

AI Opportunities in Foodtech

How AI is disrupting the food industry one byte at a time

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Introduction

In recent years, food system data capture points have dramatically expanded. This expansion includes consumer preference data captured through e-commerce, digitized food ingredients and nutritional information, and consumer and industrial equipment that can harvest vast quantities of production and distribution data. And it is not just the quantity of data that has grown but also its ability to be gathered and processed in near real time. These new data capabilities have set the groundwork for a new generation of foodtech companies that tap into food system data sources to build AI tools for a growing list of use cases, including predicting consumer trends, reducing food waste in production facilities, and helping consumers find products.

Results from recent AI-based initiatives show promising potential. Ingredient company Givaudan (SWX: GIVN) recently launched an AI-powered food and flavor formulation platform that accelerates recipe generation processes and reduces trial and error.¹ AI tools are also finding use cases in plant-based-food formulations to replicate the flavors, aromas, and textures of real meat. For example, Swiss flavor company Firmenich recently teamed up with Microsoft (NASDAQ: MSFT) to develop a grilled beef flavor for plant-based meats.² In food manufacturing, startup Seebo—which uses AI to help companies reduce food waste—reports its clients achieve 25%-70% average waste reduction and thereby generate millions of dollars in savings.³

These early successes are driving food manufacturers to increase investment into AI-based projects. Nestlé's (SWX: NESN) 2020 Annual Review cites multiple AI initiatives, including the development of chatbots such as cooking assistants to increase consumer engagement; analytics capabilities focused on production-, promotional-, and consumer-related

1: "Givaudan Leverages AI for 'Next Generation' Product Development," *Food Navigator*, Katy Askew, February 19, 2021.

2: "Firmenich Uses AI to Create Flavor Mimicking Grilled Beef," *Food Dive*, Jessi Devenyns, October 8, 2020.

3: "Seebo's AI for Food Waste Reduction: 'Our Customers Save Millions of Dollars,'" *Food Navigator*, Katy Askew, March 4, 2021.

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opportunities; and digitizing and automating factory operations.⁴ Kellogg's (NYSE: K) also announced AI-based projects to improve marketing efforts, with a focus on customer personalization and engagement. In 2019, McDonald's (NYSE: MCD) acquired AI personalization platform Dynamic Yield for \$327 million to improve upselling opportunities and hasten drive-thru service.⁵

We expect AI will have an incrementally transformative impact on the food industry as adoption among incumbents continues. While the technology will unlikely prove disruptive in the near term, the competitive advantages arising from quicker production times, reduced costs and waste, and improved customer experience will likely lead to continued strategic and financial investment opportunities. This note provides an overview of the ways AI affects the following five areas within the food ecosystem:

- Food product research & development (R&D)
- Food safety and waste reduction
- Restaurant kitchen operations
- Grocery store efficiency
- Consumer experience

Drivers of AI adoption in the food industry:

- **Improved data gathering infrastructure:** Digital shopping surged in 2020, which provided e-commerce players with unprecedented information on consumer shopping behaviors. February 2021 sales through food delivery apps grew 119% YoY, which demonstrates the ways the COVID-19 pandemic and shelter-in-place orders drove significant business online.⁶ Online marketplaces and other digital providers are collecting massive volumes of data on consumer spending habits, which can serve as inputs to AI tools.
- **Ongoing digital transformation:** In addition to data availability, macro trends driving AI adoption include widespread digitization of food business practices. The pandemic accelerated large-scale digital transformation as operating digitally became the only option for many businesses and consumer spending shifted online. The increased focus on fully digital operations heightens the potential to find AI use cases related to analytics, automation, and customer engagement.
- **Growing focus on food waste reduction:** Awareness of the costs of food waste is a looming concern for businesses and consumers alike. Food waste represents roughly \$18.2 billion annually in lost value for retailers and can total 28%-35% of restaurant sales—a significant damper on margins.⁷ The waste has environmental impacts as well, with an estimated 63 million tons of food wasted annually in the US, either sent to the landfill or left to rot in the field.⁸ Food waste has become

4. "Annual Review 2020," Nestlé, March 6, 2021.

5. "McDonald's Installs Dynamic Yield's Personalization Tech in 700 Locations," *The Spoon*, Jennifer Marston, May 1, 2019.

6. "Which Company Is Winning the Restaurant Food Delivery War?" *Second Measure*, Liyin Yeo, March 15, 2021.

7. "Restaurant Food Waste Action Guide," ReFED, 2018.

