3D-Forming of Extruded Seaweed Film

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Scan me!

Research Question

Seaweed is a biomaterial which is not only loved for its fast growth rates, but also for their content of natural polymers. At the same time, **single use plastic packaging become more restricted**: e.g. from January 2030 single use plastic packaging for condiments, sauces or cream will be forbidden in Europe[1].
The possibilities for the direct use of the whole seaweed biomass in packaging are worth to be explored.

How can seaweed biomass be used in packaging applications?

Schmidtchen et al.[2] developed a **semi-dry extrusion method** for red seaweed. This enables us to use the whole organism for the production of the seaweed film, without chemical extraction. Through the **high pressure and intensive shear forces** inside the extrusion chamber, the natural polymers of the seaweeds gelatinize and form a homogeneous slurry. Mechanical pretreatment can improve the homogeneity of the material.

Sure – solutions are already here!

Fig 1: Maki Sushi wrapped in Nori (seaweed)
Image by Tim Reckmann [3]

But where do I put the soy sauce?

Press-forming is a mechanical 3D-forming process which **transforms even blanks to hollow cup shaped objects**. The film remains solid during the forming process.

Conclusions

- extruded seaweed film suits press-forming process
- appealing features such as sealing rim and elevated bottom possible
- proven compression stability
- large potential for packaging applications

Methods and Materials

A **press-forming** setup for the forming of round cups was developed. The tooling consists of a **punch**, a heated matrix with a **cavity** and a **blankholder**. All tools are made of stainless steel. An optional PTFE film can reduce the friction between blankholder and the film.

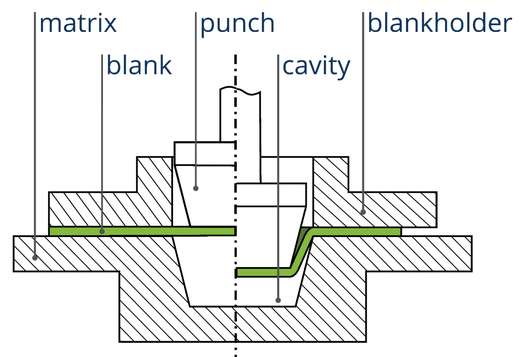
The experiments were conducted with a 0.5mm thick seaweed film extruded from **red seaweed granulate (*Eucheumatoids*), water and glycerol.**

Seaweed [a] **new!**
Ø48mm x 32mm

Polylactic Acid [b]
Ø40mm x 32mm

Paper [c]
Ø50mm x 34mm

Bagasse [d]
Ø53mm x 30mm



initial state: seaweed film blank clamped between blankholder and matrix

in-process view: punch pushes onto the blank, which then slides into the cavity

Fig 2: Press-forming of a cup from seaweed film

Results and Discussion

It is possible to use the press-forming process for the production of seaweed based cups. In compression tests, the cups performed better than paper-based or polylactic acid - based alternatives. **The press-formed seaweed cups offer decent stability.**

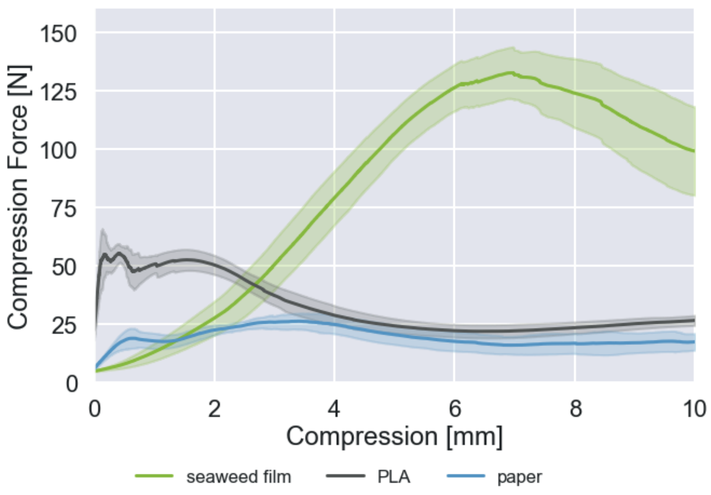


Fig 4: Compression testing as in DIN 55440-1:10-2019 (compression speed v_c= 10mm/min), envelopes show standard deviation

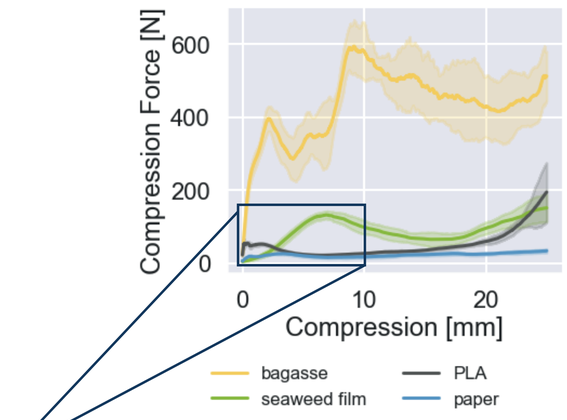


Fig 3: Compression testing as in DIN 55440-1:10-2019 compression speed (v_c=10mm/min), envelopes show standard deviation

Main Process Parameters:

- material conditioned at 85% r.h. , 23 °C
- T_{cavity} = 90°C
- max. $F_{blankholder}$ = 71 N
- Max. F_{punch} = 20 000 N
- v_{punch} = 4 mm/s

Cups with **height-to-bottom-ratio of 0.75** were manufactured.

The surface areas of the blank was larger than surface area of the final cup. When the material begins to slide into the cavity, **wrinkles appear in the upper part.** The large compression in the wrinkled areas and additional heat input consolidate the 3-dimensional shape.

The **lower section is even and free of wrinkles**. This area originates in material elongation of the seaweed film caused by tensile stresses at the beginning of the press-forming.

Footnotes:

[a] own manufacturing, extrusion film by Brabender GmbH
[b] "PLA-Portionsbecher 30 ml, Ø 45 mm ", GREENBOX GmbH & Co. KG
[c] "Papier-Becher 60 ml, weiß", GREENBOX GmbH & Co. KG
[d] "Zuckerrohr-Becher 50 ml, Ø 62 mm, rund", GREENBOX GmbH & Co. KG

Literature:

1 Ragonnaud, Guillaume. 2024. 'Briefing - Revision of the Packaging and Packaging Waste Directive'. Edited by European Union.
2 Schmidtchen, Ludwig, Michael Y. Roleda, Jens-Peter Majschak, and Matthias Mayser. 2022. 'Processing Technologies for Solid and Flexible Packaging Materials from Macroalgae'. *Algal Research* 61 (January): 102300. https://doi.org/10.1016/j.algal.2021.102300.
3 Tim Reckmann from Hamm, Deutschland, CC BY 2.0 <https://creativecommons.org/licenses/by/2.0>, via Wikimedia Commons

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