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Comment on the Food Industry's Pandemic Packaging Dilemma

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Historically, the food industry has had a complicated affiliation with the single-use plastic overuse and packaging. In food innovation, industry-driven needs such as safety and consumer convenience, will typically trump policy. Yet, with environmental concerns, the opposite holds true. Environmental policy in the Western world has driven some modest changes as producers within food industry consider options to reduce single-use plastic use, while striving to remain competitive. This perspective is designed to promote discussion in the scientific academic community on the ways in which the food retail and processing sectors have continued to seek eco-friendly alternatives for single-use plastic despite the COVID-19 pandemic, during which consumers were mainly concerned about public health risks, and not necessarily environmental risks (Goddard, 2020; Gorrasi et al., 2020; Patrício Silva et al., 2020, 2021). Food service, a sector severely affected by the pandemic, had to regroup, adapt, pivot, and learn how to deliver food outside of the typical dining-in experience. While food retail continued to mitigate environmental risks of single-use plastic and packaging, the COVID-19 pandemic forced restaurants to look for ways to survive lockdowns, by any means possible, including the adoption of single-use take-out packaging.

As we near the end of the COVID-19 pandemic with widespread vaccine rollout, the food service sector will likely try to service new markets. Several months into the COVID-19 pandemic, an estimated three quarters of all food purchased required further processing at home (Dube et al., 2021; Song et al., 2021). That includes the growing meal-kit market. The remaining quarter of the market is serviced by restaurants that sell ready-to-eat products. This represents a significantly drop in market share from before the COVID-19 pandemic.

The areas of food processing, distribution, and retailing are most acutely affected by the plastic dilemma, as they represent three quarters of the food consumers purchase. Reducing reliance on plastics within these sectors of the food industry has been challenging, mainly due to concerns related to costs, convenience, and food safety. Unlike in food service, consumers are typically more price sensitive in food retailing (Raab et al., 2009). There is a delicate balance between the desire for better environmental stewardship while maintaining food safety standards and preserving affordability for consumers. For example, in the Canadian context, while consumers were personally motivated to reduce use of single-use plastic packaging, they were less willing to pay for sustainable alternatives (Walker et al., 2021). A consumer conundrum that was further exacerbated during the COVID-19 pandemic (Kitz et al., 2021). The pandemic lessened the will for consumers to recognize a premium in being better environmental stewards while shopping for food.

Consumers have come to realize that the food industry is responsible for a significant portion of environmental plastic pollution (Usman et al., 2020). The top companies responsible for the environmental waste are in the food industry. The pursuit to find alternatives has intensified in recent years, as public pressure in Canada on the food industry to implement changes to single-use plastic and packaging has been growing. Alternatives also need to be convenient for consumers and

should not incur additional cost or effort. Likewise, alternatives need to have lower environmental impacts than their petroleum-based single-use plastic counterparts. As food products are consumed daily, most consumers are typically drawn to eco-solutions which do not require additional time and energy. The food industry faces the challenge of finding eco-solutions without compromising food affordability, costs, or convenience. Striking that balance while developing a green supply chain is no simple task.

Reusable coffee pods are a good example. The sale of recyclable coffee pod solutions lagged, as consumers were inconvenienced by dissembling used pods (Cukier, 2020). In response, companies developed a compostable pod, however, many jurisdictions disallowed these pods in compost which made building a green supply chain to support this innovative solution impossible. Advances in research on bioplastics and political representation loosened composting and recycling regulations in many parts of the western world. Indeed, the utilization of bioplastics has potential to be convenient alternative to single-use plastic and packaging, but implementing a switch is not straightforward.

The economics of bioplastics make these alternative solutions more expensive than regular petroleum-based plastics. This is especially relevant now that low oil prices make virgin-plastics even more appealing for the plastics industry to use compared to using recycled plastics. The market for post-consumer recycled plastics fell dramatically after China banned imports of recyclable plastics at the end on 2017 (Liu et al., 2018; Walker, 2018). But given how rapidly the narrative around climate change is shifting, the "green" premium is increasingly worthy of consideration by industry, especially for younger generations. The debate around climate change has impacted the energy sector for years, but it is only in the last few years that public attention has been given to the food industry and their dependence on single-use plastic packaging and how it can better serve the environment. Conventional plastics are derived from fossil fuels and account for 6% of global oil consumption. Thus, plastics and climate change are intricately linked (Zhu, 2021). While some companies were just focusing on supporting their public relations strategy and corporate image, other companies were truly committed to change. We have come to a point where underachieving companies are being reported and made accountable for failing to reach sustainable goals. It is expected that more companies will need to genuinely commit to change and achieve measurable environmental goals soon.

