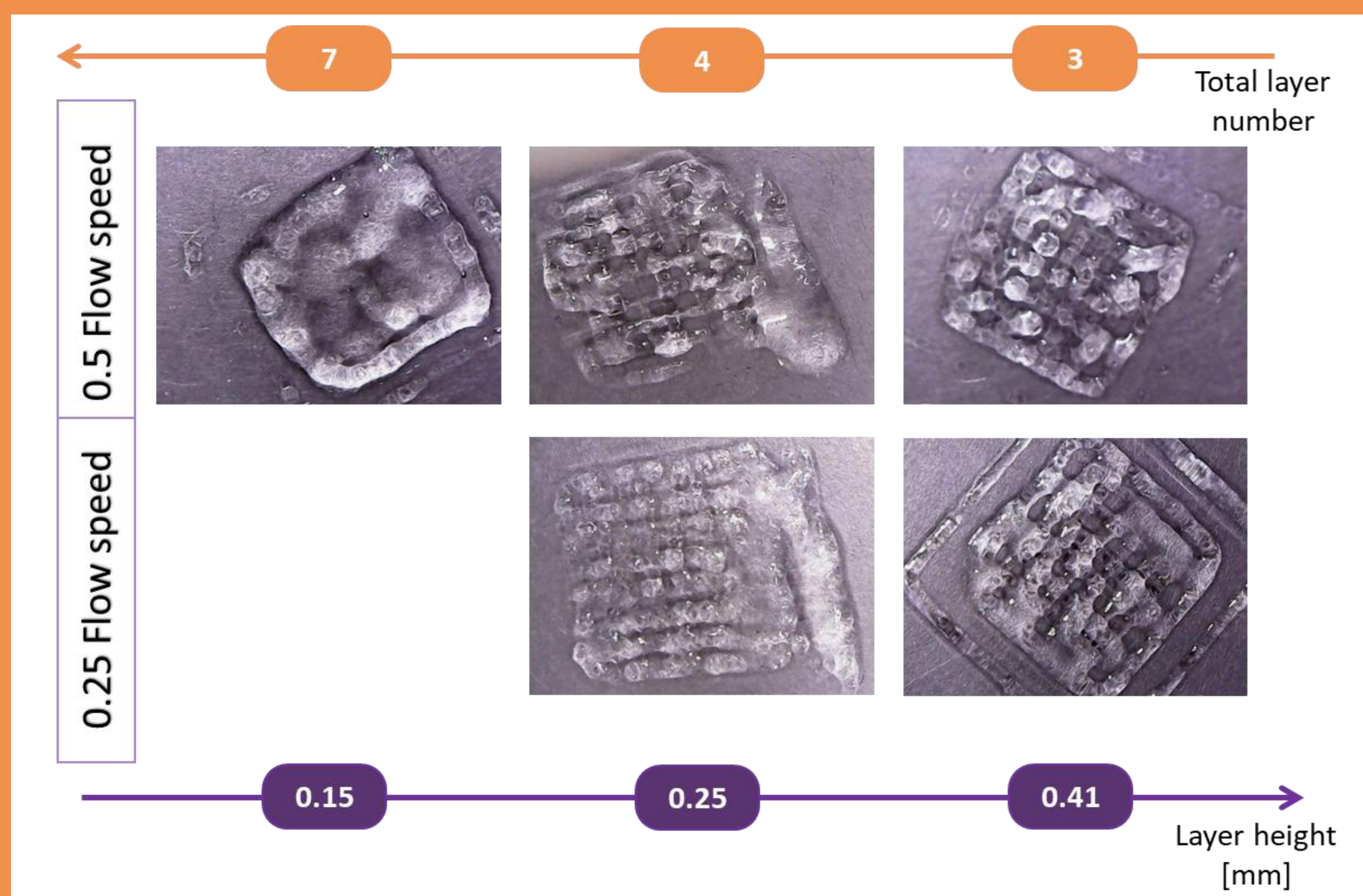

Figure 4. Printed Scaffolds with 2.5 wt% of chitosan at different flow speeds, layer height and total layer number.

Conclusions

- It was possible to print scaffolds with suitable printability when using chitosan hydrogels;
- The optimal chitosan concentration was 2.5 wt%;
- The nozzle diameter, flow speed and layer height are key parameters;
- Chitosan hydrogels produced presented a suitable viscosity.

References

Cardoso, S.; Narciso, F.; Monge, N.; Bettencourt, A.; Ribeiro, I.A.C. Improving Chitosan Hydrogels Printability: A Comprehensive Study on Printing Scaffolds for Customized Drug Delivery. Int. J. Mol. Sci. 2023, 24, 973.

Acknowledgments

The authors would like to thank the Portuguese government, Fundação para a Ciência e Tecnologia (FCT), for the financial support through national funds PTDC/BTMSAL/29335/2017, under iMED.ULisboa UIDB/04138/2020 and UIDP/04138/2020 and under IPL IPL/2022/3DWounDres_ESELx. Sara Cardoso acknowledge FCT for PhD Grant 2023.01295.BDANA

Fundação para a Ciência e a Tecnologia
REPÚBLICA PORTUGUESA

The 9th International Electronic Conference on Medicinal Chemistry
01–30 November 2023 | Online
MDPI