Pampas Grass-Derived Nanocellulose for Mechanical and Hydrophobicity Enhancement of Starch-Based Packaging Films

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INTRODUCTION & AIM

Recent advances in materials science have placed strong emphasis on renewable, biodegradable, and circular alternatives to petroleum-based plastics. Among natural biopolymers, **cellulose** is particularly attractive due to its abundance, renewability, and mechanical strength. In its nanoscale form, **cellulose nanofibers (CNFs)** exhibits exceptional tensile strength, flexibility, and surface area, making it an ideal reinforcing agent for biodegradable polymers. *Cortaderia selloana* (pampa grass), a robust and widely distributed grass species known for its resilience in extreme environments, represents an abundant yet underutilized source of lignocellulosic biomass [1].

This study presents a novel method combining mechanical treatment with subcritical water processing to extract cellulose nanofibers from pampas grass (PG). These nanofibers were then incorporated into a starch-based film reinforced with chestnut shell fibres using a solvent casting technique as described by [2].

METHOD

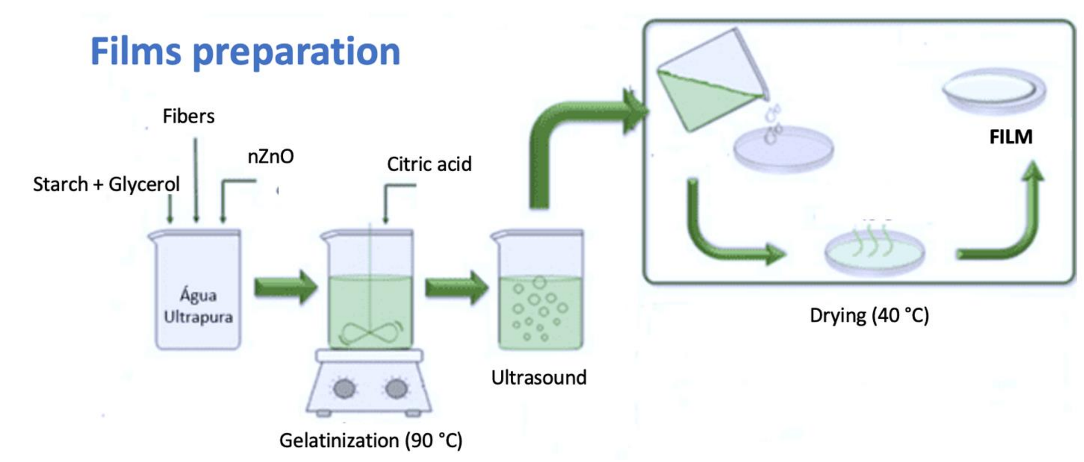
Response Surface Methodology (RSM) with a Box-Behnken experimental design (BBD) was employed to evaluate the influence of glycerol (X1), ratio of pampa grass nanofibers/ chestnut shell fibres (X2) and Zinc oxide nanoparticles (Y3) on the mechanical performance of potato starch-based film.

BBD evaluation

Run	X1: % Glycerol r.s.	X2: % Chestnut fibers r.s.	X3: % ZnO nanoparticles r.s
1	50	100	6
2	60	50	6
3	50	0	1
4	40	50	6
5	40	50	1
6	50	50	3.5
7	50	0	6
8	50	100	1
9	50	50	3.5
10	40	0	3.5
11	60	0	3.5
12	60	100	3.5
13	50	50	3.5
14	50	50	3.5
15	60	50	1
16	40	100	3.5
17	50	50	3.5

Legend: relative to starch (r.s.).