The scientific community has provided significant options for food companies looking reduce their environmental plastic presence (Kakadellis and Harris, 2020). Generally, bio-based plastics are defined as materials that are produced from renewable resources (Iwata, 2015). Bioplastics can be prepared from two principal feed stock sources. The first one is agropolymers, which include biomass products like polysaccharides, proteins, starch, cellulose, hemicellulose, and lignins. The second feed stock source for bioplastics are biopolyesters, which include monomers extracted from microorganisms [poly(lactic acid) (PLA), polyhydroxyalkanoate (PHA), poly(3-hydroxybutyrate-co-3-hydroxyvalerate), commonly known as PHBV], and petrochemical products (Iwata, 2015). All bioplastics have advantages and disadvantages associated with them (Shen et al., 2020).

Many materials can replace plastics. One example is wood, which is used to make cellulose or cellulose acetate, and it is often mixed with petroleum-based plastics. In the food industry, wood is now more commonly used to replace plastic utensils. But wood has limited value to package food products since it can easily carry pathogens, and wood's physical properties make it difficult to wrap or protect anything (Iwata, 2015).

Prawn or crustacean shells used to produce chitin or chitosan are another bioplastic option (Srinivasa and Tharanathan, 2007; Hudson et al., 2015). However, production costs are substantial, and it has limited structural applications. Scalability and access to supplies of shells are also an issue for this type of material, however, from a circular economy perspective, the appeal is obvious since most of these shells currently have no economic use. The ocean economy can also offer green algae and microorganisms, to make another type of bioplastic. Used to produce curdlan or pullulan, this can be easily scaled up, but more work is required to fully assess the structural properties for such a solution.

Starch-based materials should also be considered a viable option. These materials have great potential as biodegradable food packaging solutions that could reduce undesirable environmental pollution (Cheng et al., 2021). The functional attributes of starch-based biodegradable materials can be expanded or enhanced by adding other biopolymers or additives. However, like most biomaterials, scalability of production and building economies of scale to reduce unitary costs are a challenge. With low margins in food distribution, higher costs would compromise the products' competitive advantage.

Although there are many biobased plastic alternatives currently available the transition from fuel-based plastics to biobased plastics will remain a challenge due to scalability, costs and intense requirement for land-use and associated unintended environmental consequences (Patrício Silva et al., 2021). For example, current biobased plastic production still represents a minor share of the global plastic production (∼7.4 of 348 million Mt in 2017) (PlasticsEurope, 2019). Industry inertia for adopting biobased plastics may be due to lack of financial investment, undeveloped recycling and/or disposal facilities, uncertainty over their toxicity effects of their biodegradation in open environments (Science Advice for Policy by European Academies, 2020; Patrício Silva et al., 2021).

As the food industry attempts to find greener solutions to its plastic addiction, a growing number of retailers are offering consumers an opportunity to reduce their consumption of non-recyclable plastics. A Dutch supermarket chain opened the world's first plastic-free food store (Beitzen-Heineke et al., 2017). This project was only made possible by using innovative solutions to plastic packaging. Consumers will only find biodegradable bioplastic packaging and bags in the store. However, consumers often confuse biodegradable plastics and bio-based plastics as eco-friendly plastics (Iwata, 2015). Biodegradable plastics have been developed with biodegradability as a key consideration (and may still contain fossil-fuel based materials), whereas for bio-based plastics, biomass is used as the primary raw material,

although may still contain fossil-fuel based materials (Iwata, 2015). Consumers select an "eco-friendly plastic" under the impression that their selection is 100% biobased. In other words, bioplastic used to make packaging should not contain any non-renewable fossil-fuel based materials. One other key challenge with these alternatives, of course, is the cost. Because of costs, and until bioplastics become more affordable, a growing number of independent food stores are selling food in reusable containers. Similarly, select food retailers will allow consumers to bring their own reusable containers. Perhaps not the most practical solution, but many consumers are attracted to these services.

Encouraging more green solutions to replace the use of plastics in the food industry is truly a work in progress, when accounting for convenience, costs, and food safety. While the focus of plastic regulations attempts to create equity among stakeholders, actors within the food industry are looking to become greener without compromising its competitive advantage. It is clear, however, that more research on scaling existing bioplastics is desperately needed. Plastic-use is the responsibility of the entire food industry, not just a few companies. To entice industry to implement significant change in a timely manner, it has become undoubtedly clear that more strategically guided policy is needed, at all levels of government.

AUTHOR CONTRIBUTIONS

TW, SC, and JM: conceptualization and writing—review and editing. SC and JM: methodology. SC: investigation and writing—original draft preparation. JM: project administration. All authors have read and agreed to the published version of the manuscript.

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