Properties of biomaterials obtained from milk whey proteins at different pH values and plasticizer concentrations

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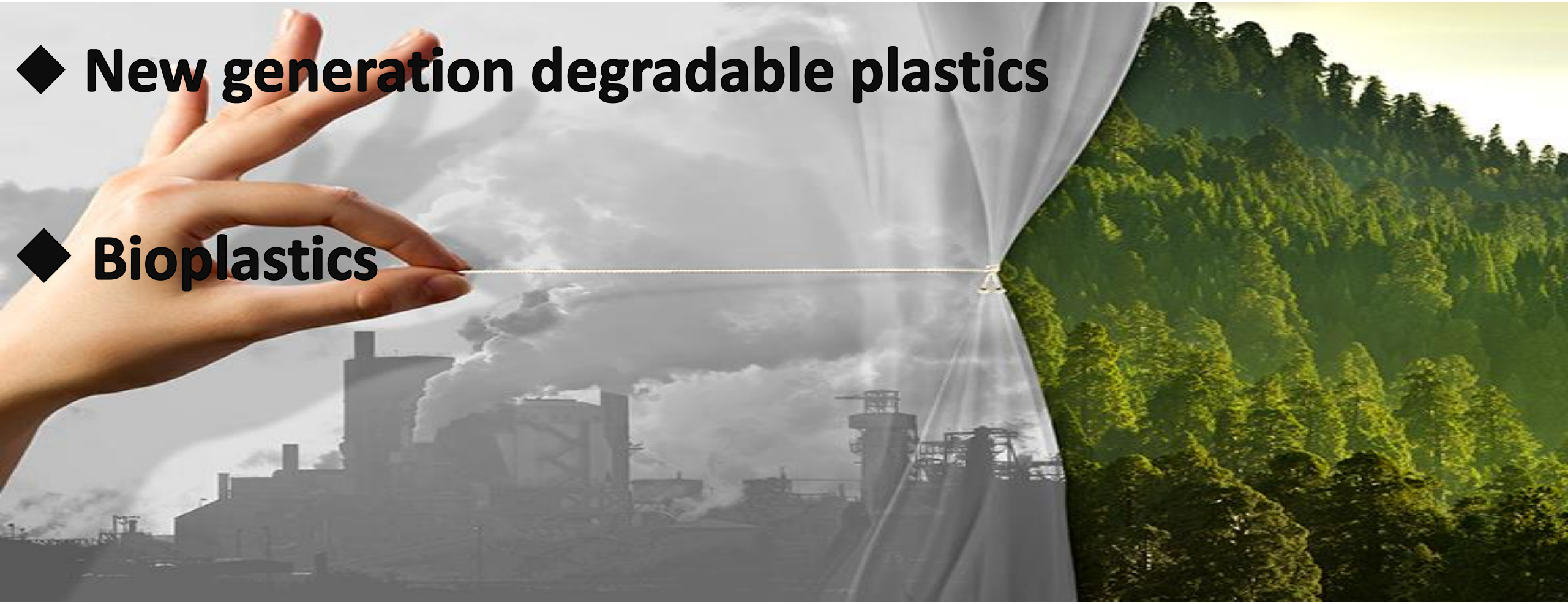
1st Coatings and Interfaces Web Conference

Plastic pollution

- Traditional plastics are not biodegradable
- Environmental pollution (air, water, soil) is harmful for animals and other living organisms
- By 2050, the oceans will contain more plastic than fish by weight

plasticpollutioncoalition.zendesk.com

Anti-pollution strategy



- New generation degradable plastics
- Bioplastics

BIOPOLYMERS

Aliphatic polyesters

Polylactic acid (PLA)

Polyhydroxyalkanoates (PHA)