8: Ibid.

a critical consumer topic, thereby creating an opportunity for food businesses to valorize their supply chains.

- **Personalization strategies:** Food personalization has become a significant driver of innovation over the past decade. Driven by media and technology, consumers have gained a more nuanced understanding of food's effects on health, well-being, and the environment, and are more food literate than ever before. Digital services created a demand for increased speed and convenience and a more personalized food experience. Virtual cooking assistant Plant Jammer aids consumers by building recipes that use ingredients already in their kitchens, thereby reducing food waste and exemplifying the ways businesses have recognized and capitalized on the demand for more-personalized, purpose-driven food experiences.
- **Venture capital fueling AI innovation:** In 2020, according to [PitchBook's latest artificial intelligence & machine learning \(AI & ML\) report](#), investors poured a record \$52.1 billion of VC capital into AI & ML companies across all sectors—up 31.5% YoY and indicative of growing AI spending that extends to the food industry.

AI-related risks and considerations:

- **Data availability and security:** As they are exposed to more data, AI tools become more accurate. Low data availability creates a quality risk and increases dependency on human processes. However, exposing AI tools to large datasets carries its own data privacy risks and susceptibility to intellectual property (IP) theft.
- **Data integrity and inherent bias:** AI tools can act quickly and accurately because they allow for bias. This can lead to discrimination when algorithms have insufficient training or limited access to data. Although the implications of inherent bias may be more limited in the food industry relative to other areas such as financial products, data integrity nevertheless merits consideration.
- **Lengthy implementation process:** Companies evaluating AI tools must also recognize that deployments take time. At first, AI tools tend to be inaccurate and may appear inferior to human alternatives. Over time, however, the AI improves as it draws on more data. Companies then decide whether to speed up development by deploying earlier or wait to build accuracy.
- **Upending workflows:** Although some tools may be integrated with ease, others require restructuring entire workflows. For example, coffee bean quality is typically assessed with a manual process that occurs down-chain from farmers. However, startup Demetria has developed a mobile bean-quality sensor that enables rapid testing at any point in the supply chain, thereby disrupting traditional quality assessment processes.

Market opportunity

The food industry is a large, growing market that can be segmented into two buckets:

- **Grocery goods:** Sales of goods available at grocery stores, such as packaged foods, produce, and drinks.
- **Food service:** Sales of prepared foods from restaurants, cafeterias, commercial kitchens, and other providers.

The global grocery goods market contributed \$11.7 trillion in revenue in 2019 and is forecast to grow at a 5% CAGR to \$17.3 trillion by 2027.⁹ This growth is driven by increased disposable income due to economic development, increased online grocery options such as meal kits and online grocers, and pandemic-led heightened demand.

The global food service market logged \$3.4 trillion in revenue in 2018 and is expected to grow at a 3.6% CAGR, reaching \$4.2 trillion by 2024.¹⁰ Most of this market's revenue is directed at full-service restaurants. However, convenience's growing importance is driving strong growth in quick-service restaurants (QSR) and fast-casual models. The pandemic has further amplified this trend, with consumers valuing digital ordering and contactless transactions.

According to Gartner Research, grocery, restaurant, and hotel enterprise information technology (IT) spending has been on the rise over the past few years, logging over \$76 billion globally in 2019.¹¹ The pandemic slowed the trend in 2020, with restaurant and hotel IT spending down 22% YoY due to economic challenges. However, we expect IT spending will accelerate over the next five years, ultimately reaching growth rates in the low teens as technology becomes increasingly essential to business strategy.

Anticipated growth in food technology spending is one reason that VCs and corporate strategists are ramping up investment in foodtech businesses. We logged \$18.1 billion invested in foodtech companies in 2020, which is up 9% YoY. Companies are investing heavily in technologies that disrupt or improve the food system. We believe significant investor appetite exists for AI-backed food technologies in the long term.

9: "Food & Grocery Retail Market Size, Share & Trends Analysis Report by Product (Packaged Food, Unpackaged Food), by Distribution Channel, by Region, and Segment Forecasts, 2020-2027," Grand View Research, May 2020.

10: "Food Service Market to Expand at a CAGR of 3.6% Over 2019-2024," Analytics News, April 24, 2020.

11: "Forecast: Enterprise IT Spending by Vertical Industry Market, Worldwide, 2018-2024, 4Q20 Update," Gartner Research, Inna Agamirzian, et al., December 22, 2020.

