
Serving the Future: Technology in Food and Beverage



Summary & Table of Contents

The **food and beverage industry** has grown from **\$6,279 billion** in 2022 to **\$7,221 billion** in 2023, with a **compound annual growth rate** of **7.3%**. Given the enduring significance of food and beverages throughout all of human history, it is no surprise that the industry has undergone numerous transformations. Recent factors, including **economic downturns** triggered by the pandemic, **rising health-conscious consumer preferences**, and **increased emphasis on sustainability**, have prompted businesses to adopt technological innovations such as **AI-based solutions, robots, and eco-friendly packaging**. These strategies aim to **enhance speed and efficiency while reducing costs**. Continued innovation in the industry is expected to yield newer and healthier products accompanied by lower production costs, both of which will ultimately increase profit margins.

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The Food and Beverage Industry

Food and beverage is one of the most **non-cyclical industries** in the world. While economic fluctuations may sway consumer behavior in areas like real estate or consultancy services, people will always need to buy food and beverages. The F&B industry consists of two major segments: **production** and **distribution** of edible goods. The production arm involves the processing of meats, cheeses, and soft drinks, and the creation of packaged and modified foods. Food has been processed for almost as long as it has been consumed: think pasteurization and salt preservation during wartime when food became a precious commodity. Now, the aisles of our grocery stores are filled with an array of convenience foods like frozen TV dinners, prepared snacks, and other instantly available foods. The distribution segment ensures that these edible goods reach retail outlets, restaurants, and consumers directly. Over time, due to **transportation** and **technological improvements**, the distribution network has expanded significantly, breaking down geographical constraints and enabling the movement of food and beverages over vast distances.

Evolution of Production and Distribution:

The scarcity of wartime caused a rise in juice **concentrates** for soldiers.

Sailors processed meat with salt to **preserve** for long journeys at sea.



Invention of aluminum cans, both **lightweight** and **indefinitely recyclable**.

Grocery stores are full of **instant meals** and **prepared snacks**.

Challenges Facing the Industry

However, even the most resilient industries have not been immune to the challenges brought out by the **COVID-19 pandemic**. The onset of economic uncertainty precipitated a **decline in consumer spending** while escalating **regulatory pressures** and **labor costs** across the entire supply chain. Food businesses that once invested in premium and natural products now find themselves under the strain of **rising operational expenses**.¹ Concurrently, the F&B industry faces labor shortages, global conflicts, climate change, and the looming potential of a recession, which all cause **record inflation**, including rising food prices and the costs of eating at restaurants.²

Shifting Industry Landscapes Due to Rising Costs



Nevertheless, humanity has proven time and time again to be able to overcome any obstacles. Amidst economic instability, businesses must **navigate evolving consumer preferences, foster loyalty, and leverage technological advancements**. Prioritizing innovation, aligning with value-driven consumer behaviors, and optimizing cost-effective nutrition become imperative in improving supply chains.

In the aftermath of the pandemic, many businesses within the F&B industry initially turned to **digital alternatives** as temporary measures for quarantine. Now, three years later, these **AI and data-driven technologies** have evolved beyond mere solutions, actively reshaping the industry's landscape.³

Changing Consumer Behaviors

Consumers have many demands, but one of the most prominent trends is the **increasing shift to vegetarianism and veganism**. While most consume plant-based products to benefit their own health goals, recent increases in the **effects of climate change** have also motivated these shifts. According to the 2014 United Nations report *Climate Change 2014: Impacts, Adaptation, and Vulnerability*, the global impact of climate change is pervasive:

80%	11
of Amazon rainforest deforestations are due to cattle ranching	times more fossil fuel is required to produce a calorie of animal than grain protein
<ul style="list-style-type: none"> • Animal agriculture is responsible for more greenhouse gas emissions than all global transportation systems combined • Meat-eaters are responsible for twice as many greenhouse gas emissions/day as vegetarians • Meat-eaters are responsible for two and a half times as many greenhouse gas emissions/day as vegans⁴ 	

