Chapter 31

SEAWEED FOAM: A Bio-foam Material for a New Type of Home-compostable Packaging Products

Austėja Platūkytė

Vilnius Academy of Arts, Vilnius, Lithuania

Abstract

The global burden of synthetic packaging waste persists because durable plastics are used for disposable products. Emerging decomposable foams made from cornstarch raise ethical concerns by diverting food resources while hunger remains. SEAWEED FOAM presents an alternative: a fully organic, home-compostable material derived from seaweed that requires no arable land and is suitable for packaging. This approach supports the European Green Deal by reducing pollution and improving resource efficiency.

Using design-oriented research methods, the project engineered a homogeneous bio-foam by processing seaweed waste. The material's suitability for diverse packaging uses was assessed with emphasis on performance under environmental stressors such as moisture and sunlight. Prototypes were fabricated, rigorously tested in these conditions, and exhibited at international design shows, where user feedback informed iterative refinements.

Results indicate that SEAWEED FOAM enables home-compostable secondary packaging—cushioning, packing peanuts, and protective padding—for consumer products like backpacks and helmets. Free of harmful additives, the material is non-toxic, safe, and even edible. It maintains structural integrity under adverse conditions and offers strong impact resistance and cushioning that meet disposable packaging requirements, protecting goods during transport and storage. After use, it can be home-composted or used as fertiliser, returning harmlessly to natural systems. Overall, the research demonstrates the practicality and environmental value of SEAWEED FOAM as a significant advance in sustainable bio-foam packaging.

Keywords: *Seaweed Foam; Compostable Packaging; Packaging Design; Renewable Resources; Circular Design*

Introduction

Single-use packaging often outlives the task it performs. From a design viewpoint, the brief is to align material lifetimes with use lifetimes while preserving protection, tactility and brand experience. Starch foams indicate a route away from petro-plastics but remain tied to edible crops, an uneasy fit for circular design.

Seaweed sets a different brief: it grows in the ocean without irrigation or fertilisers and does not compete with arable land. SEAWEED FOAM explores a material system made only from seaweed and water[1]. A

[1]Food and Agriculture Organization of the United Nations (FAO), "Seaweeds Used as a Source of Agar," accessed 8 September 2025, https://www.fao.org/4/y4765e/y4765e05.htm

DOI: 10.18502/rq457c78_31

pourable paste is cast in design-led moulds and air-dried into lightweight, cushioning parts with a natural surface feel. The intention is twofold: (1) material adequacy for secondary packaging in short delivery journeys and everyday handling; (2) clear communication of a benign end-of-life that reduces "eco-guilt" at disposal. This direction aligns with EU policy objectives under the Packaging and Packaging Waste Regulation (PPWR)[2].

Problem Framing

For protective packaging, fitness-for-use sits at the intersection of:

- Tactility and sound (how it feels/sounds when handled, opened and discarded)
- Functional assurance (cushioning, scuff resistance, shape retention through delivery)
- End-of-life clarity (disposal that is intuitive, local and guilt-free)

Conventional foams score highly on assurance but poorly on end-of-life. Biodegradable starch foams improve end-of-life yet entangle packaging with food systems. Using non-food marine biomass, SEAWEED FOAM addresses this mismatch while retaining familiar, reassuring handling cues.

Materials and Methods

Seaweed Species and Sourcing

The bio-foam is formulated from seaweeds available in the Baltic region—primarily red algae (e.g., *Furcellaria lumbricalis*)[3] and brown algae of the genus *Fucus* (Figure **1**).

Figure 1: Baltic seaweed feedstock. Brown macroalgae (*Fucus spp.*) are used alongside regional red species (*Furcellaria lumbricalis*) in current sourcing.

[2]European Commission, "Packaging and Packaging Waste Regulation (PPWR) — overview," accessed 2 September 2025, https://environment.ec.europa.eu/topics/waste-and-recycling/packaging-waste/packaging-packaging-waste-regulation_en

[3]M. Saluri et al., "Structural Variability and Rheological Properties of Furcellaran," *Food Hydrocolloids* 113 (2021)

To ensure consistency and scalability, collaboration is in place with Estonian suppliers of furcellaran (a naturally gelling seaweed extract) and Norwegian alginate suppliers[4]. Where appropriate, well-characterised by-products (e.g., fine fibres) are incorporated. This keeps sourcing regional and non-food, avoids ad-hoc beach-cast dependence, and leverages existing industrial quality control (local collections, if used, follow permits and specification checks).

