

WHERE TO PLAY:  
GAME-CHANGING  
TECHNOLOGIES  
FOR **FOOD & DRINK**



ITONICS

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# Introduction

The food & drink industry is immense, diverse, and highly consequential. It comprises a vast network of players—from farm to factory to fork. With globalization, these networks and the supply chains by which they deliver value have become increasingly complex.

This complexity has served to help meet rising and varied demands. However, it has also given rise to opaque, unwieldy, and interdependent systems that make it challenging to adapt in the event of disruption. With the onset of the pandemic, these vulnerabilities within many global food & drink supply chains have become impossible to ignore.

Lockdowns and social distancing immediately impacted the food service industry, which was one of the hardest-hit sectors after travel and recreation and remains unsteady still today with repercussions for many suppliers. Bottlenecks and blockages in transportation have limited access to critical inputs and ingredients for producers and manufacturers. And on the other end, farms and the agro-food sector continue to be heavily hit by pandemic-related labor shortages, in addition to volatile oil prices and increasingly extreme weather events.

The cascading effects of the past two years have, like in many industries, have put additional pressure on incumbents that were already facing intense competition from more agile upstarts. Evolving consumer tastes and behaviors have escalated the mandate to innovate. Food & drink organizations from restaurants to retailers must engage their customers through digital channels with new formats and distinct value.

Technological advancements in the food & drink industry have tended to lag behind other sectors. But now, with end-to-end digitalization a growing imperative, organizations cannot afford to maintain business as usual. Infusing technology throughout the entire value chain is essential for boosting productivity and efficiency, as well as improving sustainability in an industry that accounts for around a quarter of all global carbon emissions.

This report aims to provide decision-makers in food & drink with a view of the technologies that hold the greatest potential for impactful innovation. These game-changing technologies range from emerging to evolving and present several innovative use cases for enhancing resilience, relevance, and sustainability in the industry. The information contained within this report is interlinked with the ITONICS Innovation Platform to help you visualize the connections between various drivers of change and identify the technologies that align with and enable your strategic innovation goals.

## An Introduction to Technology Scouting

End2end innovation management begins by asking the fundamental question, **Where to Play**. Answering this question relies on several congruent activities and internal capabilities that primarily fall within the discipline of Foresight and Strategy, as advocated by our distinct **ITONICS COFIM** model. Organizations equipped with strong foresight capabilities can align their strategy with future scenarios and build resilience in an increasingly uncertain and competitive landscape.

Essential in **Foresight and Strategy** is an organization's capacity to scan its business environment comprehensively and continuously—environmental scanning. This is the capability to scan the horizon for weak signals that might indicate larger shifts and influence or disrupt the environment. It begins with the collection of vast amounts of data from which patterns are revealed through sensemaking analysis.

**Environmental scanning** focuses on control objectives that enhance innovation intelligence, thereby enabling the identification of new opportunities for growth, informing strategic priorities, and shaping future goals. These include capability supervision, competitor watch, trend scouting, and technology scouting.

As the focus of this industry report, **technology scouting** is the process of observing technological shifts and developments by collecting pertinent data, contextualizing change to uncover discernable patterns as weak signals, and identifying emerging technologies that hold both impact and relevance.

Actively screening for shifts in technology adoption, R&D, and patents serves as an early-warning system to help organizations anticipate and respond to changes while also minimizing risk.

Applying an industry lens to the process of technology scouting helps organizations direct their focus and resources more optimally.

And by gaining an understanding of the technological developments and adoption trends that may present future opportunities in their industry, they can equip themselves with the innovation intelligence needed to take decisive, strategic action and ultimately gain a competitive advantage.





## The Role of Technologies in Innovation

Emerging, evolving, and disruptive technologies serve as solution drivers, helping innovators connect the dots between their current and future states. These are the tools capable of meeting—and sometimes, creating—new needs, desires, and demands.

Technologies enable new business models, products, and services. They have the potential to meaningfully expand an organization's existing portfolio and transform an entire industry.

### The Interplay between Technologies and Trends

Technologies and trends are complementary elements that interact with and influence one another. Trends are expressions of new consumer attitudes, expectations, or behaviors—an indication of market pull; whereas technologies are designed either in response to these shifts or as precursors to nascent demands—representing a market push.

Together this push and pull exert force on the market, driving change forward. It is organizations' ability to pre-empt or respond to this change through innovation that determines their success.

