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SUMMARY

Plastic is versatile, durable and inexpensive material and thus the majority of food products are packed in either rigid or flexible plastics. Nevertheless, using plastic in food packaging has its limitations in terms of environmental impacts and sustainability. Therefore, bioplastic has emerged as an alternative material for traditional plastic. Bioplastics refer to plastics derived from biomass materials, biodegradable plastics, or plastics that feature both properties. This report investigates the present and future demand and market volume of food packaging materials and substitutes for them in the form of bioplastics to understand the food packaging plastic market and the potential of bioplastics in changing the market structures. The rivalry and attractiveness of the industry and the collaboration between different actors in the market are further discussed.

Traditional plastics are suggested to preserve their position in food packaging, but bioplastics are regarded as a prospective material substituting them. The bioplastic industry is steadily growing with the benefits of environmentally friendly and sustainable attributes for food packages. The global bioplastic production is predicted to rise from 2.05 million tonnes to 2.44 million tonnes in 2022 and thus the bioplastic industry is attracting new raw material suppliers, packaging producers, and food producers to enter the market. The increasing interest to utilize bioplastics is primarily driven by the demand of consumers for sustainable brands that are more aware of the impact of traditional plastics on the environment. Nevertheless, to this day, bioplastics have remained expensive material with poor functionality and performance. The change towards bioplastics is further challenged by the existing supply networks and collaborations. Long-term collaboration and contracts characterize the relationships in the existing food packaging supply chains, which tend to engender barriers for new firms to enter the market. The transition from traditional plastics towards bioplastics might further require changing the actors in the food packaging supply chain in both directions – upstream and downstream. Specifically, in the change towards later generation bioplastics, derived from non-food crops and agricultural waste, the restructuring of the value chain and new actors entering the market with feasible business models to develop technologies that transform these feedstocks into biomaterials and to gather and distribute the food waste may be critical.

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ACRONYMS AND ABBREVIATIONS

ABS	Acrylonitrile butadiene styrene
EU	European Union
EY	Ernst & Young
IfBB	Institute for Bioplastics and Biocomposites
HDPE	High Density Polyethylene
PA	Polyamide
PC	Poly carbonate
PE	Polyethylene
PEF	Polyethylene furanoate
PET	Polyethylene terephthalate
PHA	Polyhydroxyalkanoate
PLA	Polylactic acid
PP	Polypropylene
PS	Polystyrene
PUR	Polyurethanes
PVC	Polyvinyl chloride

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1. INTRODUCTION

Package design and its manufacturing process are essential in determining the shelf life of food products. The right packaging materials and technologies preserve product quality and freshness during distribution and storage. (Marsh & Bugusu 2007.) In food packages, traditional materials used are glass, metal, paper and board, and plastic. Specifically, by being versatile, durable and inexpensive material, plastic dominates the food industry regarding packing (Quantis 2018; Muncke 2012). That is, the food packaging industry has witnessed strong growth in using rigid and flexible forms of plastic materials (Marsh & Bugusu 2007). The characteristics of plastic make it extremely functional in protecting and preserving food from external and internal factors harming the product (Mihindukulasuriya & Lim 2014).

Relying on plastic has though its drawbacks. The plastic industry forms 6% of global oil consumption with the estimation of increase for 15% of the global yearly carbon budget by 2050 (Quantis 2018). This reflects the dependency of the plastic industry on global energy prices and their volatility. Furthermore, the growing environmental awareness requires that packaging films and the process include user- and environmentally friendly attributes. It is thus increasingly important to search for alternative materials for food packaging. (Siracusa et al. 2008.) To address this, the food, packaging and distribution industry has shown its interest in the development of bioplastics in packing food (Peelman et al. 2013). In this report, *bioplastics* refer to plastics that biobased, biodegradable, or feature both properties (European Bioplastics 2018a). Biobased materials are produced from renewable biomass materials, which are not always biodegradable, whereas biodegradable plastics are either made of natural or fossil resources (Food Packaging Forum 2014).

