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Preparation and Investigation of Starch-Based Hydrogels Crosslinked with Citric Acid

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INTRODUCTION & AIM

Polysaccharide hydrogels are of great interest due to their biocompatibility and environmental safety. Starch-based hydrogels modified with citric acid—a biocompatible crosslinker—form three-dimensional networks with controlled crosslinking and swelling. This work aims to synthesize and comprehensively study such hydrogels, evaluating their physicochemical properties and biotechnological potential.

METHOD

Fourteen starch hydrogel samples were synthesized with citric acid concentrations from 2.4 to 42 mmol per kmol of starch, using a hydromodule of 50 and reaction times between 1 and 5 hours. Key properties—including swelling degree, gel fraction, and sorption capacity for methylene blue (via UV–visible spectroscopy)—were measured [1]. Rheological behavior during synthesis was analyzed, and FTIR spectroscopy confirmed crosslinked network formation. Growth-stimulating activity was assessed via pre-sowing treatment of wheat seeds.

RESULTS & DISCUSSION

Swelling degree ranged from 0.9 to 1.8 g/g, with gel fraction between 68 and 97%. The optimal synthesis time was 2 hours at 2.5 mmol citric acid per kmol starch, where swelling reached 1.7 and plateaued with longer reaction times. The optimal sample sorbed methylene blue up to 0.89 mg/g. The dynamic viscosity quickly peaks at 0.027 Pa·s within 1.1–1.4 hours and then gradually decreases due to structural changes.

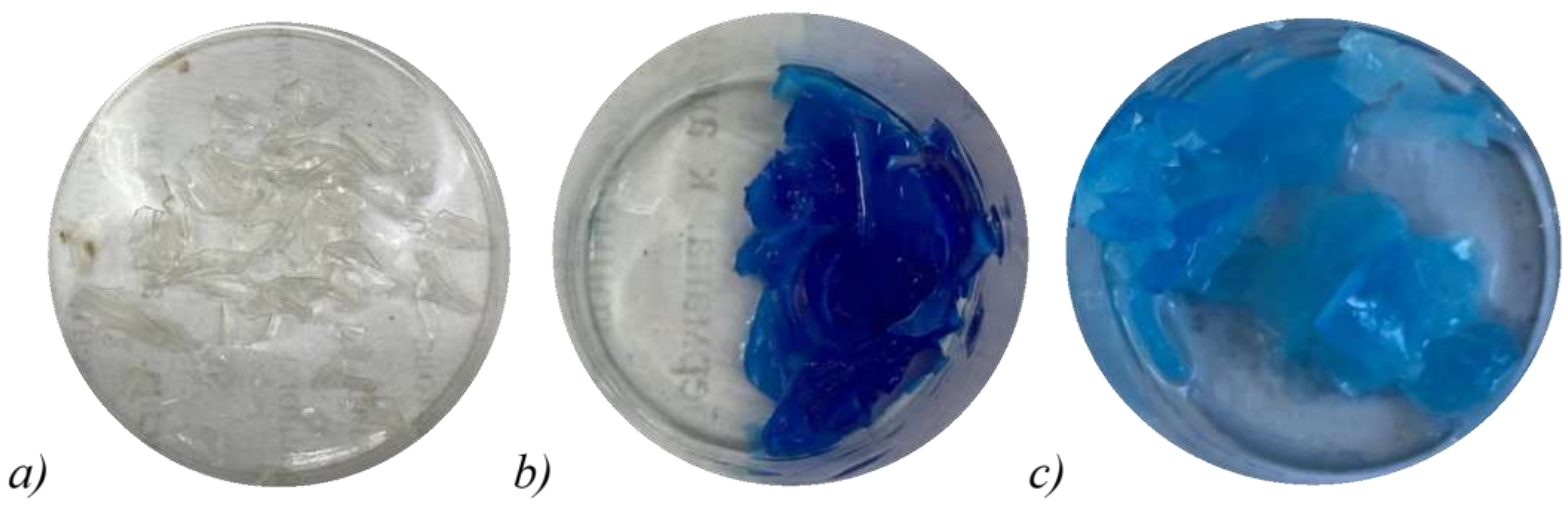

Figure 1. Sorption capacity for methylene blue of the sample obtained using 2.5 mmol citric acid per kmol starch: (a) before sorption; (b) 24 h after sorption of aqueous methylene blue solution; (c) 24 h after desorption of aqueous methylene blue solution

FTIR spectra showed intense bands at 1790–1650 cm^{-1}, indicating ester bond formation; band intensity increased with citric acid concentration, confirming higher crosslinking.