### Determining Industry Relevance

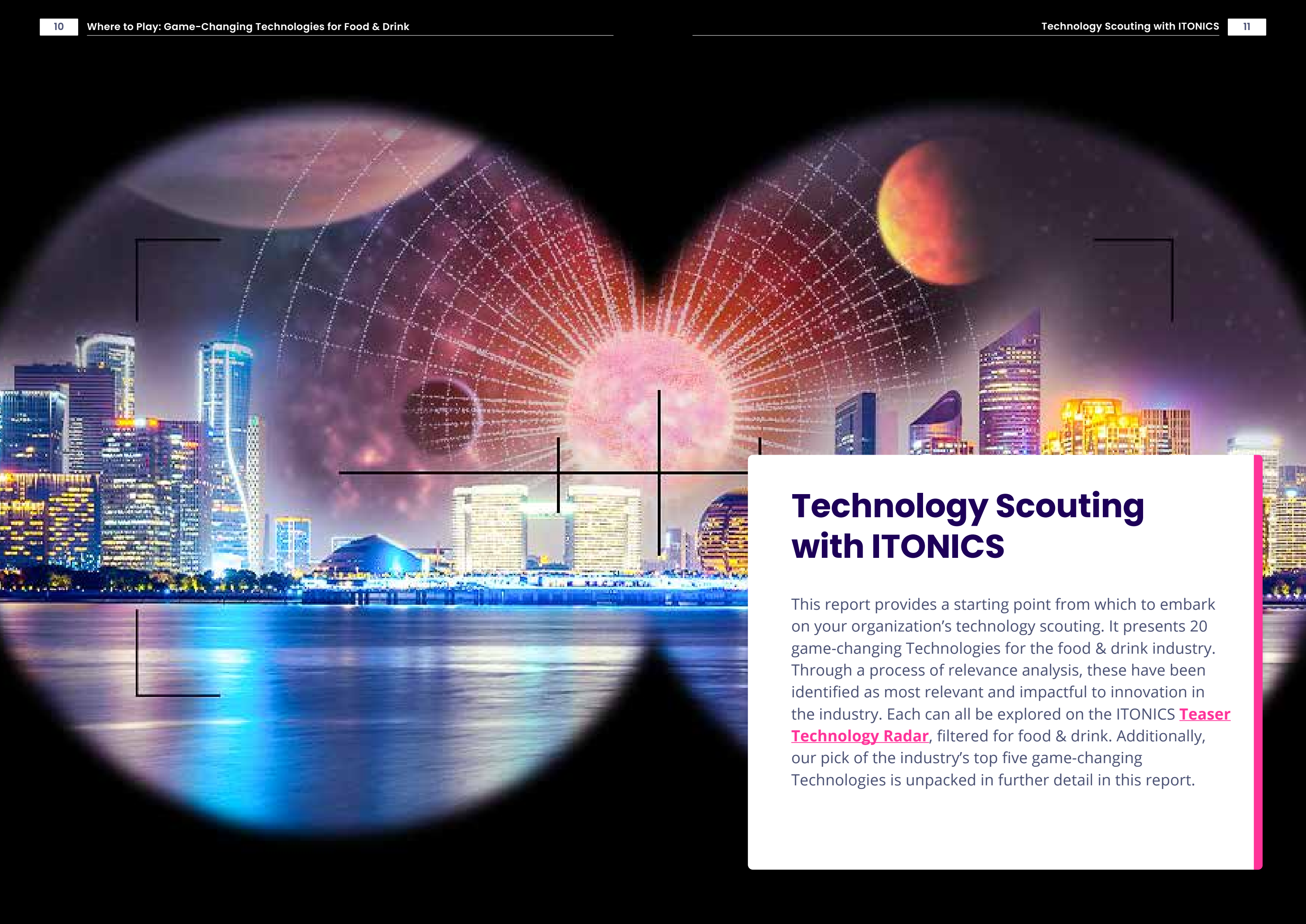
Environmental scanning is a divergent exercise; too narrow an approach and important opportunities can easily be missed. And while all elements in the ITONICS portfolio hold relevance—the degree of relevance differs depending on the industry in which your organization operates.

To help provide this industry lens, ITONICS analysts have performed relevance analysis to identify the Technologies and other elements that are most relevant and likely to be game changers in each respective industry.

Our team of analysts monitored the frequency with which each Technology appeared in a given industry. Instances of real-world applications, R&D, patents, and startup activities were tagged with relevant industries through a process combining manual and automated data classification.

This initial mapping of the ITONICS portfolio served as hypotheses of industry relevance. These hypotheses were further validated and enriched through additional quantitative and qualitative industry research to arrive at nine industry packages.

*Each industry package, available on the ITONICS Innovation Platform, displays the Technologies, Trends, and Inspirations that represent the most relevant—that is, impactful, disruptive, and transformative—areas in which to play.*



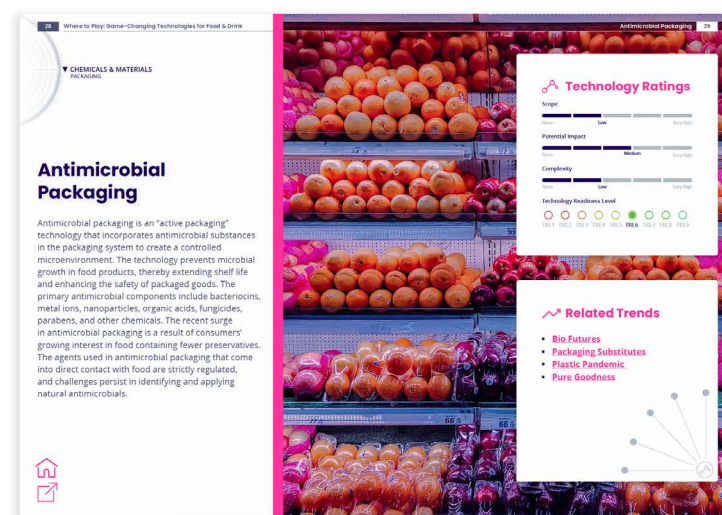
## Technology Scouting with ITONICS

This report provides a starting point from which to embark on your organization's technology scouting. It presents 20 game-changing Technologies for the food & drink industry. Through a process of relevance analysis, these have been identified as most relevant and impactful to innovation in the industry. Each can all be explored on the ITONICS [Teaser Technology Radar](#), filtered for food & drink. Additionally, our pick of the industry's top five game-changing Technologies is unpacked in further detail in this report.

