Applicability of bio-based polymer packaging in the meal kit context

A case study with HelloFresh

Executive Summary

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Introduction and Research Questions

Plastic – a ubiquitously utilized material of modern lifestyle. It offers the perfect combination of unequalled functional properties, low cost and broad applicability. Yet, the environmental impacts of plastic production and waste are slowly becoming too big to repair. As an alternative, bio-based plastics are increasingly penetrating the market, promising reduction of resource depletion by decoupling the production from fossil feedstocks. Besides, compostability is a catching asset, leaving consumers to believe that a material will simply biodegrade in nature.

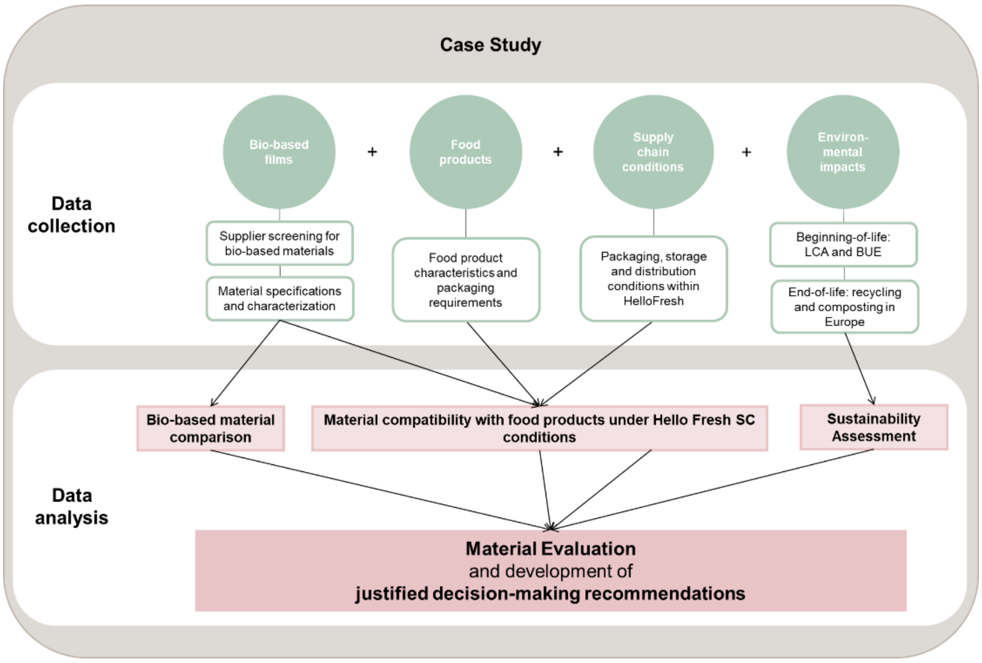
Hitherto, the applicability of bio-plastics has rarely touched upon the field of food packaging, due to limited barrier and mechanical properties. The aim of this thesis is to study:

1. *The extent to which bio-based packaging films are applicable for food packaging in the meal kit industry context* and
2. *In how far the application of bio-based materials contributes to a more sustainable packaging approach*

The study was conducted in cooperation with HelloFresh as an exemplary large-scale meal kit provider. The applicability was investigated for 3 product categories: Bakery products (BAK), fresh herbs (HERB) and ground spices (SPI).

Methodology

The study was conducted as a case study, split into three analysis parts.



A selection of 6 material types (starch-based, cellulose based, polylactic acid (PLA), polyhydroxy alkanoates (PHA), bio-based polyethylene (BioPE) and bio-based polybutylene succinate (BioPBS) were compared in terms of bio-based content, level of compostability, recyclability, industrial availability and transparency. Barrier properties (oxygen transmission rate (OTR) and water vapor transmission rate (WVTR)) were compared to conventional plastics. Furthermore, the shelf-life determining factors of the food products were identified, as well as the product specific storage and distribution conditions within HelloFresh. Based on that, packaging requirements were determined. The requirements were then aligned with the bio-based material barrier properties to identify potential material candidates. Moreover, the *Norner* barrier calculator tool was used to simulate the shelf life performance of the product-packaging systems, taking the supply chain conditions and packaging sizes into consideration. Currently applied packaging materials at HelloFresh were used as reference materials for this simulation. The environmental assessment was split into two parts: the beginning-of-life (BoL) phase and the end-of-life (EoL) phase. The BoL was evaluated by means of the global warming potential (GWP) and cumulative energy demand (CED) as well as the biomass utilization efficiency (BUE). In terms of EoL assessment, post-consumer plastic packaging waste recycling was compared to the likelihood effective compostability by evaluating insights about composting plant operations in Germany, France, the Netherlands and the UK.