This report investigates the present and future demand and market volume of food packaging materials and substitutes for them in the form of bioplastics to understand the food packaging plastic market and the potential of bioplastics in changing the market structures. The rivalry and attractiveness of the industry and the collaboration between different actors in the market are further discussed. (D1.1) The purpose of this report is addressed by applying the framework from Porter, which is designed to understand the industry rivalry and attractiveness.

This report is structured as follows. The report begins with the introduction to the food packaging industry and the trends influencing its future. Furthermore, the purpose and perspective of this report are presented. The research materials and methods applied to understand the food packaging plastic market are then described. The results of this report are discussed by reviewing the demand and market volume of existing and substitutive materials in food packaging and their advantages and disadvantages. The report further describes the rivalry and attractiveness of the food packaging plastic industry and the collaboration in food packaging supply chains. Finally, the results are summarized and their implications presented.

2. MATERIALS AND METHODS

Qualitative research methods are used to analyze the food packaging plastic market. Qualitative methods permit holistic and rich descriptions of researched events (Stake 1995, 47), which are problematic to define through specific variables (Gephart 2004). Qualitative research methods aid in describing, understanding and explaining the human interactions, meanings and processes creating real-life organizational settings (Gephart 2004).

The primary data was acquired through four qualitative thematic interviews for individuals from firms and organizations participating in the food packaging plastic industry (Tab 2.1). In this type of interviewing, interviews rely on a specific agenda, but they are merely lightly structured and the interviewer is free to attend on new ideas, probe responses and request for clarifications during the interview (Arksey & Knight 1999, 7) (Appendix 1). With strong personal interaction in qualitative interviews, some ethical issues might appear when using private discussions for public purposes (Kvale 2006). The interviews were therefore executed ethically and the identities of interviewees were kept private.

Tab 2.1 Qualitative interview data.

Role in the food packaging plastic industry	Informant(s)	Interview details
Food Producer	R&D Director and two Product Technicians	4.9.2018, 30 minutes
Food Producer	Innovation Manager	8.10.2018, 60 minutes
Material Producer and Package Designer	R&D Engineer	14.8.2018, 90 minutes
Consulting Organization	Senior Sustainability Consultant	12.9.2018, 55 minutes

The interview data were supplemented by information gathered from industry reports and statistics, web pages of the industry-related firms and organizations, and journal articles (Tab 2.2).

Tab 2.2 Written data.

Data provider	Data type	Data details
European Bioplastics	Written reports; web page	Bioplastics: Facts and figures (2013 and 2017); Driving the evolution of plastics; Bioplastics market data 2017; Bioplastics packaging - combining performance with sustainability: Materials and market development in the packaging segment; www.european-bioplastics.org
Ernst & Young (EY)	Written report	Unwrapping the packaging industry: Seven factors for success https://www.plastics.fi
Finnish Plastic Industries Federation Food Packaging Forum	Web page Written report; web page	Dossier – Bioplastics as food contact materials; www.foodpackagingforum.org
Institute for Bioplastics and Biocomposites (IfBB) Plastics Europe	Written report Written report; web page	Biopolymers: Facts and statistics 2017 Plastics - the Facts 2017; https://www.plasticseurope.org
Marsh & Bugusu (2007)	Article	Food packaging – Roles, materials and environmental issues. <i>Journal of Food Science</i> , 72, 39–55.
Siracusa et al. (2008)	Article	Biodegradable polymers for food packaging: A review. <i>Trends in Food Science & Technology</i> , 9, 634–643.
Peelman et al. (2013)	Article	Application of bioplastics for food packaging. <i>Trends in Food Science & Technology</i> , 32, 128–141.
Guecke, Groh & Muncke (2018)	Article	Food packaging in the circular economy: Overview of chemical safety aspects for commonly used materials. <i>Journal of Cleaner Production</i> , 193, 491–505.

In the data analysis, the purpose was to interpret meanings and make justifiable inferences from text and words (Weber 1990). The data were thus analyzed thematically (Miles & Huberman 1994), with the support of the framework of Porter on industry rivalry and attractiveness. In the thematic method, the researchers distinguish recurring patterns and themes to understand the similarities and differences in data (Miles & Huberman 1994, 246). The method strives for going further than just calculating words and phrases on identifying and describing implicit and explicit themes (Guest, MacQueen & Namey 2011, 9). The themes to analyze the food packaging plastic market were 1) the demand and market volume of existing and substitutive materials, 2) the rivalry and attractiveness of the industry for new market entrants, and 3) the collaboration in the market. The results of this analysis are discussed next.