Films preparation



Films characterization

Barrier properties
UV-barrier capacity
Water vapor permeability

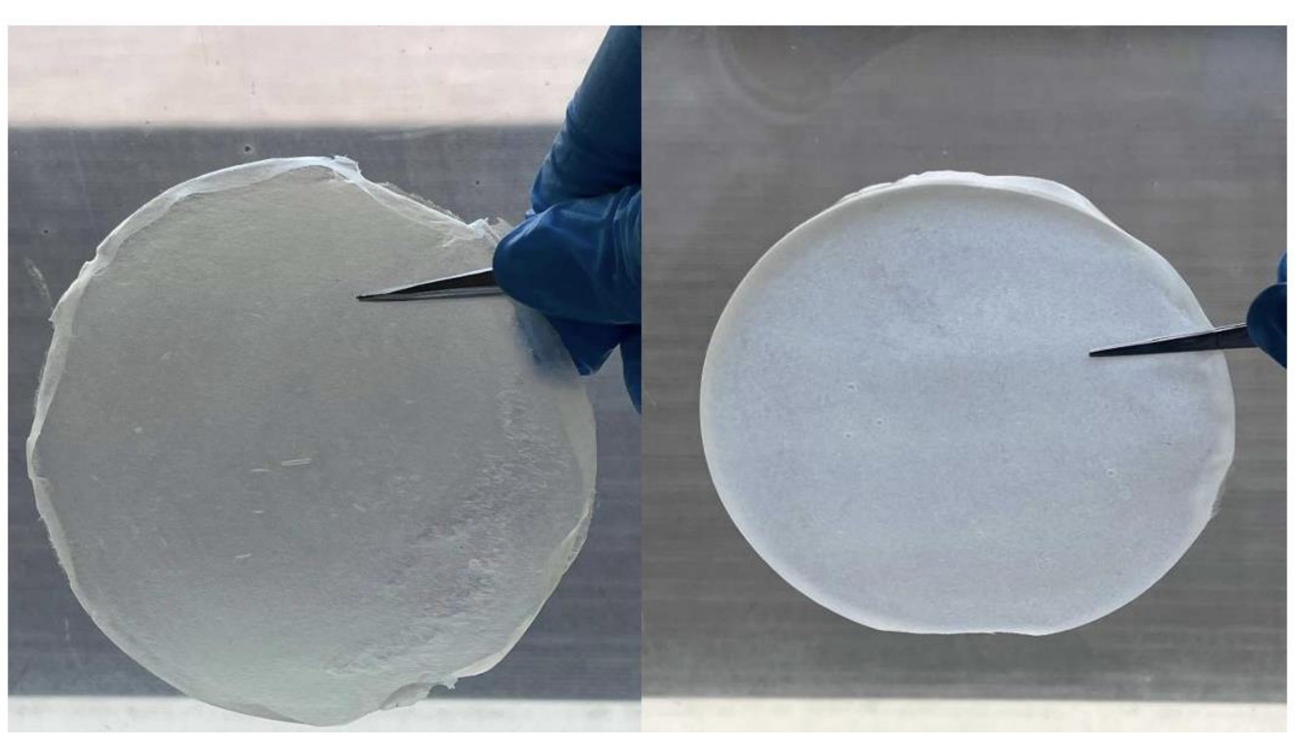
Optical properties
Color
UV-barrier capacity
Transparency
Opacity

Mechanical properties
Elongation at break
Tensile strenght
Elastic modulus

Other properties
Thickness
Water content
Water solubility
Morphological structure

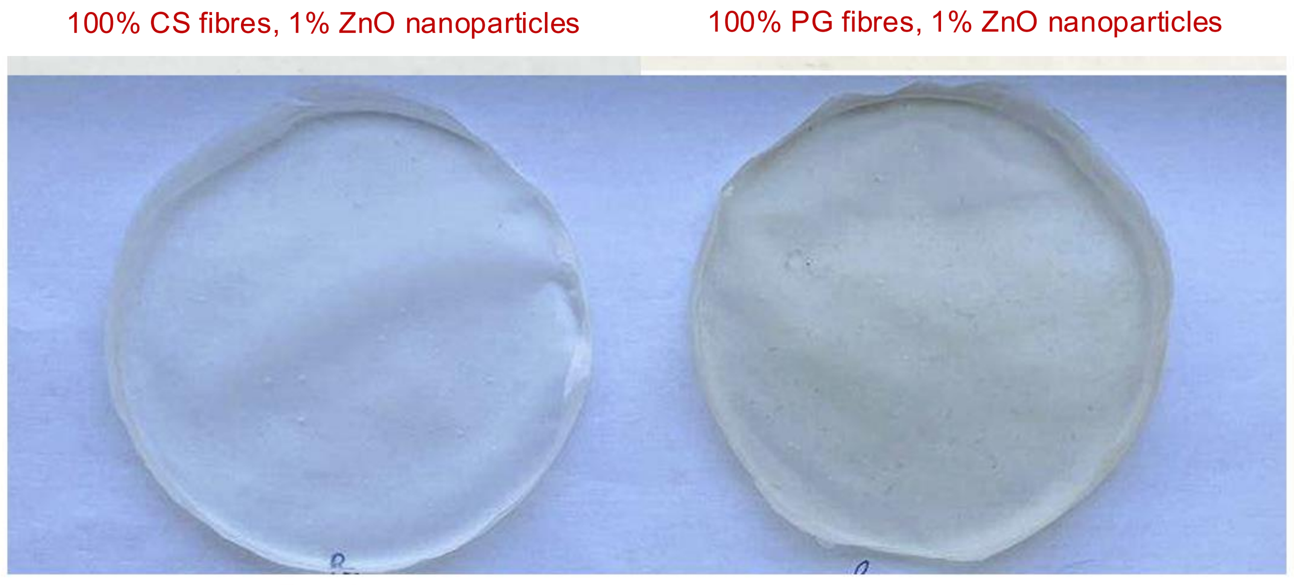
Antioxidant properties
Total phenolic content
ABTS•+ and DPPH•+ scavenging activity