As people become more cognizant of the environmental consequences of animal-based diets, the motivation to **reduce negative environmental impacts** and **alleviate animal suffering** has led many to **shift to meat-less diets** and also demand for **more sustainability** from manufacturers -- something that technological innovations can help solve.⁵

Consumers are also increasingly **more health-conscious**. Well before COVID-19, consumers from all different demographics have **pushed for healthier and more sustainable foods**. The pandemic only accelerated these trends. A McKinsey survey of 8,000 consumers in the United States, the United Kingdom, France, and Germany after the pandemic shows the following statistics:

70%	50%
at least across the markets surveyed want to be healthier	of consumers, across age groups, say healthy eating is a top priority

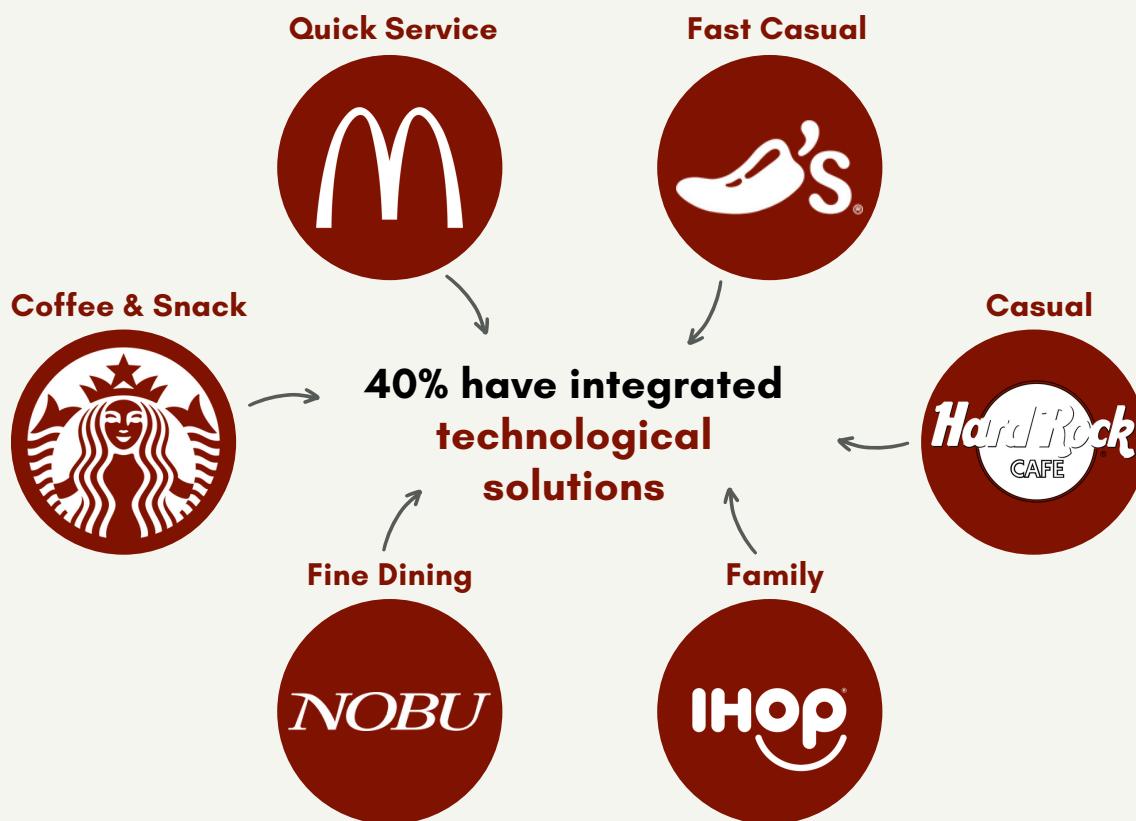
For the **50%** of consumers in which healthy eating is a top priority, healthy eating means **reducing the consumption of processed foods and sugar, fat, salt**, and sometimes **red meat**. Conscious consumers are also shifting their eating patterns and report eating **fresher, healthier foods**. **33%** avoid food with artificial ingredients and **40%** are cooking more meals at home.⁶

Technological History and Adoption

However, consumers believe that **grocery stores** and **restaurants** are **failing to adhere** to their goals for health-consciousness. Less than half of consumers believe that their grocery store stocks the products they need for healthy and sustainable eating. Particularly, consumers believe that **retailers lack plastic-free products, smaller independent brands, and organic foods**. Additionally, consumers feel that restaurants and takeout establishments need to **add more healthy and sustainable food options** to their menus.⁷

Retailers and restaurants need to change to adapt to these shifts in consumer behavior, and many are turning to technology as the answer.