Use cases

Food product R&D

Food product R&D is an expensive, risky, and time-intensive process. From ideation to commercialization, it can take between six months to five years to develop a new food product.¹² Further, new products have high failure rates, which can reach 90% in some categories.¹³ AI tools promise to reduce the time, cost, and risk of many tasks in the R&D workflow. For example, new product ideas undergo a screening process involving opportunity sizing, competitive and regulatory analysis, and ingredient availability assessment, among other steps.

Key food product R&D providers by capital raised to date*

Company	Most recent deal date	Most recent deal size (\$M)	Most recent pre-valuation (\$M)	Capital raised to date (\$M)	Most recent deal type	Country
Brightseed	September 8, 2020	\$27.0	\$100.0	\$51.9	Series A1	US
Nuritas	December 21, 2017	\$18.5	\$81.6	\$23.5	Series A	Ireland
Tastewise	September 1, 2020	\$2.9	N/A	\$9.6	Early-stage VC	Israel
Climax Foods	September 1, 2020	\$7.5	N/A	\$7.5	Seed round	US
Gastrograph AI	November 8, 2018	\$4.0	\$10.0	\$4.3	Series A1	US
Spoonshot	August 31, 2020	\$1.3	\$3.0	\$1.6	Seed round	US
Journey Foods	August 3, 2020	N/A	N/A	\$1.5	Early-stage VC	US

Source: PitchBook | Geography: Global
*As of March 26, 2021

Large food companies utilize extensive product development teams comprised of technologists, food scientists and engineers, regulatory experts, and business experts focused on sales, marketing, and supply chain implications. Startup Spoonshot provides AI tools to optimize or replace some of these manual tasks, such as surfacing trends, determining ingredient interactions, and assessing consumer insights. The company leverages industry data and layers on intelligence from food scientists to add value for clients. Another company, Journey Foods, is building an R&D platform called JourneyAI that utilizes AI tools to identify ingredients that match predetermined nutrition, sustainability, and supply chain objectives.

Startup Brightseed focuses on early R&D processes with its phytonutrient discovery tool. This tool uses a form of AI called computational biology to assess plant compounds for natural chemicals called phytonutrients that may harbor health benefits such as antioxidants. Companies can use this phytonutrient discovery tool to highlight benefits in existing products and develop new functional foods such as beverages that promote energy. The tool can also valorize existing supply chains by building brand value

12: *Methods for Developing New Food Products: An Instructional Guide*, Fadi Aramouni & Kathryn Deschenes, DEStech Publications, August 28, 2014.

13: Failure is defined as a product that is no longer available on store shelves after five years.

through storytelling about the flavor, origin story, or other ingredient characteristics. For example, a crop might have different phytonutrients in different geographies. Similar to wine regions and appellations, stakeholders could potentially decommo-ditize crops by promoting health benefits or advantages based on location. Traditional methods to research crop attributes, colloquially known as grind and find, involve grinding plant materials for extraction and analysis. Brightseed's technique is faster and more effective than traditional methods, thereby allowing food scientists to more quickly discover high-value plants and compounds.

Food safety and waste reduction

Manufacturing facilities are often described as DRIP—data rich and information poor—meaning that while manufacturing equipment is often equipped with sensors and able to collect massive quantities of data, it often goes underutilized. AI can close this gap. Seebo has developed a multi-industry manufacturing process improvement tool that uses AI to identify production bottlenecks and process inefficiencies where food waste occurs. Seebo estimates that clients can achieve 25%-75% waste reduction, which could add up to millions of dollars in savings. Similarly, startup Seeq has developed an AI platform that provides insights from factory data. Aside from waste reduction, AI tools can help food producers improve yields, quality, and equipment uptime, which would boost margins.

Key food manufacturing providers by capital raised to date*

Company	Most recent deal date	Most recent deal size (\$M)	Most recent pre-valuation (\$M)	Capital raised to date (\$M)	Most recent deal type	Country
Seeq	September 9, 2020	\$28.0	\$120.0	\$87.2	Series B	US
Seebo	March 4, 2021	\$24.0	\$46.0	\$46.0	Series B	Israel
P&P Optica	February 5, 2019	\$4.2	N/A	\$8.8	Late-stage VC	Canada
AgShift	April 30, 2019	\$4.0	N/A	\$6.2	Early-stage VC	US
Demetria	March 2, 2021	\$3.0	N/A	\$3.0	Seed round	Colombia