3. RESULTS AND DISCUSSION

The results of this report are discussed in terms of 1) the demand and market volume of existing and substitutive materials in food packaging, 2) the industry rivalry and attractiveness for new market entrants, and 3) the collaboration in the market.

3.1 Food Packaging Materials

3.1.1 Existing Packaging Materials

Food products are packed in multiple different forms and materials, which are reliant on different technical requirements throughout the supply chain, and marketing needs and other criteria (Muncke 2012). In food packages, different materials are brought together to take advantage of each material’s functional and aesthetic properties (Marsh & Bugusu 2007). In the food industry, traditional packaging materials are glass, metal, paper and board, and plastic in both rigid and flexible forms. From these materials, it is estimated that 37 % of food products are packed in rigid and flexible forms of plastics, 34% in paper and boards, 11 % in glass, 15 % in metals, and 3 % in other materials (Muncke 2012). In the future, plastic is presumed to preserve its significant position in packing food products, but paper and board are potential substitutes for them. Paper and board are versatile materials for food packaging; that is, their mechanical strength, biodegradability, and printability are good. Nevertheless, besides their poor barrier properties to oxygen, carbon dioxide, and water vapor, the drawbacks of paper and board include being opaque, porous and not heat sealable. (Raheem 2013.) Paper and board are thus used for packing dry, frozen and fast food and in secondary packaging (Geueke, Groh & Muncke 2018), which reflect their potential to replace plastic in food packaging. Coating and waxing extend this usage to serving of wet and fatty food types (Geueke et al. 2018). Figure 3.1 shows the market shares of existing materials in food packaging (adapted from Food Packaging Plastic Forum 2012).

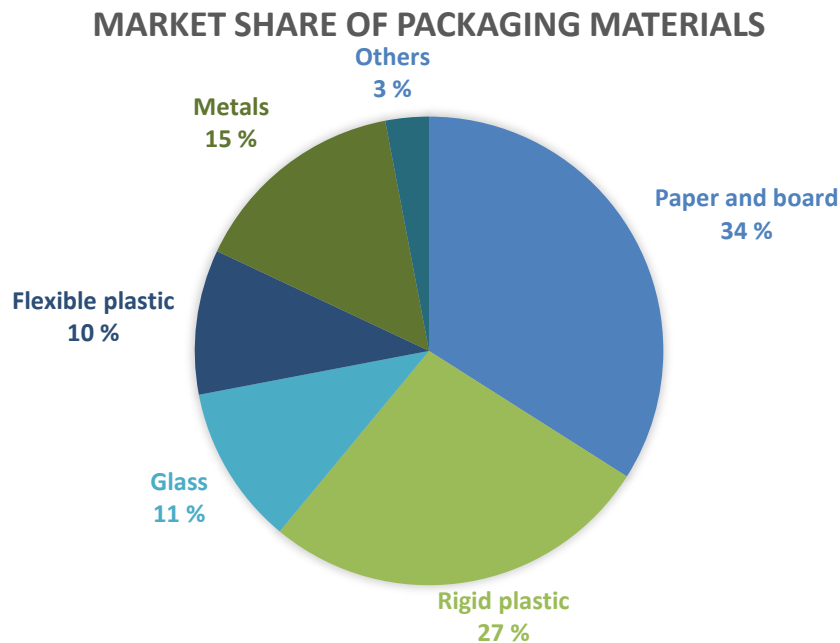


Fig 3.1 Market shares of packaging materials in food packaging (adapted from Food Packaging Plastic Forum 2012).

Plastic is versatile, durable and inexpensive material (Quantis 2018). Furthermore, the flexibility, strength, lightness, stability, impermeability, and ease of sterilization of plastic make it an ideal packaging material (Plastics Europe 2018) and thus it is an integral part of the food packaging industry (Geueke et al. 2018).

