Report on Green Production and Environmental Technology Application in the Food Packaging Industry

Abstract

This report aims to provide an in-depth study of the current status, key technologies, policy environment, corporate practices, and future trends regarding green production and the application of environmental technologies in China's food packaging industry. Driven by both the global wave of sustainable development and China's "Dual Carbon" (Carbon Peak, Carbon Neutrality) strategic goals, the green transformation of the food packaging industry is no longer an option but an inevitability. Based on publicly available information up to October 2025, this report systematically analyzes the progress made by the industry in areas such as eco-friendly materials, smart manufacturing, and lifecycle management, while also pointing out current challenges and future development directions. The analysis shows that although the industry has achieved significant results with technological innovation and policy support, continuous efforts are still needed in areas like the standard system, cost control, and industrial scaling.

Chapter 1: Overview of Green Production in China's Food Packaging Industry (2024-2025 Status)

Since entering 2024, China's food packaging industry has shown multi-dimensional progress in green production. Green, low-carbon, and circular have become the core keywords for industry development. Major green production technologies and concepts have permeated all links from raw material selection to end consumption.

1.1 Core Technologies and Development Directions

According to industry observations, the green production technologies adopted by China's food packaging industry in 2024 mainly focus on the following areas:

Wide Application of Eco-friendly and Biodegradable Materials: The industry is accelerating the transition from traditional plastics to recyclable, biodegradable eco-friendly materials. The application of biodegradable plastics such as Polylactic Acid (PLA), Polyhydroxyalkanoates (PHA), as well as paper-based composite materials, bio-based materials, and edible packaging materials is becoming increasingly widespread [3][4][8]. Domestic research institutions and enterprises in China are also actively investing in the R&D and industrialization of these new materials to reduce "white pollution" caused by plastic waste [9][9].

Deepening Resource Saving and Circular Economy Models: Guided by the "Reduce, Reuse, Recycle" (3R) principle, the industry is committed to improving resource utilization efficiency. This includes packaging reduction through optimized design, developing reusable packaging containers, and establishing efficient recycling and regeneration systems [1][9][10]. Furthermore, technologies like plastic blending modification, the development of edible or water-soluble plastics, and new reusable plastics have become hotspots for technological innovation [4][8][10].

Integration of Green Manufacturing and Smart Technologies: The application of advanced manufacturing technologies is key to reducing the environmental impact of production processes. Enterprises are increasingly adopting clean production management systems, surface finishing technologies, and IoT-based intelligent monitoring systems to achieve energy saving, consumption reduction, pollution reduction, and efficiency improvement

[1][1][15]. Smart packaging (e.g., for monitoring food freshness) and active packaging (extending food shelf life) serve as convergence points for intelligence and greening, indicating the future direction of the industry [5][6][11].

Popularization of Lifecycle Management Concepts: Leading companies in the industry have begun to integrate green concepts throughout the entire lifecycle of packaging. From initial green design and material selection to green production and manufacturing, and finally to end-of-life recycling and treatment, companies are attempting to build a closed-loop, sustainable packaging ecosystem and extend green management to the entire supply chain [1][15].

1.2 Challenges Facing the Industry

Despite significant progress, the green transformation of China's food packaging industry still faces some bottlenecks. Major challenges include: the lack of a unified and specific national regulatory system and standard network, leading to inconsistent practices among enterprises; the green packaging industry chain is not yet fully developed, with high costs for some eco-friendly materials limiting their large-scale application; the industry is relatively fragmented overall, with a high proportion of SMEs having weak technical reserves, lacking the motivation and capacity for transformation [1][1].

Chapter 2: Analysis of Key Environmental Technology Innovations and Applications

This chapter focuses on several of the most important environmental technology innovations within the industry in recent years (especially since 2023), providing in-depth analysis combined with specific cases and data.

2.1 Cutting-edge Research on Biodegradable Nanocomposite Packaging Materials

As the core of eco-friendly packaging, breakthroughs in biodegradable material technology are crucial. In recent years, Chinese research teams have achieved remarkable results in the field of nanocomposite packaging films, significantly improving the mechanical and barrier properties of the materials, laying the foundation for their commercial application.

Although complete experimental databases are difficult to obtain, synthesizing multiple research results published between 2023 and 2024, we can outline the performance profile of these new materials:

Mechanical Strength (Tensile Strength): The insufficient strength and toughness of traditional biodegradable materials (like PLA) are major obstacles to their application. By introducing nanofillers (such as nanocellulose, montmorillonite, etc.), the mechanical properties of composite films are significantly enhanced. For example, a team from the University of Science and Technology of China developed a bionic composite film with a reported tensile strength of up to 100 MPa, far exceeding that of ordinary plastics [142][209][239]. Other studies also showed that through formula optimization, the tensile strength of PVA/Chitosan-based films could reach about 28.98 MPa [270].