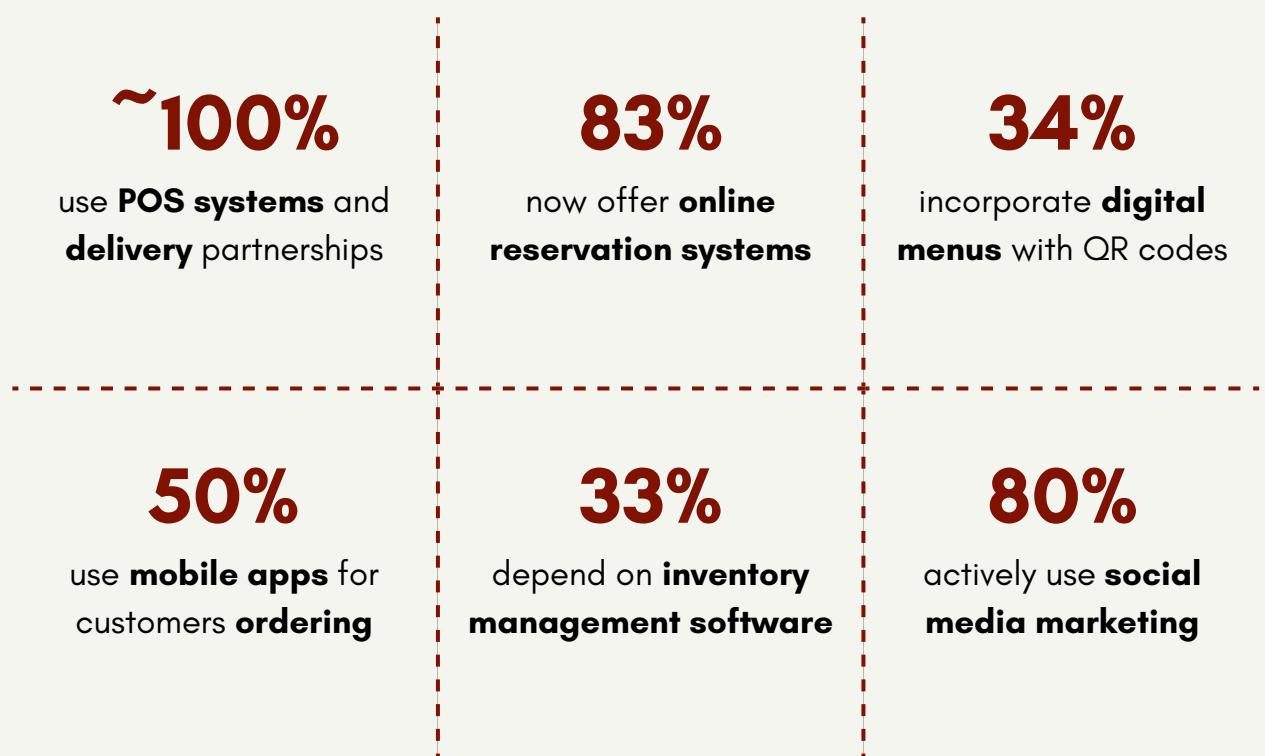
Technology's History in the Industry



Technology has become an integral part of society, and its involvement with the F&B industry is no exception. Almost all corners of the industry, from food delivery to food shortages, can be transformed by technological innovations like **drones, AI-based processing, and robots**.⁸ The National Association of Restaurants reports a swift and significant surge in technology adoption within the F&B sector, particularly accelerated during the pandemic. Across all six segments of the industry—quick service, fast casual, casual, family, fine dining, and coffee and snack—**40% of operators** have integrated **technological solutions** into their businesses. These incorporations serve as adaptive responses to meet the dynamic demands of consumers, including preferences for **healthier, more accessible, and more sustainable food and beverages**.