Polysaccharides

Pectins
Cellulose
Chitin/Chitosan
Starch
Alginate
Xanthan

Proteins

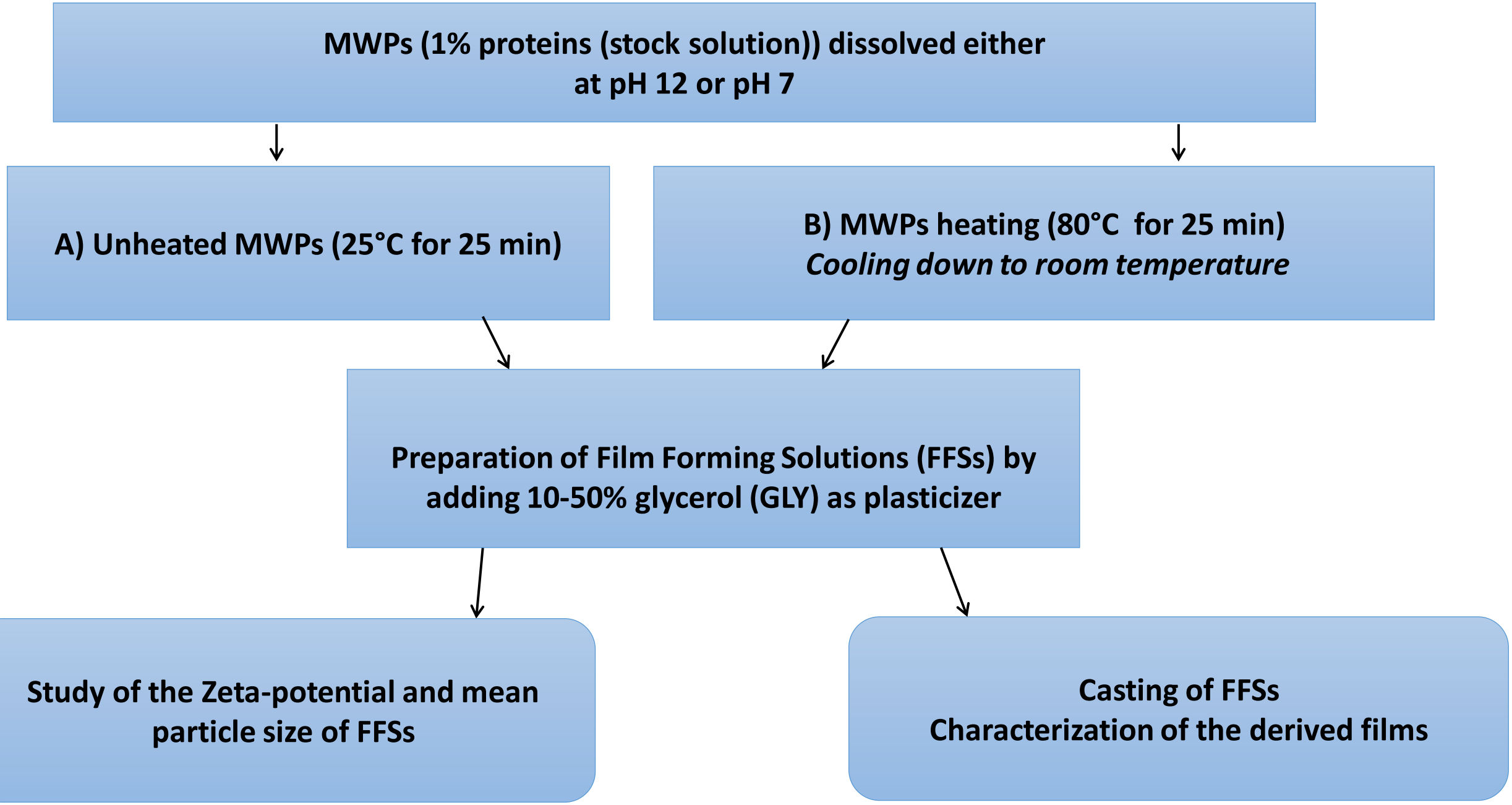
Soy proteins
Milk whey Proteins (MWPs)
Bitter vetch proteins
Phaseolin
Zein
Collagen

Dairy Industry

Worldwide a large amount (180 to 190×10^6 tons/year) of by-product as Milk Whey (MW) is produced during casein coagulation, causing environmental pollution.