## How to Read the Technologies

The **Synopsis** gives a brief overview of the Technology, explaining why it is important, what is required to enable it, how it has evolved, and any current limitations and opportunities.

The **Segmentation** of the Technology is indicated corresponding to the relevant categories that appear on the ITONICS Radar: Chemicals & Materials, Energy & Resources, Engineering, Healthcare & Life Sciences, ICT, and Mobility. Listed below, the **Sub-segmentation** provides a more narrow scope as to the area of technological development.



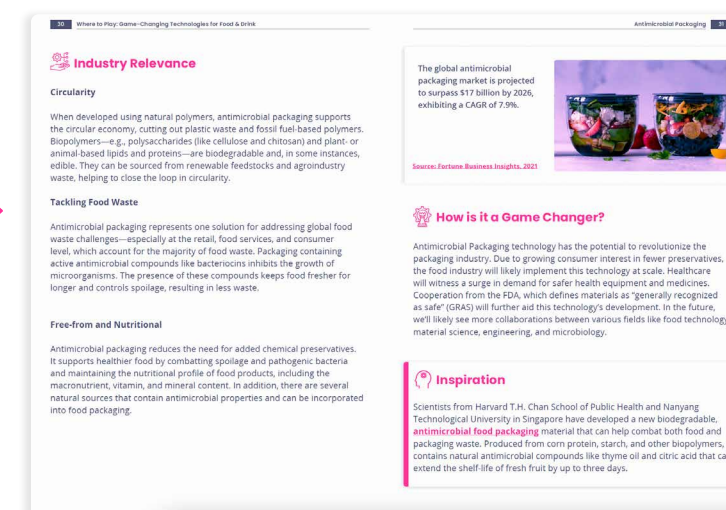
In the navigation bar, the  icon will bring you back to the Table of Contents page. The  button will open up the individual element in the ITONICS **Teaser Technology Radar**. Here you can deep dive into the Implications for Innovation associated with the Technology and view the interconnected elements that influence and impact it, including related Trends, Inspirations, and other Technologies.

The **Technology Ratings** look at the parameters of Scope, Potential Impact, Complexity, and Technology Readiness Level (TRL).

**Related Trends** show the elements that are influenced by and have an influence on the Technology, its development, and adoption. This network provides greater context as to the interplay between elements and points to possible opportunities.

**Industry Relevance** unpacks the industry-specific applications and potential use-cases that are most prominent with regard to the Technology. Each point looks at the strategic advantage gained through adoption of the Technology and the considerations for its future development.

**How is this a Game Changer?** elaborates on how the Technology may contribute to or influence possible future scenarios. The relationship between the Technology and nascent demands is explored through a future-oriented lens.

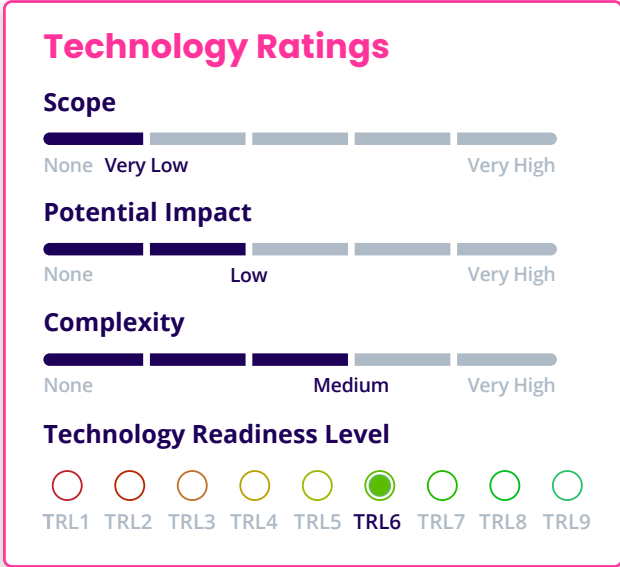


**Inspirations** provide evidence of how organizations are applying the Technology in the real world. They serve as springboards for ideation, helping innovators look beyond their category, connect information in new ways, and nurture fresh thinking.

ITONICS Ratings

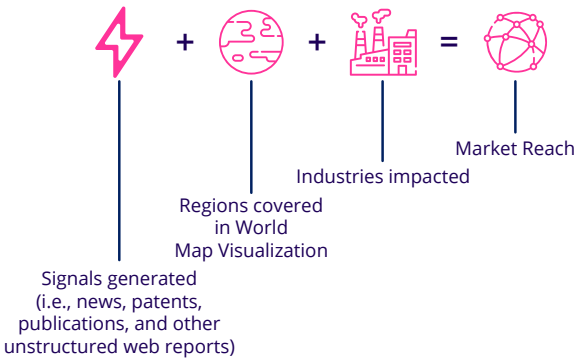
The evaluation of trends or technologies is one of the most important activities in innovation management. The goal is to predict future changes in your industry and whether they are relevant to your organization.

ITONICS Trends and Technologies are presented with ratings that help foresight teams focus their attention and identify relevance based on their unique set of strategic objectives.