Technological Trends

Restaurant Survey Insights:



Technological adoption has become **widespread** and **normalized** in many restaurants of the F&B industry, with some practices, like **point-of-sale (POS) systems** and **food delivery partnerships** emerging in **nearly 100%** of surveyed responses. Some technologies, such as robots, drones, and smart sensors, are less common, but becoming more and more prevalent with each passing day.

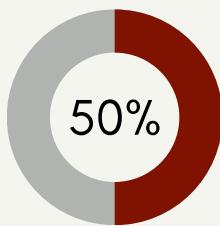
Motivations for Adoption:

- | | |
|---------------------|--|
| 1 83% | <ul style="list-style-type: none"> Increasing sales and revenue Improving data analytics and decision-making |
| 2 67% | <ul style="list-style-type: none"> Responding to customer demand |
| 3 50% | <ul style="list-style-type: none"> Streamlining operations Staying competitive Reducing operation costs Sustainability and environmental impact |

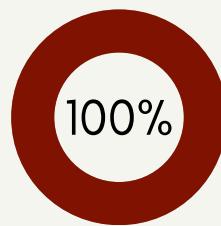
Technological Trends

Effects and Outcomes

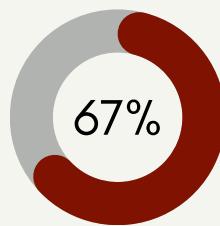
As a result of technological adoptions, **nearly all** of our surveyed restaurants saw either **notable or significant improvements** in their **profitability, efficiency, and optimization**.



have seen good **improvements in sales and revenue**, with 17% seeing **significant improvements**

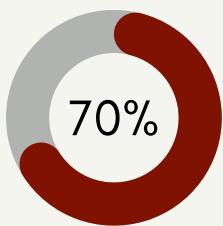


have seen improvement in **business efficiency and operations**, with 34% seeing **significant improvements**

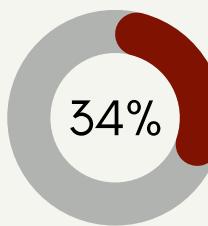


note an **optimized inventory management and supply chain process**

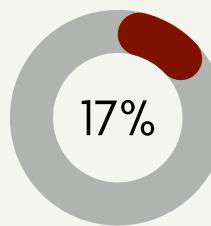
Many restaurants experienced noteworthy to substantial **improvements** in their **customer relations**, achieving **increased satisfaction** and **expanding their outreach**. Simultaneously, they made strides in **enhancing sustainability efforts**.



of restaurants have observed **increased customer satisfaction** since implementing new technologies



have seen **significant expansion of reach** to a larger customer base due to the help of technology



have seen improvements in **sustainability efforts** like reducing food waste, with 33% seeing significant improvements

Although there were certain challenges related to technological use, such as navigating operations during internet outages, bridging connectivity with older generations, and addressing user errors, the **overall consensus** among surveyed respondents was unanimous: **technology** will undoubtedly play a **pivotal role in shaping the F&B industry**, and businesses adopting the latest technologies quicker are likely to achieve greater success.