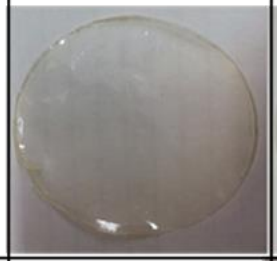
- **MW**
  - ➢ High organic content
  - ➢ Free from toxic agent
  - ➢ Protein source

MWP-BASED FILM PREPARATION



Visual inspection of the derived MWP(1%)-based films

GLY concentration

	0 %	10 %	20 %	30 %	40 %	50 %
pH 7	✗	✗	✗	✗	✗	✗
pH 12	✗	✗	✗			
pH 7	✗	✗	✗	✗		
pH 12	✗	✗	✗			

Unheated

Heated

Zeta-potential and Z-average of either heated or unheated MWP FFSs

MWP FFSs	Z-average (d.nm)		Zeta potential (mV)	
	pH 7	pH 12	pH 7	pH 12
+ 30% GLY, heated	147.1 ± 18.4	418.9 ± 31.9	-27.0 ± 1.0	-35.3 ± 2.1
+ 30% GLY	1127.0 ± 167.4	610.2 ± 56.5	-21.6 ± 0.4	-35.8 ± 2.6
+ 40% GLY, heated	110.5 ± 21.1	415.4 ± 6.7	-29.1 ± 0.6	-35.4 ± 2.8
+ 40% GLY	522.6 ± 102.5	519.2 ± 30.8	-22.9 ± 0.3	-35.9 ± 2.4
+ 50% GLY, heated	350.1 ± 13.8	403.9 ± 19.7	-27.0 ± 0.1	-36.2 ± 3.3
+ 50% GLY	516.3 ± 23.1	526.1 ± 38.6	-24.0 ± 0.4	-35.6 ± 2.9

Mechanical properties of MWP-based films prepared at pH 12

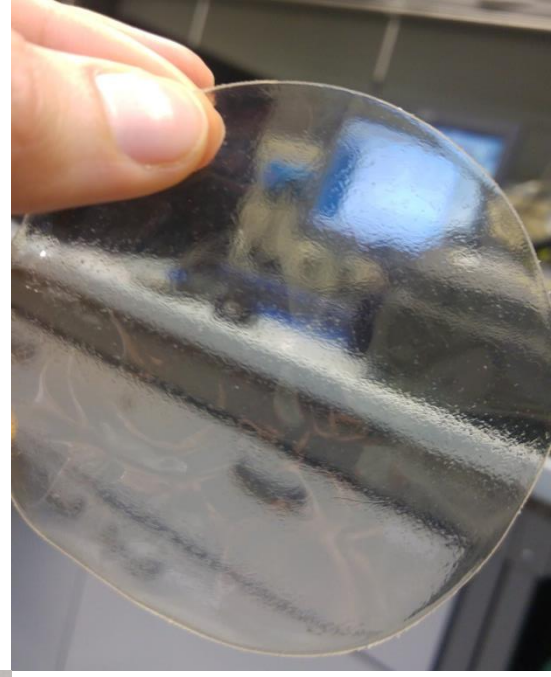
MWP films	Tensile strength (MPa)	Elongation at Break (%)	Young's Modulus (MPa)	Thickness (µm)
+30% GLY, heated	3.4 ± 0.9	8.3 ± 4.8	71.6 ± 14.2	48 ± 7.4
+30% GLY	3.7 ± 0.6	4.6 ± 0.8	185.1 ± 16.2	38 ± 4.3
+40% GLY, heated	1.4 ± 0.1	21.3 ± 5.5	34.0 ± 7.4	44 ± 4.1
+40% GLY	2.7 ± 0.1	33.9 ± 8.5	86.2 ± 3.2	66 ± 2.3
+50% GLY, heated	0.6 ± 0.1	36.9 ± 10.8	22.7 ± 5.1	105 ± 4.9
+50% GLY	1.1 ± 0.1	61.6 ± 8.6	24.1 ± 4.7	83 ± 2.1