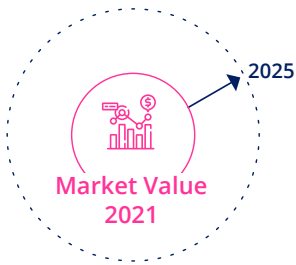
**Scope:** How far-reaching is the potential influence of this element on this market?

ITONICS Insights tool uses keywords to retrieve data across three dimensions and derive an aggregated mean value to indicate the market reach of each Technology.



**Potential Impact:** How high is the potential impact of this element on the market?

Market growth data for each Technology is collected from a minimum of 5 verifiable sources, aggregated and extrapolated to 2025.



**Scale: Projected market value in 2025 (USD billion):**

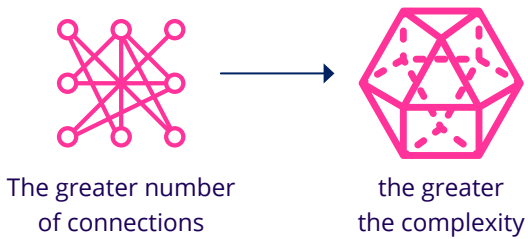
- Very Low: >10 bil.
- Low: 10-50 bil.
- Medium: 50-500 bil.
- High: 500-1,000 bil.
- Very High: >1,000 bil.

Our team of analysts uses advanced query and **ITONICS Insights** to garner the relevant information alongside our research and statistically derive the ratings from quantifiable historical and present data.

Each Technology is rated on Scope, Potential Impact, Complexity, and Technology Readiness Level (TRL) to provide targeted and tailored analysis at your fingertips.

**Complexity:** How high is the complexity of this element?

A complexity score is derived based on the number of connections each Technology forms with other elements.



**Technology Readiness Level (TRL):** How mature is this element in the market?

Each Technology is mapped by its Technology Readiness Level (TRL) to determine its relative maturity.

| PHASE       | TRL | DEFINITION                                               |
|-------------|-----|----------------------------------------------------------|
| RESEARCH    | 1   | Basic principles observed                                |
|             | 2   | Concept formulated                                       |
|             | 3   | Experimental proof of concept                            |
| DEVELOPMENT | 4   | Validated in lab                                         |
|             | 5   | Validated in relevant environment                        |
|             | 6   | Demonstrated in relevant environment                     |
| DEPLOYMENT  | 7   | System prototype demonstrated in operational environment |
|             | 8   | System complete and qualified                            |
|             | 9   | Actual system proven in operational environment          |

## Exploring the ITONICS Radar

Having the right tools to manage innovations, technologies, projects, and opportunities is vital to act on your organization's innovation strategy in an increasingly uncertain and dynamic world. After all, what you can't manage, you cannot change.

Get started by exploring the ITONICS [Teaser Technology Radar](#) and [Teaser Trend Radar](#), displaying the elements that are most relevant

to your industry. Here you will find a read-only overview of each Technology and Trend.

Beyond what's available in the Teaser, the full content on the ITONICS Innovation Platform provides deeper insight into each Technology. It allows users to interact with and configure different elements to derive greater meaning and prompt informed decision-making.

The screenshot displays the ITONICS Radar interface. On the left, a grid of 12 elements is shown, each with a thumbnail image, a title, a brief description, and a list of tags. The elements are categorized by type (Technology or Inspiration) and date. On the right, an 'Advanced Filtering' sidebar is visible, allowing users to filter elements by type (Trend, Inspiration, Technology), tags, and internal ratings. The sidebar includes sections for 'Saved Filters', 'What element types do you want to show?', 'What do you want to filter by?', and individual filter sections for Trend, Inspiration, and Technology.

The ITONICS Innovation Platform provides access to:

- The full portfolio of **175+ Trends and Technologies**, each with detailed explanations of how they have developed, where they are currently having an impact, and how they could evolve into the future.
- **7,000+ Inspirations**, continually updated to illustrate how Trends and Technologies are being activated and brought to life by innovators, businesses, and consumers.

- The ability to set **Internal Ratings** such as Business Relevance, Strategic Fit, Internal Know-How, and Need for Action. Undertaken as a collaborative evaluation exercise within your organization, these ratings help build the consensus and commitment needed in the innovation journey.

- Interactive **Network Graph** visualizations that display first- and second-level relations for a selected element. New relations that hold strategic relevance to your organization can also be added to any network graph.

Various **Tags** attributed to each element to help users focus their searches. A **Tag Filter** function allows advanced searching by tags and gives suggestions for related tags. To view the Trends, Technologies, and Inspirations that are most relevant to food & drink, use **Advanced Filtering** and select the **Saved Filter: Food & Drink**

*For full access to this content and functionality, register an account on ITONICS Cloud for free today.*

**REGISTER**

# Forces Shaping the Future of Food & Drink

## Context of Change

Defining the objectives and scope of environmental scanning activities like technology scouting requires a clear understanding of the context of change in your industry. Context provides a foundation for identifying and assessing the driving forces shaping the future. It points to evidence of where we see change happening in social, technological, economic, environmental, and political spheres and where the change will expand to next. It is the landscape upon which trends and technologies play out; the ability to navigate this landscape is the ability to adequately prepare for possible futures.