RESULTS & DISCUSSION



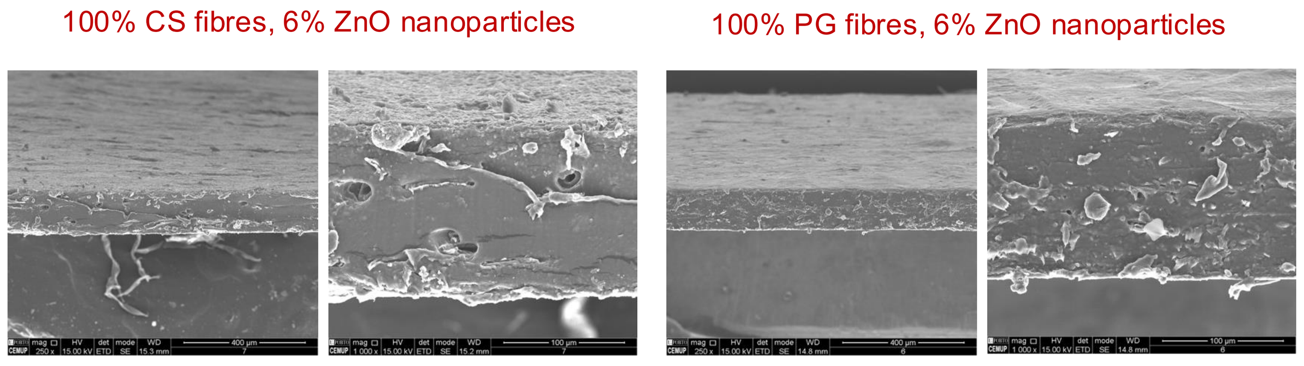
Run 8
100% CS fibres, 1% ZnO nanoparticles