Plastic packages tend to include a wide variety of different polymer packaging materials, from which the most frequently used are polyethylene (PE), high density polyethylene (HDPE), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polystyrene (PS) and poly carbonate (PC) (Wagner 2012). In 2016, 60 million tons of plastic was consumed in Europe, from which 39.9% was used by the packaging industry. The demand for the most frequently used polymers in food packaging was 19.3% for PP, 17.5% for PE-LD and PE-LLD and 7.4% for PET. In 2017, the plastic industry grew dramatically, and although this growth is estimated to diminish, the upward trend of +2.5% is assumed for the year 2018. (Plastics Europe 2017.)

3.1.2 Substitutive Materials

Relying on plastic in food packaging has its drawbacks. In general, the plastic industry forms 6% of global oil usage and this is estimated to increase for 15% of the yearly global carbon budget by 2050 (Quantis 2018). This reflects the high dependency of the plastic industry on global energy prices and their volatility (Siracusa et al. 2008). The urge to reduce the dependency on fossil resources together with the growing environmental trend of transition towards a circular economy and to dispose of waste is thus challenging the food packaging plastic industry to search for alternative materials for packing food products (Finnish Plastic Industries Federation 2018; European Bioplastics 2013a). For that purpose, a promising substitute for traditional plastics has emerged – bioplastics (Quantis 2018). Bioplastics are different configurations of materials with differing properties and applications. In this report, *bioplastics* are determined as plastics that are biobased, biodegradable, or plastics that feature both properties (European Bioplastics 2018a.) Biobased materials are produced from renewable biomass materials, which are not always biodegradable, whereas biodegradable plastics are made of natural or fossil resources (Food Packaging Forum 2014).

The packaging segment is the largest market segment in the bioplastics industry (European Bioplastics 2017a) and bioplastics are an alternative material for packing food products. For example, biodegradable bioplastics are frequently used in short-lived applications, for example, biowaste bags and fresh produce packaging (European Bioplastics 2013b). Regarding both sustainability and the environmental impact of packaging, by being derived from renewable biomass materials, bioplastics aid in saving fossil resources, reducing CO₂ emissions, and delivering additional waste management and recycling options. Some life cycle analyses show that bioplastics tend to reduce CO₂ emission by 30–80%. This makes bioplastics a substitute for traditional plastics, specifically for industries aiming to minimize their environmental impact. (European Bioplastics 2013a.) For the food packaging industry, bioplastics further answer to the consumer demand. The interview excerpts reveal that the increasing interest in using bioplastics in food packaging is primarily driven by the demand of consumers for sustainable products and brands that are more aware of the impact of traditional plastics on the environment:

“So every industry -- is really under pressure regarding the packaging, in particular because we speak a lot about plastic leakages into the environment. -- So the consumers are really putting pressure on the industry about the type of packaging they use, the amount of packaging.” (Senior Sustainability Consultant, Consulting Organization)

“We are always the final user but we are pretty affected by the opinions of the consumers, and you know that the opinion of the consumers is -- the popularity of plastic is decreasing, a lot. So, the alternative is bioplastics.” (Innovation Manager, Food Producer)

The other actors encouraging food producers to change into bioplastics are retailers. Large retailer firms and distributors may require from their partner environmentally friendly products and packaging.

Nevertheless, bioplastic is not always better for the environment. That is, if fertilizers and pesticides are utilized to produce food products required in the production of biomass materials, there tend to be other kinds of environmental impact on the diversity of ecosystems. (Quantis 2018.) Therefore, to moderate the effect of bioplastic production to the environment, researchers and firms are trying to search for ways of producing new kinds of biomass materials, which are derived from non-food crops and agricultural waste. In the literature, these are referred to as later generation bioplastics whereas 1st generation bioplastics are

plastics made from carbohydrate-rich plants; that is, food crops, for example, wheat and potato. (European Bioplastics 2018a.)

Bioplastics present roughly 1% of the 320 million tonnes of yearly plastic production. Nevertheless, with more sophisticated biopolymers, applications, and new and innovative products and materials emerging, the demand for bioplastics is increasing and the market is unremittingly growing. (European Bioplastics 2017b.) Specifically, European Bioplastics and the nova-Institute (2018a) suggest that global bioplastic production may rise from 2.05 million tonnes to 2.44 million tonnes in 2022. The bioplastic industry has thus been characterized by a high and steady growth of 20–100 % per year (European Bioplastics 2013a). Regardless of the increasing bioplastic production, the breakthrough of bioplastics is merely on the way (Finnish Plastic Industries Federation 2018). Figure 3.2 illustrates the global production of bioplastics by material type in 2017 (adapted from European Bioplastics 2018a).