Source: PitchBook | Geography: Global
*As of March 26, 2021

A critical component of food processing, quality control is often required for food safety, regulatory requirements, or the value assessment process. Traditional quality control can take many forms, including the fast but imprecise visual inspection and the accurate but slow and costly lab analysis. Startup AgShift developed an AI-powered food quality analyzer called Hydra. The device uses computer vision and AI to assess quality across the food supply chain, ultimately reducing the time and cost to perform high-quality inspections. Another provider, Demetria, is building an AI tool that examines coffee bean crop quality at any point in the supply chain, thereby allowing stakeholders to assess quality earlier in the supply chain. Coffee farmers are typically challenged to examine crops

with the traditional cupping technique, which leads crops to be treated as a commodity product until the quality can be better assessed down the supply chain. The new technology will allow farmers to receive fair compensation for high-value crops and coffee companies to drive sales by marketing premium beans to consumers.

Kitchen operations

Emerging AI tools address several of the operational pain points of managing a commercial kitchen, including licensing, manual processes, and food waste. Other AI solutions not covered in this report include kitchen and service robots, point-of-sale (POS) systems, and customer service tools such as chatbots and recommendation engines.

Professional kitchen operators must create and manage food safety documentation and obtain licensing. These documents are required for all types of food businesses—from food trucks to larger restaurant groups—and requirements vary by business type and location. These complex processes involve conducting risk assessments, providing hazard analysis, identifying critical control points and limits, establishing monitoring procedures, and maintaining accurate records. Restaurants often hire food safety specialists to manage these tasks. FoodDocs has developed an AI-powered food safety documentation platform. The software uses AI to review kitchen operations, then automates the process of creating compliance documentation. Subsequent menu or process changes can be automatically tracked and updated for compliance.

Key kitchen operations providers by capital raised to date*

Company	Most recent deal date	Most recent deal size (\$M)	Most recent pre-valuation (\$M)	Capital raised to date (\$M)	Most recent deal type	Country
Winnow	October 17, 2019	\$12.0	\$41.5	\$32.2	Series B	UK
Spyce	September 7, 2018	\$21.0	\$40.0	\$24.9	Series A	US
Miso Robotics	February 15, 2018	\$10.0	\$30.0	\$14.7	Series B	US
Phood	November 23, 2020	\$2.0	\$7.0	\$2.0	Seed round	US
FoodDocs	October 1, 2019	\$0.4	N/A	\$1.1	Seed round	Estonia

Source: PitchBook | Geography: Global
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Startup Satis.AI created an AI-powered operating system that uses computer vision to streamline commercial kitchen operations. The platform monitors order sequencing, equipment tracking, and packing accuracy. It observes food assembly and packaging processes and can flag errors such as incorrect quantity to reduce mistakes and, in turn, refunds.

Food costs account for an estimated 28%-35% of restaurant food sales, yet US restaurants annually send over 11 million tons of food waste to

landfills at an estimated cost of \$25 billion.¹⁴ Reducing this waste offers a substantial savings opportunity. Startup Winnow developed an AI-powered food waste reduction tool for professional kitchens called Winnow Vision. It uses cameras and sensors to monitor discarded food. Computer vision and AI algorithms identify the food and calculate the cost of the waste. The tool helps restaurants both quantify the wasted food and better align production with demand.

Grocery store efficiency

Grocers often struggle to choose the optimal product mix, determine the right inventory level, and set the best prices for the approximately 28,000 items on their shelves. Incorrect decisions can lead to stockouts, food waste, and missed profits.¹⁵ In addition, grocers must also factor in other variables such as seasonality, price, promotions, and competitor behavior. Daisy Intelligence provides an AI-powered retail solution that analyzes historical grocery sales data to generate grocery retail strategies.

Key grocery store efficiency providers by capital raised to date*

Company	Most recent deal date	Most recent deal size (\$M)	Most recent pre-valuation (\$M)	Capital raised to date (\$M)	Most recent deal type	Country
Shelf Engine	March 12, 2021	\$41.0	N/A	\$58.2	Series B	US
Afresh	November 19, 2020	\$25.0	\$45.0	\$32.9	Series A1	US
Deep North	January 6, 2020	\$25.7	N/A	\$25.9	Series A	US
Caper	July 18, 2019	\$10.5	N/A	\$14.2	Series A	US
Daisy Intelligence	September 20, 2019	\$7.5	N/A	\$12.3	Series A	Canada
Popspots	December 10, 2019	\$5.0	\$15.0	\$5.0	Series A	US
Wasteless	March 15, 2019	\$1.8	N/A	\$4.3	Seed round	Israel
Veeve	October 22, 2019	\$2.2	\$8.0	\$2.2	Seed round	US