## Forces Shaping the Future

Around the globe, several driving forces are impacting the food & drink industry. The pandemic has had a grave effect on global supply chains and, consequently, has hindered progress in the fight against food insecurity. Likewise, consumer tastes and preferences are constantly evolving, trending towards healthier, more sustainable, and diverse diets. Convenience and cost remain key factors influencing consumer choice and driving the massive shift to e-commerce solutions for the food & drink industry. Giving consumers more autonomy in choosing their price point and value-add is increasingly important amidst rising costs of food and drink.

*Here we'll discuss some of the forces shaping the future of the food & drink industry.*

## GLOBAL FOOD SECURITY

*will require food systems transformation.*

Despite global commitments to achieve zero hunger ([SDG 2](#)), more than 30% of the world's population now faces moderate or severe food insecurity. This figure has risen gradually in the last several years due to climate change, economic downturns, and conflict. The pandemic further exacerbated the issue of food insecurity, exposing weaknesses in food systems and supply chains. Unable to keep pace with growing populations and food demands, existing food systems must undergo transformation. This will require new technologies, corporate governance, and diplomacy to ensure equitable and affordable access to healthy, sustainable diets.

## THE WELLNESS MOVEMENT

*will bolster the market for purer products with functional benefits.*

The idea of food as medicine has grown alongside greater awareness and adoption of integrative and holistic approaches to health. The global market for healthier, less processed food and drink will continue to grow as more consumers take control over their health. Meanwhile, the pandemic triggered a rise in demand for products and supplements labeled with "immune support." There is persistent interest in herbal, CBD, and other functional, natural ingredients that tout therapeutic, cognitive, or anti-aging benefits. However, these so-called nutraceuticals are largely unregulated in many countries, and consumers are increasingly scrutinizing products, seeking evidence-based value.

## III PLANETARY HEALTH

*will demand transparency and optimization throughout the entire value chain.*

A new definition of healthy eating is emerging to encompass more than just nourishment. The impact of the food & drink industry on planetary health has come into stark focus. As a result, more consumers are adopting climate-friendly diets that incorporate alternative, plant-based proteins and local, seasonal foods. There is a growing demand for minimizing food waste and supply chain transparency to validate claims of sustainable, ethical production. These shifts require examination and optimization of the entire value chain—from precision and regenerative agricultural practices to reducing food and packaging waste.

## IV E-COMMERCE

*will be an essential channel for reaching and retaining customers.*

Much like retail, the food & drink industry experienced massive disruption due to the pandemic. Restaurants, supermarkets, and food & drink manufacturers rushed to meet their customers online with e-commerce solutions and on-demand (contactless) delivery. Lockdown periods accelerated the rollout and adoption of these solutions. While some habits are likely to revert to pre-pandemic “normalcy,” the online presence of the food & drink industry and demand for direct-to-consumer services will have permanence. This will require infusing technology (e.g., AI, automation, IoT, and dynamic routing) into existing distribution and delivery models to streamline operations and elevate the customer experience.

## V GLOBAL FLAVORS

*will inspire consumer curiosity and product innovation.*

Interest in different food cultures and cuisine continues to rise. Consumers are seeking the novelty of new flavors and the health benefits of traditional ingredients like herbs, spices, fruits, teas, etc. Food & drink companies are competing to identify the next promising local or even hyperlocal flavor to introduce in new markets. Making these flavors mainstream and engaging consumers, in some cases, calls for new formats, creative combinations, and authentic storytelling around the product. However, global supply chain disruptions and shifting climate conditions threaten not only the availability of indigenous crops but their very existence.

## VI SUPPLY CHAIN RESILIENCE

*will be a primary aim for navigating future uncertainties.*

Disruptions to the food & drink industry have persisted since the start of the pandemic. Labor shortages and transportation bottlenecks have exposed vulnerabilities, especially in global supply chains. The situation is made worse by increasingly severe and frequent weather events. As a result of these factors, the cost of doing business and, in turn, food prices continue to rise. To break this cycle of disruption and inflation, food & drink producers are seeking ways to improve the resilience and agility of their supply chains—from localizing production and reducing wastage to digitalizing and automating workflows.



*Use this context to help better understand the strategic importance and innovation opportunities associated with the game-changing technologies identified for the food & drink industry.*

# Game-Changing Technologies for Food & Drink

## Technology Navigation

Through a process of qualitative and quantitative industry research, our team of analysts conducted relevance analysis in order to identify the Technologies within our portfolio that are **most relevant and influential in the food & drink industry**.

### Game-Changing Technologies for Food & Drink

Explore the selection of Technologies at play in the food & drink industry. Click on the Technology below to view it in the ITONICS [Teaser Technology Radar](#):

- [3D Printing\\*](#)
- [Antimicrobial Packaging\\*](#)
- [Biomufacturing\\*](#)
- [Conversational Systems](#)
- [CRISPR](#)
- [Distributed Ledger Technology](#)
- [Extended Reality](#)
- [Geofencing](#)
- [Intelligent Manufacturing\\*](#)
- [Internet of Behavior](#)
- [Internet of Thinking](#)
- [Nanomanufacturing](#)
- [Natural Language Processing](#)
- [No-Touch Payments](#)
- [Precision Agriculture\\*](#)
- [Programmatic Advertising](#)
- [Responsive Materials](#)
- [Synthetic Biological Engineering](#)
- [Unmanned Deliveries](#)
- [Water Treatment Technologies](#)

\*These Technologies make up ITONICS' pick of the food & drink industry's top 5 game-changing Technologies. These are unpacked in further detail in this report.