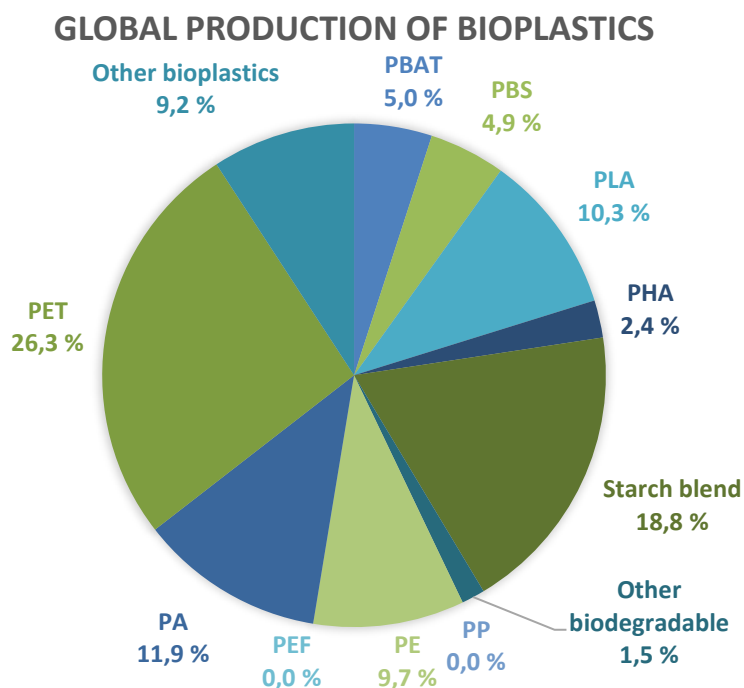


Fig 3.2 Global production of bioplastics by material type in 2017(adapted from European Bioplastics 2018a).

Specifically, at present, polyhydroxyalkanoates (PHA) are entering the market at commercial scale, with the production that is estimated to triple in the next five years. The production of polylactic acid (PLA) is further predicted to grow by 50% by 2022. The polyethylene (PE) production is similarly expected to rise, whereas the production of polyethylene terephthalate (PET) has not increased at the rate presumed in previous years. Instead, the polymers of polyethylene furanoate (PEF) and bio-based PP are alleged to enter the market with strong growth potentials. Biobased polyurethanes (PUR) are another essential and versatile group of polymers that have large production potential, which is expected to grow faster than the traditional PUR market. (European Bioplastics 2017b.)

The attractiveness of bioplastics in substituting traditional plastic in food packaging is negatively impacted by their relatively high price. The experts in the food packaging plastic industry describe that price is too high for firms to pack their food in bioplastics, although they are interested in their potential. Specifically, if further regulations are set related to using plastic in food packaging, food producers are ready to act and transit from traditional plastics towards bioplastics and biodegradable plastics.

“Companies are trying to get in the market to be aware of what is going on. Just in case, [if] they need to go that way. So, so far, it is not set that this is the way to go. -- The bioplastics have not really reached the market, but companies are trying to invest a little bit in that, just in case legislation changes or consumers demand that. But until the price does not go lower, they will not start buying these products” (R&D Engineer, Material Producer and Package Designer)

Limitations in functionality (Peelman et al. 2013) and performance regarding the mechanical and barrier properties of bioplastics tend to influence further the intentions of using bioplastics. That is, materials with new and improved properties and functionalities have emerged (European Bioplastics 2017b), but thermal instability, low melt strength, difficult heat sealability, both high water vapor and oxygen permeability, and brittleness are restricting using, for example, PLA for food packages. With regard to starch, the problems include low water vapor, processability, brittleness, and vulnerability to degradation. Brittleness, stiffness, poor resistance and thermal instability are further factors restricting the usage of PHA/PHB films. There are also problems with the availability of feedstocks and the usage of land in the production of bioplastics. (Peelman et al. 2013.) Nevertheless, the development work and innovations in the bioplastic industry on innovative materials are increasing the attractiveness of bioplastics (European Bioplastics 2017b).