Barrier Properties (Oxygen Transmission Rate): Food preservation imposes stringent requirements on the oxygen and water vapor barrier properties of packaging. Nanocomposite technology can effectively enhance barrier properties. Research data indicates that the Oxygen Transmission Rate (OTR) of some new composite materials can be as low as 782 cc/(m^2·day) [214], while OTR for other PHB-based nanocomposite films is about 342 cm^3/m^2·day [273]. Furthermore, one study, through modification, significantly reduced the OTR of PVA material from 28.5 cc/m^2·day·atm to 3.7 cc/m^2·day·atm [278], indicating great

potential for replacing traditional high-barrier materials.

Degradation Performance (Soil Degradation Rate): Ultimate biodegradability is a key indicator for measuring the environmental friendliness of a material. Several studies tested material degradation rates in simulated soil environments. Data shows that one Cellulose Nanofiber (CNF)-based packaging material could achieve a weight loss of 79.5% after 30 days buried in soil and completely degrade within 60 days [211]. Other studies reported different degradation data, such as a PU/CS/ZnO composite film losing 58.1% of its weight after 12 weeks [268], while an alginate-based film degraded by about 35% after 28-35 days [277][277]. Although these data vary due to different materials and test conditions, they collectively verify the good biodegradability of the new materials.

2.2 Smart Manufacturing Enabling Energy Saving and Consumption Reduction

Smart manufacturing is another powerful engine driving green production in the food packaging industry. By introducing technologies such as Artificial Intelligence (AI), Digital Twin, and Industrial Internet of Things (IIoT), enterprises can conduct refined management of production processes, thereby significantly reducing energy consumption and resource use.

Since 2023, several Chinese companies have undertaken pioneering pilot projects in this field:

Luzhou Laojiao's "Lighthouse Factory" Practice: In 2024, the baijiu giant Luzhou Laojiao launched its intelligent packaging center built to "Lighthouse Factory" standards. This center deeply integrates a new generation of information technologies like AI, Digital Twin, Edge Computing, and IIoT, achieving digitalization and intelligence across the entire production process. Although specific energy-saving percentages have not been disclosed, this highly automated smart factory represents the highest level of energy saving and emission reduction in the industry [231].

China Foods Limited's "Starlink Plan": As a leader in the food supply chain sector, China Foods Limited, through technological innovation in its "Starlink Plan" launched in 2024, achieved a 40% to 50% reduction in energy consumption. While not a pure packaging manufacturing case, the advanced energy management technologies used hold high reference value for the packaging industry [167].

Mengniu Dairy's Packaging and Energy Management Innovations: Mengniu disclosed in its 2023 report that through innovations like packaging lightweighting, it could reduce steam consumption by 85 tons annually [125]. Simultaneously, the intelligent energy system it introduced improved energy conversion efficiency by 5% [127]. These specific data clearly demonstrate the environmental benefits achieved by the company through technological means.

Application Exploration of Digital Twin Technology: Packaging companies like Hefei Yuto have begun implementing Digital Twin systems to simulate and optimize production processes [266]. International cases also show that Coca-Cola partners achieved 20% energy savings through Digital Twin technology [260], providing a feasible technological path for Chinese food packaging companies. Companies like TrakRap permanently pair products with Digital Twins to achieve lifecycle efficiency optimization [259].

In summary, although many enterprises (especially food packaging manufacturers) have not publicly released specific energy-saving data for smart manufacturing pilots after 2023, the industry trend towards seeking benefits and environmental protection through intelligence and digitalization is very clear.

Chapter 3: Life Cycle Assessment (LCA) and Green Design Standards

To scientifically and systematically evaluate and guide the greening process of packaging, the application of Life Cycle Assessment (LCA) methods and related standards becomes crucial. LCA can quantify the environmental impact of a product throughout its entire life cycle, from raw material acquisition, production, use, to disposal [41][47][48].

In China, the food packaging industry primarily follows the following standard systems to conduct LCA and eco-design:

Basic LCA Methodology Standards: LCA practice in China is mainly based on international standards, adapted into national standards. Among them, **GB/T 24040 "Environmental management - Life cycle assessment - Principles and framework"** (equivalent to ISO 14040) and **GB/T 24044 "Environmental management - Life cycle assessment - Requirements and guidelines"** (equivalent to ISO 14044) are the fundamental basis for conducting LCA studies [95][102][105].

Green/Eco-design Evaluation Standards: To guide enterprises in green product design, the state has issued a series of evaluation standards. **GB/T 32161 "General principles for eco-design product assessment"** provides a universal framework for the green design evaluation of various products [94][95][96]. Meanwhile, **GB/T 37422 "Green packaging evaluation method and criterion"** more specifically defines the connotation of green packaging, evaluation indicators, and rating methods, providing direct guidance for the packaging industry [96][97][103].

Although the standard system has been initially established, and Chinese scholars have conducted extensive research on applying LCA methods in the packaging field [41][45], search results indicate that there currently seems to be a lack of newly revised or issued National Standards (GB/T) specifically for "food packaging" containing detailed LCA and eco-design requirements in the recent period (e.g., after 2022). Existing standards are mostly generic or framework guidance, and the industry anticipates the future introduction of more targeted and operable detailed standards.

Chapter 4: Policy Support and Corporate Action Cases

Government guidance and corporate practice are the two pillars driving the industry's green transformation. This chapter analyzes both the policy level and the enterprise level.