### ITONICS Top 5 Game-Changing Technologies for Food & Drink

**Click below** to read more about the industry potential of these Technologies and examples of how organizations are applying them as solutions:

1. [3D Printing](#)
2. [Antimicrobial Packaging](#)
3. [Biomufacturing](#)
4. [Intelligent Manufacturing](#)
5. [Precision Agriculture](#)

## ▼ ENGINEERING PRODUCTION

# 3D Printing

3D Printing, also known as “additive manufacturing,” is a process of creating three-dimensional solid objects by printing successive horizontal layers of an object’s digital file. This technology is revolutionizing the global manufacturing industry and has tremendous economic value. Initially limited to prototyping, the technology has come a long way and has been pivotal in producing vital applications in the face of COVID-19. Sectors including healthcare, automotive, defense, construction, aerospace, and food are continuously pushing the boundaries of custom manufacturing, reducing material waste and production time. The high initial investment required is the primary limiting factor for 3D printing adoption across verticals.



## Technology Ratings

### Scope



### Potential Impact



### Complexity

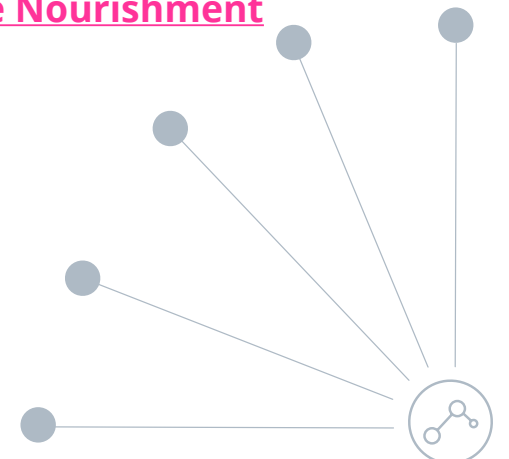


### Technology Readiness Level



## Related Trends

- Circular Economy
- Localized Production
- Me Commerce
- Sustainable Nourishment





## Industry Relevance

### Tailored Nutrition

3D printing can deliver personalized, precision nutrition, seamlessly altering the exact amounts of macronutrients, vitamins, minerals, or active ingredients based on individual needs and preferences, e.g., dietary requirements, age, gender, or health condition. In addition, 3D printed “nutrition pods”, engineered to optimize functional nutrition and increase stability, can support targeted malnutrition treatment.

### Creative Product Design

The ability to customize ingredients and shapes through 3D printing represents an opportunity to experiment with new products and formats. Companies that manufacture and prepare food can creatively combine ingredients, create new dishes, and architect intricate designs. 3D food printers can also facilitate culinary arts, food marketing, and co-creation with end customers.

### Sustainable Printed Protein

3D printing represents a solution for producing sustainable, ethical meat alternatives and even real meat. There is potential to render sustainable protein sources like insects and plant ingredients, replicating meat’s texture, taste, and behavior. Additionally, emerging bioprinters can print muscle cells stimulated from stem cells for slaughter-free meat products. Challenges include cost, scalability, and—in the case of bioprinting—working with delicate living cells.

“What we still don’t have is what we call ‘Food CAD’—sort of the Photoshop of food. We need a high-level software that enables people who are not programmers or software developers to design the foods they want. And then we need a place where people can share digital recipes like we share music.”

- Professor Hod Lipson, Director of the Creative Machines Lab  
at Columbia University

[Source: Newsweek, 2021](#)



## How is it a Game Changer?

3D Printing is transforming the global manufacturing industry. Artificial intelligence and machine learning are integral to the technology, enhancing the value chain in material development, workflow setup, and design automation. 3D Printing will disrupt global supply chains, as distribution and production will no longer be restricted to centralized manufacturing units, and its potential impact on healthcare is enormous. In the future, almost every industry will reap the benefits of 3D printing, not just in prototyping but also throughout production and distribution.



## Inspiration

In a collaboration between Osaka University and Toppan, a Japanese printing technologies provider, researchers have produced **cultured Wagyu beef** using a novel tissue modeling technology. The technology is based on 3D printing and can replicate the complex tissue structures and unique profile of Wagyu beef, including muscle, fat, and blood vessel composition.

## ▼ CHEMICALS & MATERIALS PACKAGING

# Antimicrobial Packaging

Antimicrobial packaging is an “active packaging” technology that incorporates antimicrobial substances in the packaging system to create a controlled microenvironment. The technology prevents microbial growth in food products, thereby extending shelf life and enhancing the safety of packaged goods. The primary antimicrobial components include bacteriocins, metal ions, nanoparticles, organic acids, fungicides, parabens, and other chemicals. The recent surge in antimicrobial packaging is a result of consumers’ growing interest in food containing fewer preservatives. The agents used in antimicrobial packaging that come into direct contact with food are strictly regulated, and challenges persist in identifying and applying natural antimicrobials.