Key Technological Innovations

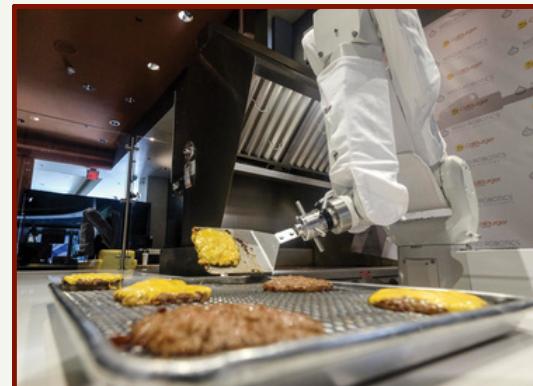
Robots

In the F&B industry, robots are intelligent machines designed to perform different kinds of tasks such as **increasing production, assisting line workers, and taking over unsafe procedures**. Some prototypes focus on speeding up sorting and packing in production, while some like “robot butchers” handle intricate cuts of meat. A notable company in this field is **Miso Robotics**, a company pioneering **restaurant AI and robotic automation** that helps solve **back-of-the-house kitchen operations**. Their goal is to create robots that **eliminate dull, dirty, and dangerous tasks** in restaurant kitchens and work with **speed and precision**, promoting food safety and quality standards. Some of their products that are found across various restaurants around the country are Flippy, Drippy, Sippy, and Chippy. Panera uses Miso’s **Drippy** to **brew its coffee**, CaliBurger uses **Flippy** to **flip burger patties**, and Chipotle uses **Chippy** to **make and season its tortilla chips**.

Drippy



Flippy



- ☑ Powered by Miso AI, Drippy helps brew coffees and teas automatically and at any time
- ☑ Uses temperature sensors to ensure hot beverages are always available hot and fresh while cold beverages are always cold and refreshing
- ☑ Alleviates spending on additional employee health benefits or training periods
- ☑ Autonomous robotic kitchen assistant that automates the fry station for QSRs restaurants
- ☑ Fries items like french fries and chicken nuggets alongside humans to enhance quality and consistency
- ☑ Increases kitchen throughput by 30%, or around 60 baskets per hour

Key Technological Innovations

Eco-friendly Food Packaging

In 2018, the United States generated **291.4 million tons of trash**, and **a third** of this waste was **packaging material** of some kind. Now, consumers demonstrate a willingness to **pay extra for sustainability**, with 74% actively seeking **environmentally friendly packaging options**. Businesses are responding.⁹

Renewable and Recyclable Materials



- Prioritizes use of renewable and recyclable materials like bioplastics, compostable or biodegradable materials, or responsibly sourced paper
- Helps **reduce reliance on finite resources** and contributes to a **more circular economy**

Reduction of Packaging Waste



- Minimizes waste by **optimizing packaging dimensions** as much as possible to reduce material usage
- Avoids unnecessary layers of components and promotes **more lightweight designs**

Incorporation of Innovative Designs



- Incorporates innovative designs that further enhance eco-friendliness of packaging
- Includes edible packaging which **aims to eliminate waste**, or minimalist packing which **reduces the need for excessive materials**

Common Alternatives for Food Packaging

- **Bioplastics:** Packaging materials with similar functionality to traditional plastics but are compostable or biodegradable. Made from renewable sources like cornstarch, sugarcane, or algae.
- **Compostable Materials:** Packaging made from compostable materials that will break down naturally and can be composted. Made from sugarcane fiber, bamboo, molded pulp, or mushroom mycelium.
- **Edible Packaging:** Packaging that offers a sustainable solution or even eliminates waste for single-use packaging and enhances the consumer experience. Made from materials like seaweed or starch
- **Minimalist Packaging:** Packaging that has minimalist designs to reduce unnecessary materials and optimize space efficiency. Minimizes waste but still maintains product protection.

Key Technological Innovations

Eco-friendly Beverage Packaging

A significant portion of the million tons of packaging material constituting our waste is attributed to **beverage packaging**. In response, F&B companies are also increasingly shifting towards more environmentally friendly directions for their beverage packaging.

Emphasis on Recyclability



- Prioritizes materials that are **widely recyclable** with high recycling rates
- Includes materials like glass, aluminum, and certain types of plastic like PET (polyethylene terephthalate)

Reducing Single-Use Plastic



- Aims to minimize the use of single-use plastic by offering alternative solutions
- Promotes the use of refillable containers or **transitioning to more eco-friendly materials**

Efficient Use of Resources



- **Optimizes resource usage in its life cycle**
- Minimizes waste during production, reduces energy consumption, and considers the environmental impact of packaging, from raw material extraction to end-of-life disposal

Common Alternatives for Beverage Packaging

- **Plant-Based Bottles:** Use of plant-based materials to create bottles that are both recyclable and derived from renewable sources. Have reduced carbon footprint compared to traditional plastics.
- **Paper-Based Cartons:** Cartons made from responsibly sourced paperboard and plant-based or water-based coatings that are lightweight, recyclable, and have high renewable content, as an alternative to plastic bottles.
- **Edible Packaging:** Aluminum is highly recyclable and can be recycled indefinitely without compromising its quality, contributing to a closed-loop recycling system. Aluminum requires fewer resources during the manufacturing process and is also lightweight, reducing transportation-related emissions, resulting in a lower carbon footprint.
- **Flexible Drink Pouches:** Typically made from lightweight materials like recyclable plastics or compostable films, reducing material usage and transportation emissions.

