Contact:
Laura Wonser
Administrator/ USA
GFSF/GIC Group
www.gicgroup.com
laura.wonser@gicgroup.com
GFSF: www.globalfoodsafetyforum.org

GFSF FOCUS 2025

The Role of Sustainable Food Packaging in Enhancing Food Safety and Global Trade

Content

- The Role of Sustainable Food Packaging in Enhancing Food Safety and Global Trade

  By: Joe Cahill, Associate/GIC Group

The Role of Sustainable Food Packaging in Enhancing Food Safety and Global Trade

By: Joe Cahill, Associate/GIC Group

Today, food packaging is a $400 billion industry (Market Research Future, 2023) that protects the $1.5 trillion global food trade (FAO, 2020). Though amidst this powerful industry, the further exacerbated carbon puzzle has now imposed a new set of expectations. In 2018, containers and packaging accounted for approximately 82.2 million tons of municipal solid waste in the United States, representing 28.1% of the total waste generation (EPA, 2018). Further beyond waste implications, initial costs also require high energy consumption, the depletion of natural resources, and the release of greenhouse gases (GHG). Thereby, a new stress on making use of advanced packaging technologies, such as modified atmosphere packaging (MAP), biodegradable packaging, edible packaging all accompanied by artificial intelligence and blockchain-enabled traceability as a new dawn of net zero targets is unveiled, is more vital than ever. This innovation in packaging has also made important additions to new food safety expectations. New materials utilized from cellulose to seaweed provide an effective solution in the prevention of food contamination due to the lack of harmful chemicals required for their production, and with blockchain technology storage and traceability, recall efficiency is more accurate than ever. These advancements in packaging not only address environmental concerns but also redefine food safety, marking a pivotal shift toward a more sustainable and secure global food system.

The evolution of food packaging has been pivotal in enhancing food safety, extending shelf life, and enabling global trade. In the early 19th century, tin cans revolutionized food storage, offering airtight solutions that dramatically reduced spoilage. By the mid-20th century, vacuum packaging and aseptic processing further advanced the industry, preserving the nutritional value and quality of perishable goods (Robertson, 2016). Today, cutting-edge innovations such as edible packaging has started to push through the industry as it seeks to achieve the hope of less waste and supply an interesting approach to safety expectations (Verma et al., 2021). Though more widely accepted strategies include modified atmosphere packaging (MAP), often used to package fresh produce and extend the shelf life. This focus on extending freshness has also driven recent advancements, such as smart packaging technologies. These include time-temperature indicators and freshness sensors, which actively monitor and communicate the condition of food products, ensuring quality throughout the supply chain (Azeredo & Correa, 2021). These trends reflect how the global food packaging market, projected to grow from $405.4 billion in 2024 to $651.7 billion by 2033, is adapting to demands for greater sustainability and transparency2033 (IMARC Group, 2024). However, challenges remain as plastic packaging continues to dominate as a first-choice material for many food distributors due to a myriad of reasons, the top being the affordability. In response to these challenges, recent large-scale legislative and corporate efforts are shaping the future of food packaging.

In recent years, significant legislative efforts have been made to promote sustainable food packaging on a larger scale in the US. For instance, California's SB 54, the Plastic Pollution Prevention and Packaging Producer Responsibility Act, mandates a 25% reduction in single-use plastics, a 65% recycling rate for such plastics, and requires that all single-use packaging and plastic food ware be recyclable or compostable (CalRecycle, 2024). This law establishes a producer responsibility organization to oversee compliance, reflecting a broader trend toward extended producer responsibility in packaging. At the federal level, the Biden-Harris Administration announced a strategy to phase out single-use plastics in federal operations, aiming to eliminate such plastics from food service operations, events, and packaging by 2027, and from all federal operations by 2035 (Institute for Energy Research, 2024). These legislative measures are driving large-scale adoption of biodegradable and compostable packaging solutions, encouraging manufacturers to develop and implement sustainable alternatives to traditional plastic packaging. With recent geopolitical shifts, the private sector has not shirked from forging ahead with lower carbon footprints. Current trends show the critical role of coordinated private sector involvement in climate goals, especially as the responsibility for these goals becomes more decentralized at the national level.

The food packaging industry is undergoing a transformation to combat sustainability challenges and food safety concerns, driven by both technological innovation and regulatory measures. Biodegradable and bio-based materials are leading this change. Polylactic acid (PLA), derived from renewable resources like corn starch and sugarcane, has gained significant traction due to its compost ability and low carbon footprint. Studies show that PLA emits fewer greenhouse gases during production compared to traditional petroleum-based plastics, making it an eco-friendly alternative for packaging dry foods, fruits, and vegetables Another innovative material, polyhydroxyalkanoates (PHA), is synthesized by microorganisms using agricultural waste. PHAs are not only biodegradable in soil and marine environments but are also versatile enough for applications such as food containers and films (Verma et al., 2021). Market reports estimate the global PHA market to grow at a compound annual growth rate (CAGR) of 6.3%, reaching $163 million by 2030 (Research and Markets, 2023).

