Cassava starch blends: Properties and potential application in tissue engineering

H.E.E. Tan[1], C.P. Lim[2], B.L. Ong[2], S.H. Teoh[3] and H.H. Yeoh[2]

[1]Department of Chemistry, [2]Department of Biological Sciences, Faculty of Science, [3]Department of Mechanical Engineering, Faculty of Engineering, National University of Singapore, Kent Ridge, Singapore 119260

Introduction

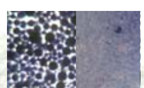
- Natural polymers have advantages over synthetic ones for tissue engineering, being non-toxic, biodegradable, amenable to fabrication, biocompatible, affordable etc.
- Starches from corn and potato have been exploited. Why not cassava starch?
- Could be an additional boost for cassava into the world markets for starches.

Objectives

1. Investigate the contribution of amylose and amylopectin in pasting and gel properties of cassava starch and its blends.
2. Evaluate the mechanical properties of non-plasticized and plasticized films, and fabrication of water-stable films.
3. Assess if starch film is suitable as medium for growth of human chondroycte cells.

Starch blends with defined amylose/amylopectin ratios

Cassava/ Amioca		Ratio amylose/ amylopectin
Proportions of starch		
Cassava	Amioca	
1	0	0.68
3	1	0.50
2	2	0.36
1	3	0.25
0	1	0.15

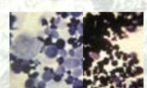


Cassava starch

Cassava/ Hylon VII		Ratio amylose/ amylopectin
Proportion of starch		
Cassava	Hylon VII*	
1	0	0.68
3	1	0.68
2	2	0.68
1	3	0.68
0	1	0.00

Amioca starch

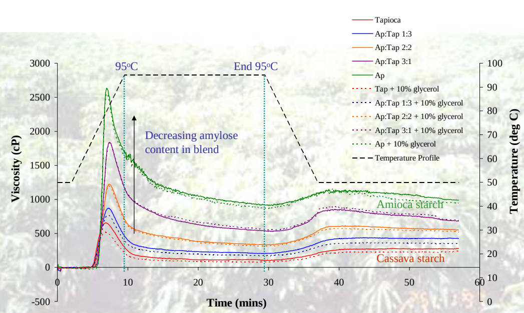
Amioca/ Hylon VII		Ratio amylose/ amylopectin
Proportion of starch		
Amioca	Hylon VII*	
1	0	0.15
3	1	0.15
2	2	0.15
1	3	0.15
0	1	0.00



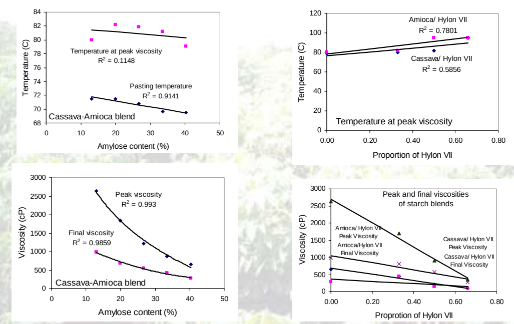
Hylon VII starch

*Hylon VII starch granules did not gelatinize

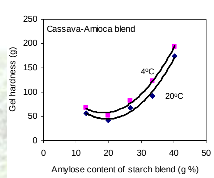
Pasting profiles of cassava-Amioca starch blends

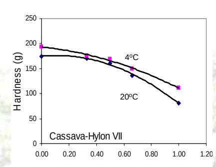


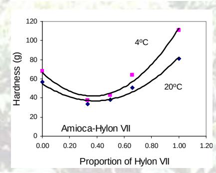
Amylose content and presence of non-gelatinized starch granules have impact on pasting properties of starch blends



Gel properties of starch blends: Hardness

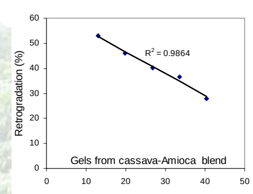


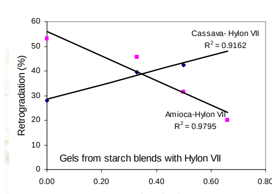




1. Marginal increase in hardness of gels kept at 4°C
2. Gel hardness increase with higher cassava starch fraction for cassava-Amioca blend (increasing amylose content)
3. Hylon VII fraction also impact on gel hardness

Gel properties of starch blends: Retrogradation





- Cassava starch exhibited better resistance to retrogradation
- Increase amylose content lead to lower percent retrogradation

- Increase Hylon VII in cassava starch blend ended with gels having higher retrogradation property
- With Amioca-Hylon VII, increase in Hylon VII resulted in gels with lower retrogradation

Air-dried films from starch blends

Film thickness

Non-plasticized films 0.18 ± 0.01 mm

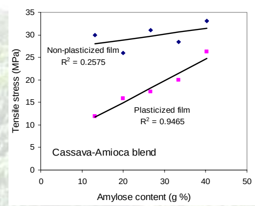
Plasticized films 0.17 ± 0.01 mm

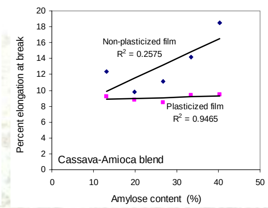
Hylon VII starch and blends containing high proportion of Hylon VII are not amenable to forming films. Therefore, these are not useful as scaffolds for tissue engineering.

Non-plasticized films are more brittle.

Cassava starch film broke under when it was bent to test its flexibility.

Mechanical strength starch films from cassava-Amioca blends
Tensile stress and elasticity





1. Plasticized films exhibited lower tensile stress values
2. Tensile stress of starch films can be increased by increasing amylose content (cassava starch).

1. Non-plasticized film can be subjected to higher degree of strain compared to plasticized film.
2. Plasticized films from different starch blends withstood similar level of strain applied

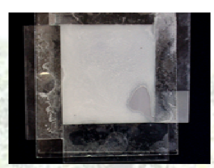
Stability of starch films in aqueous environment

Gel cast films swelled and eventually disintegrated in aqueous medium. The structural instability in aqueous medium make them unsuitable as scaffolds for cell growth. An another approach must be found to prepare water stable film.

Non-plasticized film in aqueous medium lost its shape and could not be retrieved.

Plasticized gel cast film soaked in aqueous medium loses its form

Water-stable starch film by gel extrusion method



- 4 g cassava starch, 1g glycerol and 2ml water heated at 80°C for 10 minutes.
- Film formed is about 1.2 mm
- More elastic compared to gel cast film. Lower modulus and more flexible.

- Structurally more stable in aqueous solution
- Mechanical stability starts to weaken after 9 days in aqueous solution but film could be kept intact for up to 2 weeks.

Water-stable starch films and cell growth

Set up for cell growth experiment

Starch film	Cell Viability (540 nm)		
	Day 1	Day 2	Day 3
Cassava	2.17	2.27	1.25
Corn	2.23	2.00	1.60

Viability of human chondrocyte cells were assessed using a MTS based cell assay kit (Celltiter 96 ® Aqueous One Solution Cell Proliferation Assay Kit (Promega Corp, USA)).

Conclusion

1. Cassava starch can be used to create blends giving rise to a range of gel properties and films of specific mechanical strengths.
2. Ratios of amylose/amylopectin of starch blend influence the preparation and final outcome of the gel and films. Such information is useful in crafting gels or films of specific mechanical strength that may be suitable for use as tissue scaffolds.
3. Starch films prepared by extrusion method are water stable and they can support growth of human chondrocytes cells.
4. Cassava starch has potential use as biomaterial for tissue engineering and should be further exploited.

Thank you

Acknowledgement

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