Key Technological Innovations

AI-Based Solutions

AI-based solutions are **pre-built** and/or **customizable solutions** designed to address specific cases using **artificial intelligence**. Machine learning allows computers to not only take in information but also use complex algorithms to learn.

Front of the House

- AI Phone Answering**
 - Avoid missing customers' calls
- Voice Ordering**
 - Allow guests to place orders on the go or while multitasking
- Personalized Kiosks**
 - Adjusted for consumers based on past orders and preferences

Back of the House

- Track Inventory and Purchasing Data**
 - Make recommendations for the amount of ingredients and supplies to buy
- Track Staffing and Sales Data**
 - Determine how to appropriately staff for the expected traffic and sales
- Predictive AI Technologies**
 - Anticipate rushes and popular dishes during a given time of day

Data Privacy Concerns

However, guidelines on the use of artificial intelligence are unclear. Given how much time we collectively spend online and the extensive data shared with companies, data privacy emerges as a significant concern. The Pew Research Center's findings on Americans and data privacy reveal that some people harbor reservations on this issue.¹⁰

- **70%** – have little to **no trust** in companies to make **responsible decisions** about the use of AI in their products
- **81%** – think that the information companies collect will be **used in ways** that they are **not comfortable** with
- **80%** – think data will be used in ways that they were **not originally intended** to be used

However, **62%**, or the **majority of Americans**, still believe that companies using AI to analyze personal details could make life easier. This illustrates the emergence of a "**privacy paradox**," in which people express concern for their privacy, but continue to willingly contribute their personal information through the technologies and systems that they use. For businesses adopting AI-based solutions, it is worth noting that customers would desire **increased transparency** of their processes, despite this paradox.

Key Technological Innovations

Online Marketing

Online marketing is a form of marketing that **leverages the internet** and **technology** to **connect with potential customers**. It is particularly beneficial for smaller businesses like **local producers**, as online marketing provides a means for consumers to discover their products. Additionally, it makes it easier to **facilitate the organization** and **promotion of events** like farmer's markets. Due to online marketing, those looking into more local food options to reduce carbon emissions and support local businesses can conveniently explore these businesses globally using just their smartphones.

Traditional marketing channels include billboards, radio, print, and television. However, these solutions are quickly being **replaced by digitalized methods** due to the ability to **reach wider audiences** and be more **cost-effective**.

Online marketing and e-commerce make it possible for **customer relationships to be built completely digitally**. People can discover businesses, engage with businesses, make purchases, and advocate for businesses all online.¹¹

Digital Examples

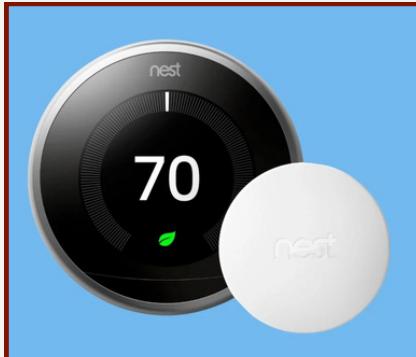
- Social media marketing
- Influencer marketing
- Search engine optimization
- Web design
- Email marketing
- Affiliate marketing
- Display advertising
- Marketing automation
- Customer relationship management
- Conversion rate optimization
- Paid advertising
- Online events and webinars

Benefits

- **Cost-efficiency**
 - Digital means are often cheaper than producing print
- **Efficiency**
 - Your audience can act right away, giving a quick turnaround on investment
- **Trackability**
 - Can track audience interaction like whether they are clicking and opening links
- **Targeting**
 - Allows targeting of specific audiences and customizing for them
- **Personalization**
 - Can be responsive to online behavior and change based on personalized information