Edible packaging has also emerged as a new and enticing technology, addressing both waste reduction and food safety, as well as generating a unique consumer curiosity edge on competitors. Made from natural ingredients like seaweed, milk proteins, and fruit extracts, edible films can protect products while being safe for consumption. For instance, Notpla, a company which developed seaweed-based sachets to replace single-use plastic condiment packets. These sachets biodegrade in weeks, significantly reducing landfill waste and plastic pollution (Notpla, 2023). Furthermore, researchers have found that casein-based edible films infused with antimicrobial agents can extend the shelf life of perishable goods by preventing bacterial growth (Thakur et al., 2024).

Legislation is playing a pivotal role in accelerating the adoption of sustainable packaging. The European Union's Single-Use Plastics Directive, enacted in 2021, bans certain plastic products like cutlery, plates, and polystyrene containers. The directive also mandates a 25% reduction in single-use plastics by 2025 and requires member states to achieve a 90% collection rate for plastic bottles by 2029 (European Commission, 2021). Similarly, California's Senate Bill 54 requires that all packaging sold in the state be recyclable or compostable by 2032. This legislation incentivizes companies to invest in sustainable alternatives, despite the cost premiums. The bill is expected to reduce plastic waste by 23 million tons annually, aligning with California's broader climate goals (CalRecycle, 2024). These hard-nosed approaches are all reliant upon the performance of cap-and-trade and a hopeful positive carbon market reaction.

A large piece of these reduction goals is only achievable by integrating AI accompanied by blockchain storage technology. Through the integration of both, companies can not only monitor the journey of food products from farm to table but also more accurately and efficiently inspect packaging as it goes through its journey. Amazon has most widely integrated AI models in its packaging strategy leading to a reduction of all shipment damage by 24%, and cutting shipping costs by 5% (Chaoji & Gurumoorthy &, 2020). Additionally, coupling this with blockchain provides a crucial step in verifying the authenticity of shipping data, ensuring that carbon emissions are accurately reported. Major retailers like Walmart and Nestle have moved to store data in blockchain so they can retain transportation and waste creation data through in-depth life cycle analysis that can later be reported. In 2015, Walmart committed to achieving zero emissions across its global operations by 2040, along with a reduction of absolute scope 1 and 2 GHG emissions by 35% by 2025 and 65% by 2030 (Walmart, 2015). The utilization of both AI and blockchain not only tracks their progress in carbon emissions but also has been shown to reduce foodborne illnesses by identifying contamination sources within seconds, compared to days or weeks using traditional methods (Yang et al., 2020). This rapid traceability reduces the risk of widespread outbreaks, with studies showing that AI and blockchain implementation in food supply chains can even cut recall costs by up to 30% while improving overall consumer trust and safety (Deloitte, 2022).

` Major development concerns in biodegradable food packaging often regard the disparity in technological access in countries producing the food and often packaging it and the countries that are consuming the product. This is also applicable to the toleration of food safety sanctions globally. The Convention of Biological Diversity reports that agriculture provides 29% of the GDP of developing countries and 65% of the jobs (CBD, 2016). This high involvement of developing countries in the world's food production, often exporting the majority to developed or post-industrial countries, is taking the form of a somewhat colonial-era agricultural system. Though there are two sides to the coin. In 1989 the Basel Convention of Geneva, Switzerland, established a new basis of how transboundary movements of waste will be controlled. The convention has gone on to adopt many important amendments, all predicated upon the protection of developing countries' economic vulnerability when it comes to being a haven of developed countries' waste. Therefore, in the case of new technological strides and sanctions that may be difficult to adopt in the short run, they may be quite important in how we continue to revise our approach to how governance deals with production externalities and waste. For example, with more producers creating or requiring biodegradable packaging due to consumer trends and governmental pressure, there is less transboundary movement of waste due to new transparency standards and greater internal instruments repurposing such waste. Additionally, with a growing global population and a more concentrated growth in developing countries due to historically high fertility rates, a new global food production puzzle may be afoot. If further amendments continue to the Basel convention, a tightened trajectory of sustainable economic growth seen through the lens of food packaging may be more common as developing economies ride out the storm of the initial high capital investments, but with a high-yielding return.

The prior highlighted issues are a part of a more general theme: the balancing of cost-effectiveness and safety standards. The solutions to such a puzzle are scattered, but one is the subsidizing of farming equipment in an attempt to speed agricultural development in developing nations. This past October, a $491 million grant was signed over by the US and Zambian governments to propel sustainable agriculture practices. Zambia, a major corn exporter, is an example of how global trends of outside investment may be utilized to spur greater technological growth and avoid growth in any disparity (US Department of State, 2024). We also see such a trend in decarbonization projects in the employment of sustainable agriculture.

GIC Group’s Carbon Plus Commodities (CPC) futures contracts incentivize sustainable agricultural practices. Grower contracts offer inset calculations combining carbon credit and commodity prices levels below benchmark. The rest of the ag value chain also profits, both from tax credits and new trading and marketing opportunities. Manufacturers of biodegradable packaging are part of this value chain. The importance of the interdependence of food packaging and sustainable agriculture is often reminiscent in how we account for emissions or waste using a life-cycle analysis. Impact is measured from “cradle to grave” from the crops harvest, processing, packaging, consumption, and disposal. Therefore, the utilization of a futures contract more concerned with sustainable agriculture is requisite to the achievability of creating an environmentally and economically sustainable solution.