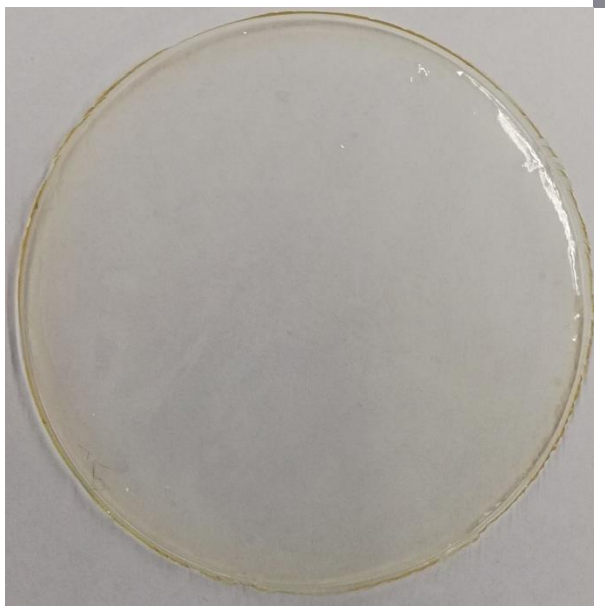
Mechanical properties of MWP-based films prepared at pH 7

MWP films	Tensile strength (MPa)	Elongation at Break (%)	Young's Modulus (MPa)	Thickness (µm)
+40% GLY, heated	2.8 ± 0.7	3.6 ± 0.7	350.5 ± 63.4	96.0 ± 5.9
+50% GLY, heated	3.1 ± 0.2	20.8 ± 4.4	164.7 ± 77.5	129.0 ± 35.0

Opacity (A_{600nm} /mm) of different film types

MWP films	Opacity (A600nm /mm)
+30% GLY, heated, pH 12	1.18 ± 0.64
+30% GLY, pH 12	2.65 ± 0.11
+40% GLY, heated, pH 12	1.23 ± 0.05
+40% GLY, pH12	2.07 ± 0.25
+50% GLY, heated, pH 12	1.57 ± 0.13
+50% GLY, pH 12	2.20 ± 0.81
+40% GLY, heated, pH 7	1.66 ± 0.01
+50% GLY, heated, pH 7	1.27 ± 0.01
polypropylene*	32.02 ± 3.35
cellulose triacetate*	0.54 ± 0.09





**Values from Giosafatto et al. 2018*

Film moisture content (%) and film moisture uptake (%) of MWP-based films prepared at pH 12

MWP film	Moisture content (%)	Moisture uptake (%)
+30% GLY, heated, pH 12	15.24 ± 1.32	10.31 ± 1.00
+30% GLY, pH 12	20.35 ± 1.20	15.05 ± 0.73
+40% GLY, heated, pH 12	18.39 ± 1.94	15.70 ± 0.04
+40% GLY, pH 12	25.65 ± 0.69	15.98 ± 2.10
+50% GLY, heated, pH 12	18.93 ± 3.30	14.90 ± 0.66
+50% GLY, pH 12	29.50 ± 2.30	16.56 ± 0.77
+40% GLY, heated, pH 7	21.43 ± 0.32	9.12 ± 0.85
+50% GLY, heated, pH 7	33.27 ± 0.50	9.01 ± 0.72

Conclusions

- Rod-like microstructures, forming fine-stranded fiber-like matrices, obtained under alkaline conditions of MWPs lead to the production of handleable biomaterials without any heating and with a minimum concentration of GLY (30%)
- At pH 7 it was necessary to previously heat at 80°C for 25 min the MWP-containing FFS and to increase the GLY concentration at least 40% to obtain handleable biomaterials
- The developed experimental conditions allowed to produce hydrocolloid films with higher flexibility and transparency with respect to the MWP-based films obtained at pH 7 following FFS heat treatment

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