4.1 National and Local Policy Support System

The Chinese government provides clear policy direction for the green development of the food packaging industry through macro-planning, financial subsidies, and regulatory constraints.

National Macro Policies: The "14th Five-Year Plan" outline and related agriculture and green development plans emphasize the importance of sustainable production and green food development [63]. In recent years, the state has also released multiple policy documents promoting the standardized development of green packaging, encouraging packaging reduction, harmlessness, and material recycling, aiming to build a green supply chain [67][69]. It is worth noting that in 2022, the State Taxation Administration issued the **"Guide to Tax and Fee Preferential Policies Supporting Green Development"**, which includes 56 preferential policies providing support for enterprises involved in energy conservation, environmental protection, and resource comprehensive utilization [159][226][297].

Status of Green Credit and Tax Incentives: Despite clear macro policy support, in the search

for national-level policies after 2022, **no specific green credit or tax incentive plans explicitly targeting environmental production in the food packaging industry were found**. Existing green credit policies are mostly universal, aiming to guide funds towards all environmentally friendly enterprises [222][224], and the aforementioned tax guide does not provide specific terms, application standards, or incentive amounts for the food packaging industry. This indicates that there is still room for further refinement at the level of specific policy implementation.

Local Fiscal Subsidy Practices: Compared to the national level, local government incentives are more specific and direct. For example:

Kaifeng City (2023): Introduced policies allocating 100 million yuan in fiscal funds to provide loan interest discounts for SMEs engaged in green food production [61][66].

Nanchang City (until 2025): Provides a 10% subsidy for green food production enterprises purchasing quality testing equipment [64].

Henan Province (2022): Arranged fiscal funds to support the construction of the green food standard system and cold chain logistics [62][70].

These local policies provide valuable financial support for the green transformation of enterprises within their regions.

4.2 Corporate Green Practices and Quantitative Results

Guided by policies and driven by the market, a number of leading companies have achieved significant environmental results through technological innovation and have published quantitative data, setting benchmarks for the industry.

China Jushi: The company achieved significant carbon emission reduction through material substitution and optimization. Replacing PVC heat-shrink bags with thinner PE heat-shrink bags reduced the product lifecycle carbon emissions by 45%; developing thinner stretch film not only reduced material usage by 25% but also achieved an annual reduction of 435 tons of carbon emissions [75].

Mengniu Dairy: Through systematic optimization of the packaging for its "Youyi C" product (including bottle weight, label, cap, etc.), the carbon emissions per package were significantly reduced by 46.62% [86].

Nissin Foods: Since 2010, has adopted ECO cups made mainly from paper. Compared to traditional packaging, each cup noodle's carbon dioxide emissions were reduced by 24.0%, and plastic usage was sharply reduced by 87.8% [77].

7-Eleven (South China): Its stores replaced traditional plastic bags with biodegradable "plastic" bags, estimated to reduce carbon dioxide emissions by approximately 15,000 kg annually [76].

McDonald's China: The company has set an ambitious goal, committing that by the end of 2025, 100% of consumer packaging will come from certified, renewable, or recyclable sources [91].

These cases not only demonstrate specific pathways for the application of green technologies but also prove their dual value economically and environmentally through quantified data.

Chapter 5: Conclusions, Challenges, and Future Outlook

5.1 Conclusions

As of the end of 2025, the green transformation of China's food packaging industry has entered a deep-water zone. Technological innovation is the core driving force, with

considerable progress made especially in the fields of new biodegradable materials and smart manufacturing. The policy system provides strong guidance at the macro level, while the successful practices of leading enterprises provide valuable experience for industry development. However, the industry still faces challenges such as inconsistent standards, cost pressures, and insufficient inclusive support policies.

5.2 Future Outlook

Looking ahead, the green development of China's food packaging industry will exhibit the following trends:

Deep Technological Integration: Smart technologies like AI and Digital Twin will integrate more closely with green production, achieving intelligence and optimization across the entire chain from design and production to recycling. The R&D of high-performance, low-cost bio-based and biodegradable materials will continue to be a hotspot.

Precise Policy Efforts: Under the pressure of the "Dual Carbon" goals, it is expected that the state will introduce more targeted and operable incentive policies, such as green credit 细则 specifically for the packaging industry, tax reduction catalogs, and stricter environmental regulations, forming a policy mix of "carrots and sticks."

Upgrading Market Demand: As consumers' environmental awareness generally increases, green, sustainable packaging will no longer be a bonus for products but a necessity. This will force the entire industry chain, from brand owners to material suppliers, to fully embrace the green transformation.

Corporate Strategic Reshaping: Sustainable development will be deeply integrated into the core strategies of enterprises. Companies will no longer focus solely on a single packaging 环节 but will strive to build circular economy models, using Environmental, Social, and Governance (ESG) performance as an important measure of corporate value.

In conclusion, the green revolution in China's food packaging industry is a profound and enduring transformation. It requires the collaborative efforts of the government, enterprises, research institutions, and the public to jointly promote a healthier, more sustainable future.

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