Source: PitchBook | Geography: Global

*As of March 26, 2021

Fresh foods such as produce, meat, baked goods, and prepared foods create additional perishability challenges. Successfully forecasting fresh products can reduce stockouts as well as food waste. Grocers often still use paper sheets, notes, and other nondigital forecasting methods to manage perishable inventory, or they may use tools designed primarily for nonperishable goods. Startup Afresh developed an order optimization platform that targets the fresh food supply chain. Its technology digitizes grocery ordering tasks and layers AI tools to improve decision-making. Historical data points serve as inputs to operating models to recommend inventory management decisions.

14: "Restaurant Food Waste Action Guide," ReFED, 2018.

15: "Supermarket Facts," The Food Industry Assoc., 2021.

When choosing between two identical products with different expiration dates, consumers will generally choose the fresher option. This means products with shorter expiration dates are more likely to be discarded. Startup Wasteless is developing a dynamic pricing engine that optimizes prices based on expiration date. AI tools are used to predict the perceived value of perishable goods based on shelf life and then adjust the pricing accordingly using smart price tags and POS integrations. This helps grocers reduce food waste and drive sales of goods that would otherwise be discarded.

Other AI tools focus on in-store customer experience and employee operations. Mounted sensors and cameras can capture in-store data, powering cashierless checkout systems that reduce labor requirements and increase customer convenience. Stocked inventory can be monitored in real time, notifying staff to replenish bare shelves or reorder items. New platforms also focus on capturing consumer information, such as age, gender, and shopping patterns to create more-personalized grocery experiences.

Consumer experience

While many consumer sites dedicated to food and restaurant reviews exist, AI innovates food and beverage discovery processes. Given wine's variety of attributes, taste characteristics, and prices, wine selection is a particularly challenging product for consumers to navigate. Consumers have traditionally relied on word of mouth, store recommendations, and professional reviews from publications such as *Wine Spectator*. Mobile apps such as Vivino have followed Yelp's (NYSE: YELP) path by crowdsourcing reviews. Vivino recently improved its recommendation platform by incorporating AI & ML tools, including a tool that uses machine learning to build aggregate taste characteristics such as boldness, sweetness, and acidity from reviews, thereby allowing users to search for wines by their desired profile. Vivino also uses AI tools to predict the likelihood that users will enjoy a particular wine. Another feature uses reviews to assess personal preference and then assigns users a score based on their likelihood of enjoying certain wines over others. As users rate more wines, the algorithm's prediction accuracy improves. Recommendation and review tools such as these have become widespread over the past two decades.

Key consumer experience providers by capital raised to date*

Company	Most recent deal date	Most recent deal size (\$M)	Most recent pre-valuation (\$M)	Capital raised to date (\$M)	Most recent deal type	Country
Vivino	February 3, 2021	\$155.0	N/A	\$221.5	Series D	Denmark
Lose It!	January 11, 2012	\$9.1	\$18.8	\$10.6	Series A	US
Chefling	May 15, 2019	\$2.5	\$4.5	\$3.7	Series A	US
Bite AI	August 25, 2017	N/A	N/A	\$0.1	Early-stage VC	US
Passio	January 1, 2020	N/A	N/A	N/A	Early-stage VC	US

We expect that this type of prediction tool will take recommendations to the next level, helping brands and retailers better target customers and helping customers improve buying-decision confidence.

Whisk developed a recipe discovery platform to help users save, organize, and shop for recipes. Its platform tags recipes by calculating nutrition information based on quantity, ingredients, and cooking time. Users are then matched to recipes based on food preferences, dietary restrictions, or geographic location and are assigned health scores along the way.¹⁶ Whisk's platform also converts recipes into customizable shopping lists that are linkable to major grocery chains.

AI tools help drive the food-logging trend, wherein consumers log foods, quantities, and calories in a digital food journal to bolster eating habit mindfulness, lose weight, or achieve a fitness goal. Food logging apps such as Lose It! compile nutrition information from popular restaurants and store-bought foods to automate and streamline the otherwise tedious process for their users. A new generation of food logging tools uses computer vision to simplify this process further. Bite AI's app identifies foods in photos and estimates quantity and nutritional information. It also recommends personalized diets based on user information such as body mass index.

¹⁶: Location data informs the algorithm on local weather, which is an input to the recommendation.