Formulation and Processing

A straightforward studio-to-pilot workflow is used. A seaweed-based mix is hydrated and blended to a pourable paste, then cast into silicone or rigid moulds (S/M/L/XL) or spread as sheets for inserts.
Parts are air-dried at ambient or with gentle airflow and demoulded (Figure **2**); off cuts are returned to the wet mix to minimise waste. Air-drying also produces a fibrous, lightweight cell microtexture that contributes to the material's natural tactility (Figure **3**).

Figure 2: Cast rectangular pad: Air-dried pad for lining/spacing; dimensions are set by the mould family.

Figure 3: Surface microtexture: Fibrous, lightweight cell structure from air-drying gives a natural tactility.

[4]R. Abka-khajouei et al., "Structures, Properties and Applications of Alginates," *Polymers* 14, no. 12 (2022), https://doi.org/10.3390/polym14122452

Form-giving is prioritised over additives: dimensions are selected via the cavity rather than by changing the recipe. For air-dried parts single-wall sections are kept to about 2 cm to support even drying and shape stability; thicker pieces can be built up by laminating thinner layers. The mould library acts as a design system, enabling families of parts without proliferating formulations.

Design Methods

A combination of research-through-design (RtD), material-driven design (MDD) and the Double Diamond structured the work:

- Discover — desk research, material probes (swatches at varying thickness/density) and bodystorming of packing/unboxing rituals to surface tacit needs (e.g., low dusting on dark garments; clean handling).
- Define — a brief matrix balancing cushioning targets, humidity tolerance, sensory expectations and on-pack communication; definition of two archetypes (pads/blocks, loose-fill) and a family of moulds.
- Develop — iterative prototype loops (sketch → mould → air-dry → handle → adjust), guided by a simple scoring sheet covering feel, edge integrity, dusting, odour neutrality, squeeze recovery, shape retention after brief moisture contact, and disposal clarity.
- Deliver — public showings and co-evaluation with designers, brands and logistics partners; refinement of plain-language disposal messaging and use-scenarios (e.g., cosmetics, small electronics, refills).

Performance Evaluation

Prototypes were evaluated in the ways people handle packaging: grip, stack, squeeze and short drops for small parcels; brief exposure to daylight and steamy rooms; and home-compost checks for end-of-life. To broaden stakeholder input, prototypes were presented at Prototypes for Humanity during COP28 (Dubai, 28–30 Nov 2023), MaterialDistrict Utrecht (8–10 Mar 2023; 6–8 Mar 2024), and the EU Strategy for the Baltic Sea Region Annual Forum 2023 (Riga, 4–5 Oct 2023). Feedback from designers, architects, brand owners and policymakers informed refinements to density, surface finish and geometry.

Industry Engagement

Since 2023, SEAWEED FOAM has attracted inquiries and evaluation requests across consumer goods, mobility, packaging, hospitality and design. Interested parties include Unilever, CHANEL, Toyota, Aston Martin Lagonda Ltd, Normann Copenhagen, MAX Luxury Packaging, Semcon Sweden AB, WFN Fish Farm (Nova Scotia), Thermowave Packaging, EstraHub (thermal insulation), EDRINGTON, PENTATONIC, TVS Motor Company Ltd, Merveyl Hotel Supplies, CARRE BASSET, Luna & Solis, Sakshi Innovations and Threadz NOLA (upholstery). Additional interest came from material libraries, research projects and independent designers. These engagements focus on void-fill, bottle cushioning and pads/blocks, and inform pilot validation in fulfilment environments.

Results

SEAWEED FOAM parts retained shape and cushioning behaviour after short-term humidity/light exposure, typical of last-mile logistics. Hands-on trials also demonstrated the material's suitability for loose-fill applications, where it surrounds products and fills voids in a standard e-commerce box (Figure **4**). In home-compost settings, samples fragmented and disintegrated within a short horizon (target ≤ 180 days)[5] without visible residues. The recipe is benign and simple (seaweed + water). User feedback highlighted pleasant tactile warmth, low dusting, and clear disposal messaging.

Figure 4: Loose-fill "packing peanuts" in use. Seaweed foam surrounds products and fills voids in a standard e-commerce box.