3.2 Industry Rivalry and Attractiveness

The food and drink industry is the European Union’s (EU) biggest manufacturing industry, in which 37% of food packages are produced either from rigid or flexible plastics. This indeed makes the food packaging plastic industry attractive for new entrants. The maturity of technology applied in the food packaging plastic industry further increases this attractiveness by making it rather straightforward for new firms to enter the market. Nevertheless, although the service offerings of plastic manufacturing firms are differentiated by the material type they are producing, the food packaging plastic industry is characterized by intense rivalry. That is, there are many SMEs and larger firms producing plastic for food packaging purposes (Europages 2018). The industry further relies on sophisticated printing and converting machinery with relatively high investments, which reflects the industry’s high capital intensiveness (EY 2013). The food packaging plastic industry is also regulated by strict regulations that aid in protecting the food. The EU has legislated plastic food packaging materials by the [Framework Regulation EC 1935/2004](#) on materials and articles that food is exposed to and [Commission Regulation EC 10/2011](#) on plastic materials and articles that are in touch with food. The [EU regulation EC 1895/2005](#) further restricts using certain epoxy derivatives in materials and articles intended to be in touch with food. (Wagner 2012.)

From bioplastics’ perspective, entering into the food packaging plastic industry is more attractive regarding the number of material providers and packaging producers. That is, bioplastics and transforming biomass materials to packaging products are not produced in the same extent than traditional plastics. There are nevertheless SMEs and larger firms in the industry producing and providing packages from 1st generation biomass materials, for example, PLA (Members of European Bioplastics Association). Furthermore, these firms tend to grow in the industry by buying each other and that might lead to the increase of the power of some firms and thus decrease the interest of smaller firms to enter the market. Nevertheless, the number of materials, applications, and products are persistently growing and the industry is attracting steadily new raw material suppliers, packaging producers, and food producers to enter the market. Thus, the bioplastic industry is characterized by dynamic growth and high diversification rates. (European Bioplastics 2018b.) The bioplastics’ market share is presently 6% of the global plastic markets, but authorities estimate that the demand for bioplastics is increasing (Institute for Bioplastics and Biocomposites 2017), thus making it attractive for new firms to enter. The growth of the bioplastic industry is primarily driven by the innovative biopolymers of PLA and PHA. Specifically, PHA is in the stage of entering the market at commercial scale and its production is estimated to triple in the upcoming years. The production of PLA is further predicted to grow by 50% by 2022. (European Bioplastics 2017b.)

Although some bioplastics are rather technologically mature materials (European Bioplastics 2018a), the technology applied in the bioplastic production is not entirely developed, yet. Therefore, development work related to different mechanical and barrier properties are required. Specifically, the technology to produce

later generation bioplastics derived from non-food crops and agricultural waste is in its development stage and there are not many, if any, raw material suppliers delivering them.

“There has been lots of improvements in the production of the bioplastics recently, but I think that we have to give the time to bioplastics producers to reach the same level of maturity than the fossil plastics” (Senior Sustainability Consultant, Consulting Organization)

Nevertheless, the production of new generation bioplastics is estimated to increase in the future, especially if new actors would enter the market with feasible business models to develop technologies that transform these new feedstocks into biomaterials and to gather and distribute the food waste. To attract investments and increase the attractiveness of the bioplastic industry, an investment framework and support from policy makers that foster the framework is though required to provide a stimulus to the market growth (European Bioplastics 2018b).

3.3 Industry Collaboration

The food packaging plastic industry tends to rest on long-term collaborations and contracts between different actors in the food packaging networks. Figure 3.3 illustrates the key actors in the supply chain of the food packaging plastic industry (adapted from EY 2013).



Fig 3.3 The supply chain of the food packaging plastic industry (adapted from EY 2013).