## Technology Ratings

### Scope



### Potential Impact



### Complexity

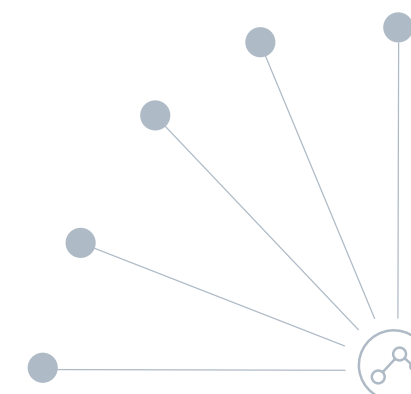


### Technology Readiness Level



## Related Trends

- [Bio Futures](#)
- [Packaging Substitutes](#)
- [Plastic Pandemic](#)
- [Pure Goodness](#)





## Industry Relevance

### Circularity

When developed using natural polymers, antimicrobial packaging supports the circular economy, cutting out plastic waste and fossil fuel-based polymers. Biopolymers—e.g., polysaccharides (like cellulose and chitosan) and plant- or animal-based lipids and proteins—are biodegradable and, in some instances, edible. They can be sourced from renewable feedstocks and agroindustry waste, helping to close the loop in circularity.

### Tackling Food Waste

Antimicrobial packaging represents one solution for addressing global food waste challenges—especially at the retail, food services, and consumer level, which account for the majority of food waste. Packaging containing active antimicrobial compounds like bacteriocins inhibits the growth of microorganisms. The presence of these compounds keeps food fresher for longer and controls spoilage, resulting in less waste.

### Free-from and Nutritional

Antimicrobial packaging reduces the need for added chemical preservatives. It supports healthier food by combatting spoilage and pathogenic bacteria and maintaining the nutritional profile of food products, including the macronutrient, vitamin, and mineral content. In addition, there are several natural sources that contain antimicrobial properties and can be incorporated into food packaging.

The global antimicrobial packaging market is projected to surpass \$17 billion by 2026, exhibiting a CAGR of 7.9%.



Source: [Fortune Business Insights, 2021](#)



## How is it a Game Changer?

Antimicrobial Packaging technology has the potential to revolutionize the packaging industry. Due to growing consumer interest in fewer preservatives, the food industry will likely implement this technology at scale. Healthcare will witness a surge in demand for safer health equipment and medicines. Cooperation from the FDA, which defines materials as “generally recognized as safe” (GRAS) will further aid this technology’s development. In the future, we’ll likely see more collaborations between various fields like food technology, material science, engineering, and microbiology.



## Inspiration

Scientists from Harvard T.H. Chan School of Public Health and Nanyang Technological University in Singapore have developed a new biodegradable, **antimicrobial food packaging** material that can help combat both food and packaging waste. Produced from corn protein, starch, and other biopolymers, it contains natural antimicrobial compounds like thyme oil and citric acid that can extend the shelf-life of fresh fruit by up to three days.

▼ HEALTH TECH & LIFE SCIENCES  
BIOTECHNOLOGY

# Bio manufacturing

Biomanufacturing is a production method that draws on biological systems to create biomaterials, mainly within the medicine and food & drink industries. Recent applications include biology-based therapeutics and lab-grown meats. Using biomanufacturing to reengineer biological organisms enables scientific and engineering innovation, and integrating AI with biomanufacturing allows manufacturers to implement smart processes. Transitioning to smart systems currently has its limitations as it relies on processing large datasets that currently aren't centralized. Biomanufacturing at scale for commercial use remains problematic. However, advances like single-use bioprocessing systems seek to address this obstacle and are likely to impact the agriculture and chemical industries.



## Technology Ratings

### Scope



### Potential Impact



### Complexity

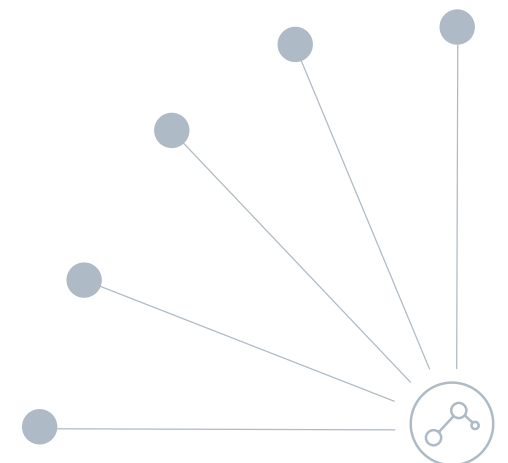


### Technology Readiness Level



## Related Trends

- [Bio Futures](#)
- [Plastic Pandemic](#)
- [Sustainable Nourishment](#)



## Industry Relevance

### Cultured Meat

Advances in stem cell technology and biomanufacturing have made slaughter-free, lab-grown meat a reality. It is grown outside of the animal in controlled laboratory settings yet is identical to conventional livestock meat and can be produced anywhere locally. Biomanufactured meat could help meet rising food demands while mitigating the climate impact from livestock farming. However, significant investment is needed to scale production and reduce costs.