Industrial Scalability and Input Volumes

At pilot scale two archetypes were produced: (i) rectangular pads/blocks in multiple sizes for lining and spacing, and (ii) loose-fill "packing peanuts." Pads slide straight into everyday packing workflows, while peanuts behave like conventional loose-fill. Dimensions are standardised via a shared mould set that maps to parcel formats. Off-cuts, where present, are returned to the wet mix. Co-location with packaging partners or seaweed processors shortens logistics and supports small, local runs as demand grows. Pilot deployments with partners will validate handling and cushioning in fulfilment, followed by third-party home-compostability and safety certification.

Environmental and Safety Considerations

The bill of materials is seaweed + water, free from harmful additives. After use, parts are home-compostable and may serve as a benign soil amendment. Production avoids petrochemical monomers and arable land, supporting circularity goals. Future work includes a full life-cycle assessment (LCA) and certification under recognised home-compost schemes, alongside transparent on-pack guidance

5ÜV AUSTRIA, "OK compost HOME — Certification Scheme," accessed 2 September 2025, https://en-trustit.tuv.at/ok-compost-home-en/

for disposal or simple re-use. Figure **5** symbolically evokes the material's marine origin and a benign end-of-life narrative, suggesting reintegration into natural systems rather than persistence as pollution.

Figure 5: End-of-life narrative (symbolic): Visualising a benign material story; this is not a disposal pathway—home compost is the intended end-of-life.

Discussion and Limitations

SEAWEED FOAM is a material-system guided by non-food circularity, home-compostable by design, and credible tactility. In this study, performance comes from cast form and sizing rather than additives, with two practical archetypes: pads/blocks for lining/spacing and loose-fill for void-fill (dimensional constraints and lamination options in Section 2.2). During demonstrations, plain-language disposal guidance ("home-compost or place with organic waste where permitted") and a simple bill of materials (seaweed + water) helped build trust.

Performance can drift under prolonged high humidity; seasonal differences in seaweed supply require clear specs for consistency; and drying efficiency should continue to improve (better airflow, heat recovery). Standard-based lab tests (impact curves, creep, compost disintegration) are in progress. On the experience side, continued refinement of CMF (colour–material–finish) supports consistent aesthetics and odour neutrality.

Conclusion

SEAWEED FOAM reframes protective packaging as a designable, bio-based system rather than a petrochemical default. Regional species and sourcing are specified, homogeneous parts that provide effective cushioning and short-term stability are demonstrated, and validation through public demonstrations and industry engagement is documented. The contribution is threefold: (1) clear principles for non-food, home-compostable packaging; (2) form-first, casting-led strategies that deliver performance with a minimal recipe; (3) a modular, converter-ready pathway suitable for distributed capacity. Next steps include standardised testing, refined end-of-life messaging and pilot deployments with partners—advancing a designed route to compostable protective packaging that returns safely to the biosphere after use.

Acknowledgements

This work was supported by the "Promotion of Competence Centre Activities: Vilnius Academy of Arts Entrepreneurship Programme" (Project No. 01.2.2-CPVA-K-703-04-0002, 2021), and by Cultural and Creative Industries: Cultural Startups 2023-1, "Dissemination, market entry and promotion in Lithuania and abroad of a seaweed-based biodegradable packaging material."

References

Abka-Khajouei, Roya, Latifa Tounsi, Nasim Shahabi, Anil Kumar Patel, Slim Abdelkafi, and Philippe Michaud. 29 May, 2022. "Structures, Properties and Applications of Alginates." *Marine Drugs* 20 (6): 364. doi:10.3390/md20060364.

European Commission. 2023. "Packaging and Packaging Waste Regulation (PPWR) — overview." Accessed September 8, 2025. https://environment.ec.europa.eu/topics/waste-and-recycling/packaging-waste/packaging-packaging-waste-regulation_en.

Food and Agriculture Organization of the United Nations (FAO). "Seaweeds Used as a Source of Agar." Accessed September 8, 2025. https://www.fao.org/4/y4765e/y4765e05.htm.

Mihkel Saluri, Kadri-Liis Kaljuvee, Tiina Paalme, Indrek Reile, and Rando Tuvikene. 2020. "Structural Variability and Rheological Properties of Furcellaran." *Food Hydrocolloids* 111 (August): 106227–27. https://doi.org/10.1016/j.foodhyd.2020.106227.

TÜV AUSTRIA. "OK compost HOME — Certification Scheme." Accessed September 8, 2025. https://en-trustit.tuv.at/ok-compost-home-en/