In the supply chain of the packaging industry, the feedstock suppliers are typically characterized by their large size and global production and therefore they might take advantage of their power to pass on higher raw material costs and increase prices to their customers when supply is tight, which increases input prices for the packaging producers. From the packers' point of view, there are large and powerful firms that may not wish to pass price increases to users and threat by switching the partner to keep suppliers in the line. (EY 2013.) Nevertheless, long-term collaboration and contracts between the actors in the supply chain of food packaging plastic industry create partnerships, in which switching the partner is not always possible or even wanted. Specifically, in partnerships, in which customized packages are produced, switching the food packaging producer would imply changing the product and its package. The customization increases the switching costs of the food producer and diminishes their bargaining power. Therefore, although there would be multiple potential manufacturing firms producing food packages, the ability of a buyer to change their manufacturer might be limited. The relationships between packaging producers and their customers are described by long-term collaboration and customizing the manufacturing process that suits the best the intricate customer needs and wants. Indeed, the excerpts show that the relationships in food packaging are highly influenced by the degree of standardization and customization of food packages:

“If you are producing a specific packaging, and that is your product, you have to stay loyal as otherwise your product will change... So, you cannot really change the product that easily” (R&D Engineer, Material Producer and Package Designer)

“So, when you are using standard packages, it is very easy to change [partners]. It is a question of costs. In case that you have a personalized, customized project... -- In this case, the relationship is closer with the packager. So, in this case, it will be more difficult to change, because you are under a contract, which regulates the exclusivity of the packaging, so in case that you change, you have to supply all the technology to the new provider. So, it's not impossible but it's more difficult.” (Innovation Manager, Food Producer)

The new firms entering into the food packaging plastic industry with biomaterials might thus confront strong barriers of finding customers and developing effective channels for distribution. This further implies that although no specific machinery is required to make bioplastics (European Bioplastics 2017a), the intention of food producer to change from traditional fossil fuel plastics towards biomaterials might require changing the packaging producer. This change might further influence the whole food packaging supply chain of customer enterprise in both directions – upstream and downstream. That is, it is not always possible to utilize the same production processes of traditional plastics to produce bioplastics. The restructuring of the value chain might be required to enable the large-scale production and commercialization of bioplastics.

4. CONCLUSIONS

In this report, information from qualitative thematic interviews and written reports were gathered to analyze the market demand and volume of materials in food packaging and their advantages and disadvantages. The rivalry and attractiveness of the food packaging plastic industry and the collaboration within the actors in food packaging supply chains were further characterized.

This report identifies that food products are packed in glass, metal, paper and board, or plastic. From these materials, the majority of food is packed in either rigid or flexible plastics. The report suggests traditional plastics to preserve their position in food packaging, but bioplastics are regarded as a prospective material substituting them. The number of materials, applications, and products derived from biomass materials is increasing and the bioplastic industry is attracting new raw material suppliers, packaging producers, and food producers to enter the market. Especially, global bioplastic production is predicted to rise from 2.05 million tonnes to 2.44 million tonnes in 2022 (European Bioplastics 2018a). This report identifies both internal and external drivers and limitations for the growth of the bioplastic industry in different packaging segments. Interestingly, multiple external drivers are stimulating the breakthrough of bioplastics, whereas the limitations of using bioplastics in food packaging are primarily internal to the market, including existing collaborations and networks in the food packaging industry, the functionality and performance challenges of bioplastics, and a high price of producing biomass materials. Figure 4.1 summarizes the internal and external drivers and limitations of bioplastic markets (adapted from European Bioplastics 2013a).