Run 3
100% PG fibres, 1% ZnO nanoparticles

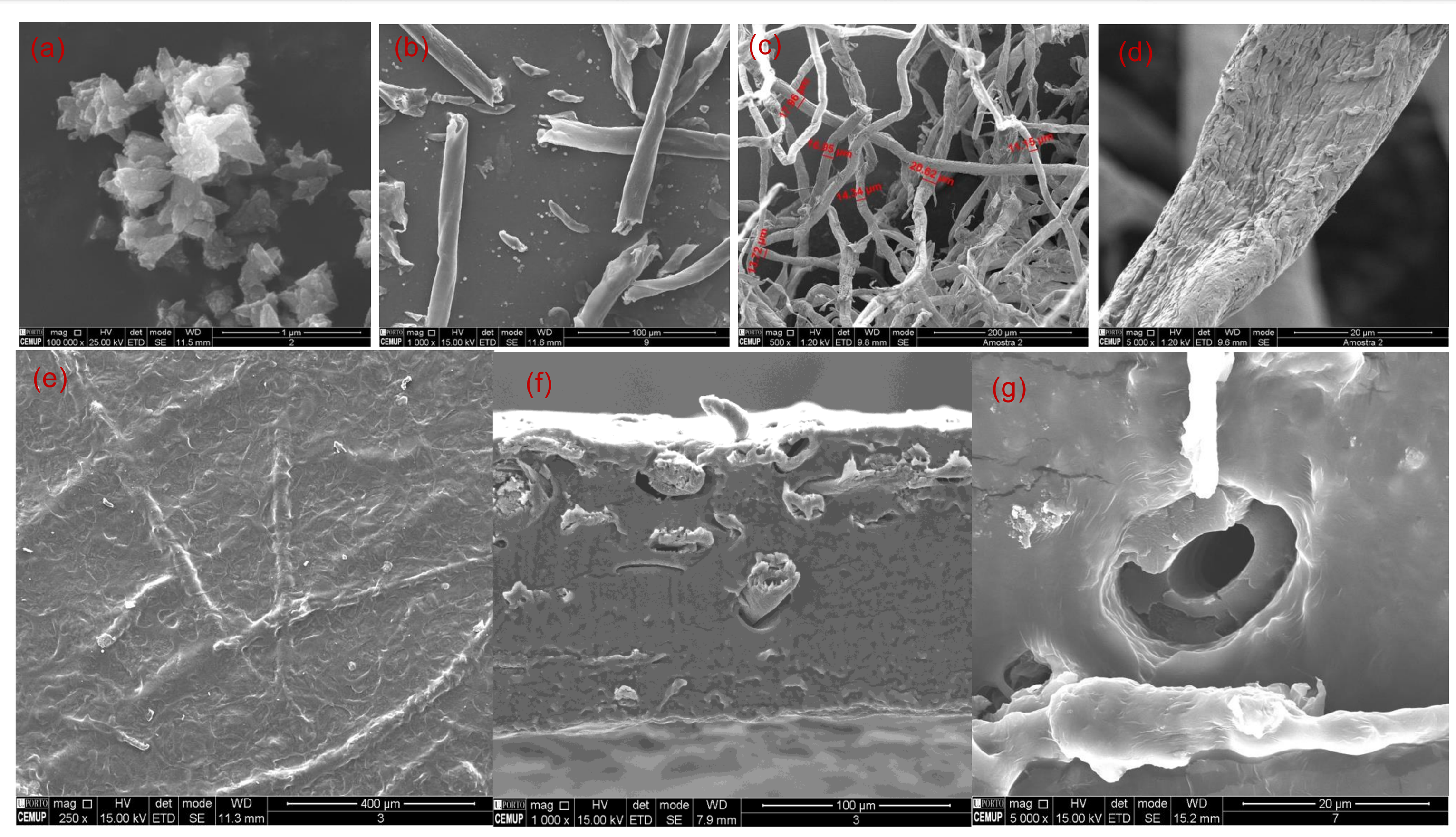


Run 1
100% CS fibres, 6% ZnO nanoparticles

Run 7
100% PG fibres, 6% ZnO nanoparticles



Photographs (0 x) and SEM micrographs of cross-section (250 × and 1 000 x) of starch-based films obtained in Runs 1 and 7. Legend: Pampa grass (PG), Chestnut shells (CS).