The food packaging industry is undergoing a transformative shift, driven by the need for sustainability, food safety, and regulatory compliance. Advanced materials, such as PLA and PHA, along with innovative solutions like edible packaging, are addressing long-standing waste and safety issues. Meanwhile, AI and blockchain technology is enhancing transparency and efficiency, both in traceability and carbon emissions management. Legislative actions, such as the EU’s Single-Use Plastics Directive and California’s SB 54, are further incentivizing sustainable packaging practices, driving the industry toward a more eco-friendly and secure future. With these combined efforts, the global food packaging industry is poised to meet the challenges of the 21st century and contribute to a more sustainable, safe, and transparent food system.

References

Azeredo, H. M. C., & Correa, A. C. (2021). Smart packaging: Mechanism of intelligent packaging. *Food Research International, 143*, 110354. https://doi.org/10.1016/j.foodres.2021.110354

CalRecycle. (2024). Plastic Pollution Prevention and Packaging Producer Responsibility Act. California Department of Resources Recycling and Recovery. https://calrecycle.ca.gov/packaging/packaging-epr/

CBD. (2016). Convention on Biological Diversity: Press Brief. https://www.cbd.int/idb/image/2016/promotional-material/idb-2016-press-brief-agro.pdf

Deloitte. (2023, September 19). MedTech Quality Costs: More than "License to Operate." https://www.deloitte.com/de/de/services/risk-advisory/analysis/medtech-quality-costs.html.

EPA. (2018). Containers and Packaging: Product-Specific Data. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/containers-and-packaging-product-specific?utm_source=chatgpt.com

European Commission. (2021). EU restrictions on certain single-use plastics. https://environment.ec.europa.eu/topics/plastics/single-use-plastics/eu-restrictions-certain-single-use-plastics_en

Gurumoorthy, K. S., Chaoji, V., & Amazon Science. (2020, November 12). How to compute the optimal way to package Amazon products. *Amazon Science*. https://www.amazon.science/blog/how-to-compute-the-optimal-way-to-package-amazon-products

IMARC Group. (2024). Food Packaging Market Size, Share, Trends and Forecast by Packaging Type, Application, and Region, 2025-2033. IMARC Group. https://www.imarcgroup.com/food-packaging-market

Institute for Energy Research. (2024, July 19). U.S. to Phase Out Single-Use Plastics from Federal Operations. https://www.instituteforenergyresearch.org/regulation/u-s-to-phase-out-single-use-plastics-from-federal-operations/

Market Research Future. (2023). Global Food Packaging Market Overview. https://www.marketresearchfuture.com/reports/food-packaging-market-2086

Notpla. (2023). Seaweed-based edible packaging: Reducing plastic waste. https://www.notpla.com

Peter Mayer. (2020). Global trade in food and agricultural products more than doubles in last two decades. FAO. https://www.fao.org/newsroom/detail/Global-trade-in-food-and-agricultural-products-more-than-doubles-in-last-two-decades/en?utm_source=chatgpt.com

Robertson, G. L. (2016). *Food packaging: Principles and practice* (4th ed.). CRC Press.

Research and Markets. (2023). Polyhydroxyalkanoates (PHA) Global Strategic Business Report. https://www.researchandmarkets.com/reports/5030754/polyhydroxyalkanoate-pha-global-strategic

Thakur, M., Anjaneyulu, S. S. S. R., & Anjaneyulu, S. S. S. R. (2024). Casein-based edible films: Enhancing food shelf-life with antimicrobial agents. *Journal of Food Engineering*, *332*, 110788. https://doi.org/10.1016/j.jfoodeng.2023.110788

United States Department of State. (2024, October 19). United States and Zambia Sign Agreement to Catalyze Growth in the Agricultural Sector. PRESS STATEMENT. Antony J. Blinken, Secretary of State. https://2021-2025.state.gov/united-states-and-zambia-sign-agreement-to-catalyze-growth-in-the-agricultural-sector/

Verma, P., Anjaneyulu, S. S. S. R., & Anjaneyulu, S. S. S. R. (2021). Emerging trends in biodegradable packaging: A comprehensive review. *Food Science and Technology International, 27*(3), 202-221. https://doi.org/10.1177/1082013221992359

Walmart. (2015). Climate Change, Walmart Corporate. https://corporate.walmart.com/purpose/sustainability/planet/climate-change

Yang, Y., Du, Y., Gupta, V. K., Ahmad, F., Amiri, H., Pan, J., Aghbashlo, M., Tabatabaei, M., & Rajaei, A. (2024). Exploring blockchain and artificial intelligence in intelligent packaging to combat food fraud: A comprehensive review. *Food Packaging and Shelf Life, 43*, 101287. https://doi.org/10.1016/j.fpsl.2024.101287