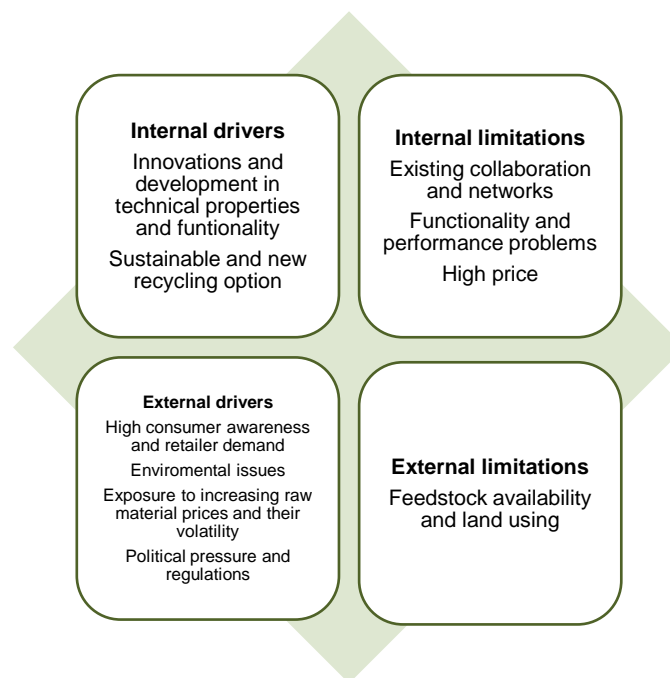


Fig 4.1 The internal and external drivers and limitations of the bioplastic industry.

The food packaging plastic market was further tentatively analyzed from the perspective of the different actors in the value chain related to food packaging. Table 4.1 presents the results of this analysis.

Tab 4.1 Current state and required or anticipated changes in the bioplastic industry.

Actor in supply chain	Current state	Required or anticipated changes
Feedstock supplier	Stabilized availability of 1 st generation raw materials (no direct rivalry with food and feed production) Availability of later generation feedstocks (for example, potato peels and sweet corn residues) is hidden	New actors and business models are required to detect and circulate food waste for later generation bioplastics
Raw material supplier	Few key actors in the market producing primarily 1 st generation biopolymers, for example, PLA and PHB	Existing raw material suppliers change their technology to facilitate the emergence of later generation bioplastics and/or new actors enter the market
Packaging producer	Few packaging producers in the market making packages from bioplastics Stabilized and long-term relationships between packaging producers and food producers (if packages are customized)	New actors may enter the market Role of packaging machinery and required changes when using later generation bioplastics?
Food producer	Positive attitude towards opportunities emerging from bioplastics Bioplastics present roughly 1% of the 320 million tonnes of yearly plastic production	Importance of external regulations and incentives (including the demand/consumption) Restructuring the partner network?
Retailer	Mediating the pressure from consumers towards bioplastics and sustainability	Possible influences on in-store infrastructure and logistics?
Consumer	Increasing demand for sustainable products Understanding from environmentally-friendly products is on a superficial level	Educating the market to transform their consumption habits

Concerning feedstock suppliers of 1st generation raw materials, it seems that there are a reasonable stable and good availability of feedstocks for the present bioplastics production for the food packaging industry. It is notable that the production of these feedstocks is not competing to a significant extent with the food and feed production. Nevertheless, to secure feedstocks for later generation bioplastics, the availability of the feedstocks require new actors and respective business models to be fully operational in large-scale.

The existing raw material suppliers and packaging producers of 1st generation bioplastics are suggested to have a reasonably good competency to turn into later generation bioplastics actors. New market actors are further proposed to emerge. Nevertheless, the data did not reveal explicitly enough what is the role of the packaging machinery and respective changes to it.

From the food production perspective, the external regulations and incentives, including market pressure from the end-consumers towards sustainability, seem critical in the transitioning towards both 1st and later generation bioplastics. Similarly, regarding retailers, it is vital to examine the possible changes required to in-store infrastructure and logistics, for example. To summarize, in the consumer-level, although there is an increasing responsibility awareness and demand by consumers for sustainable products and brands, greater education of the market is needed.

In these different levels of food packaging supply chain, the restructuring of the value chain and new actors with feasible business models entering the market might be required to enable and facilitate specifically

the production and utilization of later generation bioplastics. Furthermore, this implies that further research is required on renewable biomass materials that are derived from non-food crops and agricultural waste, and how such innovation would change the value chain of the food packaging industry.

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APPENDIX 1 Interview Themes

- Industry characteristics
- Technologies and materials and alternatives for them
- Industry trends and the influence of bioplastics
- Primary actors in food packaging supply chains and their roles
- The characteristics of relationships between the actors of the food packaging supply chain
- Raw material suppliers and their service offerings
- Packaging producers and their service offerings
- Retailer and consumer influence on packaging decisions
- Factors making the industry attractive
- Advantages and disadvantages of bioplastics
- Regulations related to the food packaging plastic industry