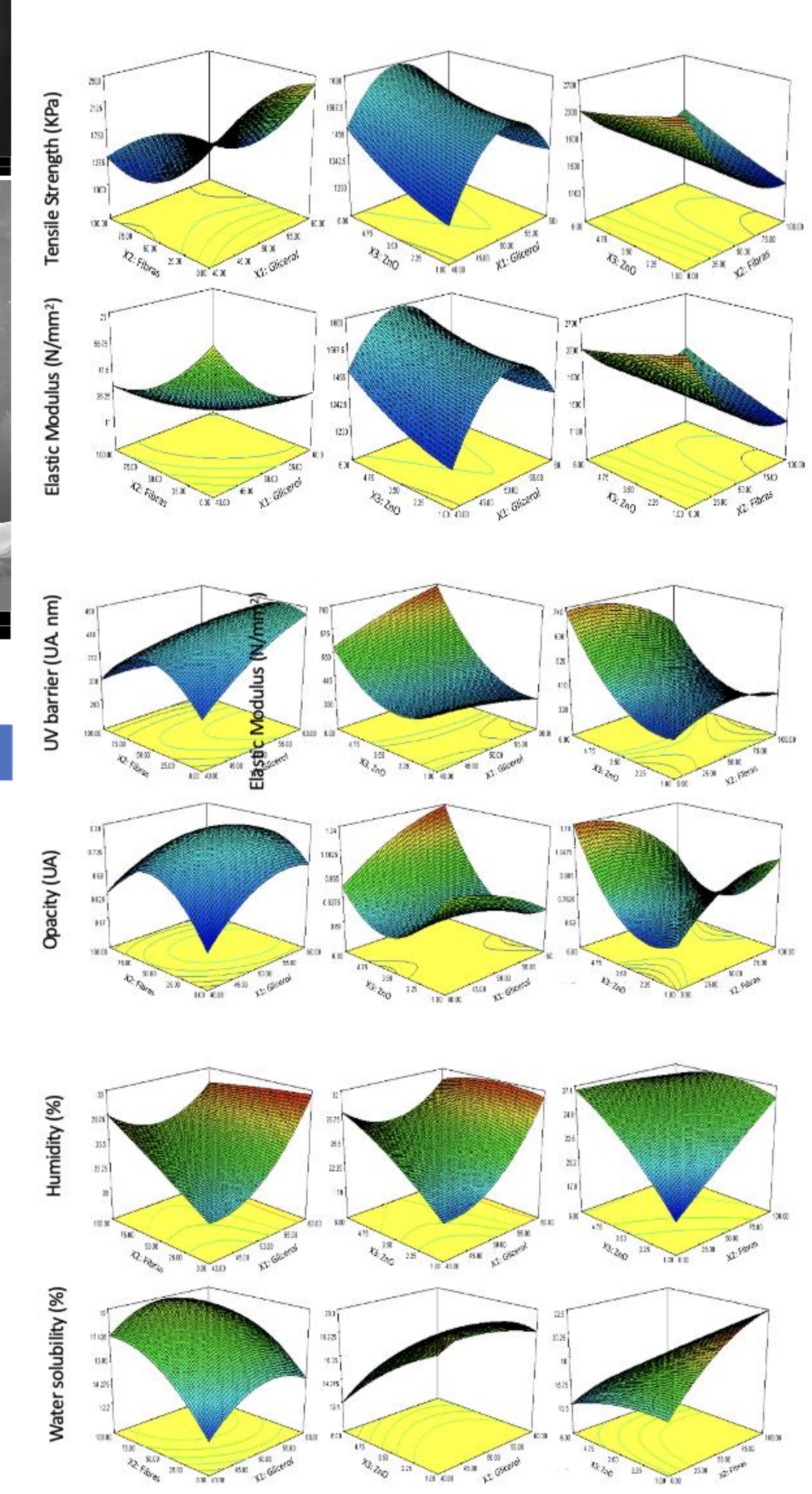


SEM micrographs of (a) ZnO nanoparticles, (b) Pampa grass nanofibres, (c-d) Chestnut shells fibres; (e) Optimzed film surface, and (f-g) Optimized film cross-section.

	Control Film	Optimized Film
Y1, Tensile Strengtht (kPa)	1070.25	1954.56
Y2, Elastic Modulus (N/mm²)	50.53	41.85
Y4, Humidity (%)	27.23	18.43
Y5, Solubility (%)	24.01	16.50
Y6, UV barrier (UA.nm)	234.00	349.99
Y7, Opacity (UA)	0.51	0.73
Desirability		0.781
FILM COMPOSITION:		
Potato starch (%)	50	50
Glycerol (% r.s.)	50	44
Fibers (% r.s.)	10% CSf	10% (17% CSf + PGf)
ZnO nanoparticles (% r.s.)	0	2

Legend: relative to starch (r.s); Chestnut shell fibers (CSf); Pampa grass fibers (PGf).

Response surface plots



CONCLUSIONS

A starch-based nanocomposite film reinforced with nanofibres from Pampa grass and chestnut shell fibres was successfully developed, exhibiting improved mechanical strength and water resistance. This environmentally friendly approach offers promising potential for sustainable food packaging applications.

REFERENCES

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