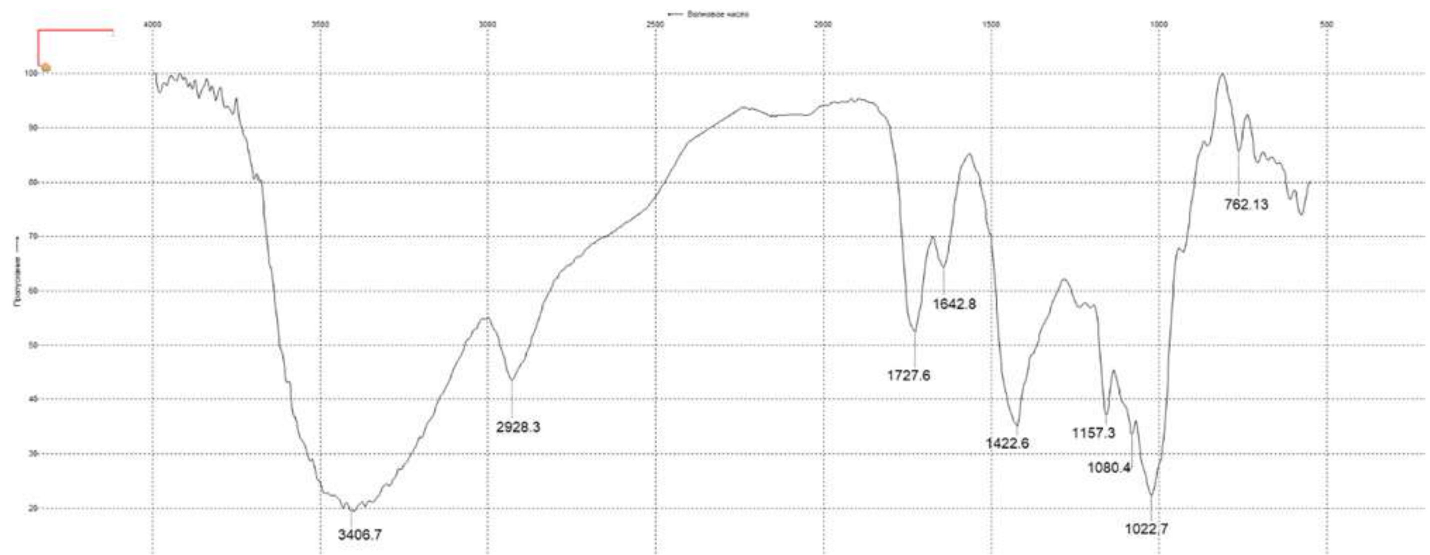

Figure 2. FTIR spectrum of the sample prepared with 2.5 mmol citric acid per kmol starch

Growth stimulation varied by conditions: stems grew better in sandy soil, while root development and biomass were higher in Petri dish cultures. Hydrogel-treated seeds showed 10–25% greater germination than controls in both cases.