Eventually, overall material preference recommendations were determined.

Results and Discussion

The study proved that most currently available bio-based films exert overall weaker barrier properties compared to conventional plastics. Following the product characterization, BAK and HERB products theoretically benefit from weaker barrier properties offered by bio-based materials, especially lower water vapor barriers, providing naturally occurring anti-mist properties. SPI on the other hand require both high gas and water vapor barriers.

Nevertheless, the study revealed limited applicability of bio-based films at current shelf life conditions at HelloFresh. Logistical challenges and procurement strategies do not allow just-in-time delivery for all product categories, thus the required shelf lives for the considered products were found to be 30 days for BAK, 8-10 days for HERB and 12-18 months for SPI.

To avoid the risk of food waste, it is of high priority to provide adequate product protection in order to reach the required shelf life. Therefore, the following material candidates were identified: HERB category is predicted to be compatible with all considered materials, except BioPBS and PHA, while the compatibility for BAK and SPI is limited to two identified high-barrier cellulose-based films. Additionally, BioPE is expected to be applicable for BAK, provided that BAK products are stored at frozen conditions for the majority of the supply chain duration. Practical shelf life tests need to be conducted to verify the predictions.

With regards to the environmental assessment, the BoL analysis has shown that most bio-based polymers outperform fossil-based counterparts in terms of GWP and CED. Starch-based and cellulose-based polymers proved to be most efficient in terms of biomass utilization amongst their bio-based competitors.

However, the outlooks for EoL options for bio-based materials, are rather disillusioning. Most bio-based packaging materials are intended to be disposed in industrial or home composting facilities, except for BioPE which is considered as a drop-in material that can be recycled in existing recycling streams. Yet, the study proved that compostable plastics, despite carrying the compostability certifications, are rarely compatible with composting facilities in Germany, the Netherlands, France and the UK at current stage. Effective composting is hence an unlikely scenario, resulting in the materials being sent to landfill or incineration. Similarly, recycling is not an option, since compostable materials require designated recycling streams, which have not been implemented in Europe's waste infrastructure yet.

Considering the small likelihood of compostability, recyclability in existing recycling streams turns out to be a preferred material feature. Yet, the probability of effective recycling is reduced once considering a packaging *film* which is likely to be *contaminated with food residues*. The choice of material and hence the choice of EoL is thus dependent on the product to be packaged. BioPE is preferred as a recyclable option. However, if excessive food contamination residues avert recycling, cellulose-based films are recommended as a compostable alternative.

Conclusion and future research recommendations

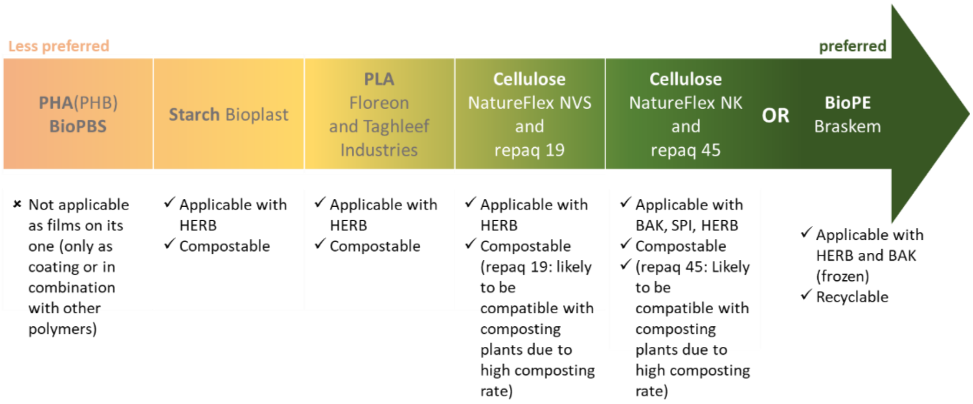
The following decision making priorities were set:

product protection >>> arbitrary packaging reduction

recyclability >>> compostability

bio-based >>> fossil-based

The below material preference recommendation was developed.



Investigations bio-based material applicability for further food products is recommended, especially for products with low chances of recyclability, such as meat and dairy. Further, opportunities for recyclable and/or recycled materials should be investigated. Concerning the meal kit industry, it is also recommended to explore potential optimization of the secondary packaging, e.g. improving volume and weight efficiency or the potential of implementing a packaging return system.