Key Technological Innovations

Smart Sensors



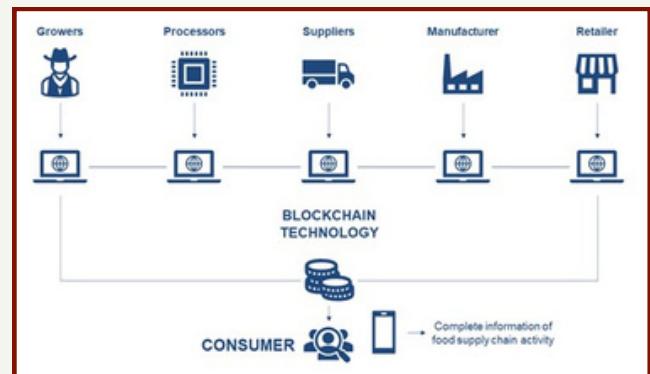
Smart sensors are devices that take input from the physical environment, utilize built-in computing resources, and perform predefined functions upon detecting specific inputs.

This technological innovation helps production managers **count inventory, examine ingredients, maintain temperatures, and smooth distribution in delivery vehicles.**

Blockchain Methods

Blockchain methods allow access to shared information on a continuously growing list of records via an application.

This allows businesses to gather information about a product's origin, allowing **customers to scan a product ID and see more transparency.**



Drones



Drones are small or medium-sized unpiloted aircraft that can drive remotely and autonomously and are capable of maintaining a controlled, sustained level of flight.

Businesses can use drones to **assess agricultural conditions, saving time and enhancing productivity.**

Technological Implementations

Case Study: Panera Bread and New Technology

Panera stands out as one of the **leading technological innovators** in the restaurant industry. But, they don't just adopt any technology. According to **George Hanson**, Panera's former Senior Vice President and Chief Digital Officer, new technology must also be **easy, frictionless**, and **relevant to guests**.¹² Hanson states that his 70-year-old mother must be able to order with ease. Panera is committed to **preserving its warm customer service**, recognizing the enduring appeal of an "**in-person, dine-in experience.**" Panera's overarching goal in leveraging technology is to achieve this balance: to **optimize efficiency** and **provide customers with more options**, all while **maintaining their personal warmth and touch**.

 Coffee-Brewing Robots	<ul style="list-style-type: none"> • Uses predictive analytics on data such as volume, time, and temperature to brew a "quality cup of coffee" each time • In partnership with Miso Robotics to let AI free up some menial tasks so employees can interact more with guests¹³
 Geofencing	<ul style="list-style-type: none"> • A location-based technology RFID (Radio Frequency ID) that notifies devices when a user enters or exits a boundary • Panera Curbside: allows guests to have their order delivered directly to their car
 Mobile Pickup Lane	<ul style="list-style-type: none"> • Drive-Thru Pick-Up: the addition of a new drive-thru line dedicated solely to mobile orders • Digital sales are more than 50% of total system sales
 New App Features	<ul style="list-style-type: none"> • Crunch Time Ordering: allows users to pre-program their meals to be ordered at a set date and time with one swipe • Simplifies the ordering process as people can select a "Crunch Time," or busy period, that suits their schedule
 Automated Ordering	<ul style="list-style-type: none"> • 'Tori': an AI-powered automated ordering system in drive-thrus to reduce wait times and improve order accuracy • Enhances the customer experience as Panera staff can focus on other tasks such as preparing quality food

Conclusion

The F&B industry is **digitally transforming**, and producers and restaurants have adapted to match shifting consumer demands. Though some customers harbor hesitations about new technological shifts, whether that be with AI-based solutions or having their food made by robots, the **adoption of new technology** has been **overall beneficial**. With **more accurate supply and demand forecasts, reduced risks of perishable goods, improved customer experience, safer production environments, and cost-efficiency**, technology has become integral to the F&B industry and consumers are becoming more accepting of experiencing food and beverages in this way.

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