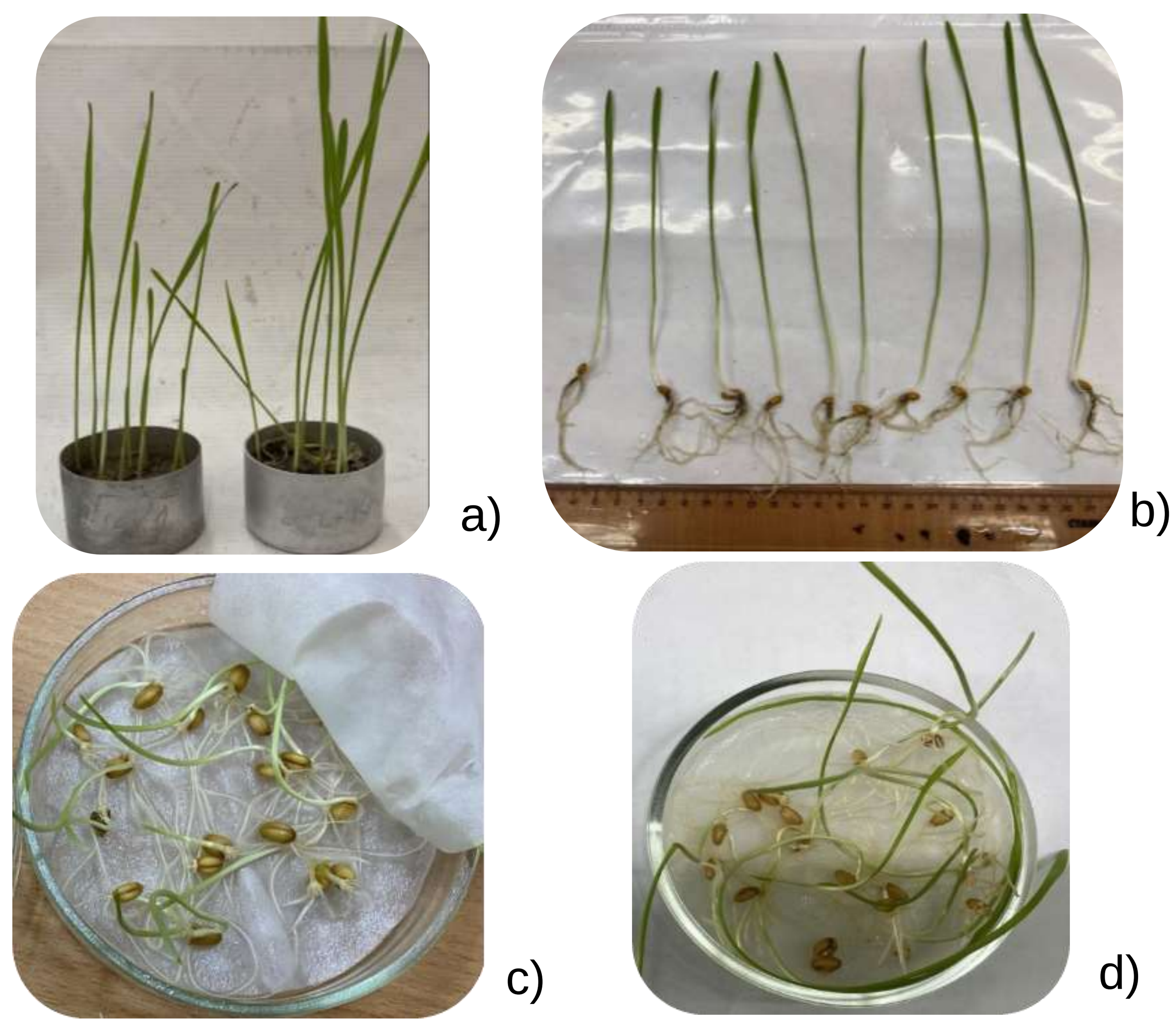

Figure 3. Evaluation of the growth-regulating properties of hydrogels on wheat seeds using a sample prepared with 2.5 mmol citric acid per kmol starch: (a) in sand bed; (b) seedlings extracted from sand; (c) in Petri dish; (d) control.

CONCLUSION

The developed hydrogels exhibit high swelling, stable gel structure, and enhanced sorption properties. They effectively stimulate plant growth and show promise for agritechnology applications, particularly pre-sowing seed treatment and soil moisture management.

FUTURE WORK / REFERENCES

[1] Mohammadzadeh F, Golshan M, Haddadi-Asl V, et al. Sci Rep. 2023;13:11900.