### Natural Food Ingredients

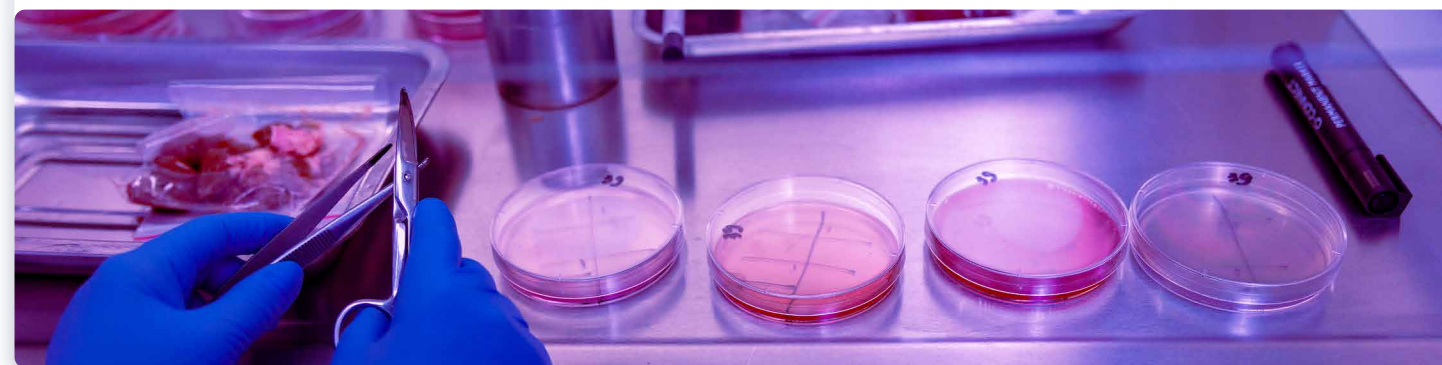
Biomanufacturing produces several natural food ingredients through microbial fermentation and enzymatic activity. These include food colorings, sweeteners, preservatives, and flavorings, which enhance food taste and shelf life and are most often derived from microbes or plants. Biomanufacturing food ingredients is more sustainable, efficient, and economical than conventional agricultural or petrochemical processes.

### Mitigating the Food Crisis

Scientists can genetically engineer food crops through biomanufacturing to create new varieties with enhanced traits, including tolerance to diseases, greater environmental resilience, and improved nutrient profiles. The benefits of more productive agricultural yields serve the full value chain and also hold the potential to mitigate global food insecurity. However, there are persistent concerns about genetically modified foods' long-term environmental and health effects.

"We envision that within 5 to 10 years, we will have two categories of meat available: one is slaughter-based, and one is slaughter-free."

— *David Kraus, Senior Food Scientist at Alpha Farms*



Source: [Nutritional Outlook, 2021](#)



## How is it a Game Changer?

The fields of sustainable bioplastics, climate-friendly protein production, and biopharma will be heavily impacted as innovations affect time to market, connected treatment, and analytics uses. Designed-for-purpose organisms will provide targeted solutions in healthcare and food & drink, and biomanufacturing also has the potential to simplify chemical production processes. More sustainable products will be able to go to market quickly due to smart biomanufacturing. The COVID-19 pandemic will influence biomanufacturing demands and require regulation and certification processes to keep pace with accelerated development.



## Inspiration

Chemical company DIC is partnering with [Debut Biotech](#) to use the startup's cell-free biomanufacturing platform to create natural pigments for food colorants and cosmetics. The ingredients are intended to replace synthetic petroleum-derived colorants amid growing consumer demand for more sustainable ingredients that are natural and biodegradable.

# Intelligent Manufacturing

Intelligent Manufacturing involves applying artificial intelligence to the physical aspects of a manufacturing process. Intelligent Manufacturing seeks to increase productivity, improve product quality, reduce costs, and minimize equipment downtime. Intelligent Manufacturing uses real-time data from machine sensors, IoT, AI, and ML to examine the health of the manufacturing equipment and processes, predict critical events and take preventative action to avoid these problems. Challenges to adoption include high initial investment costs, security issues, skills shortages, and difficulty integrating technology with legacy infrastructure.



## Technology Ratings

### Scope



### Potential Impact



### Complexity

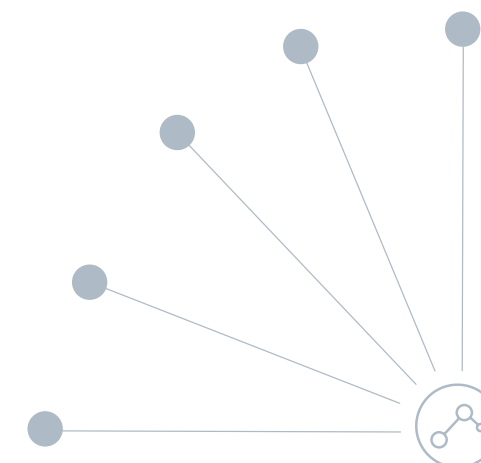


### Technology Readiness Level



## Related Trends

- [Automating a Greener World](#)
- [Green and Lean](#)
- [Radical Transparency](#)





## Industry Relevance

### Farm-to-Fork Traceability

Infusing the manufacturing process with IoT and AI allows for greater visibility and traceability. Manufacturers can track ingredients as they come into the factory and are incorporated into end products. This can prove especially useful in the event of a contamination issue or recall. Additionally, the ability to track items through the production line helps close the gap between suppliers and customers, establishing farm-to-fork traceability.

### Analytics for Agility

Smart factories generate an immense amount of data that provide actionable insights in real-time. This allows food & drink manufacturers to continuously optimize operations, inventory, and even product value. They can dynamically adjust settings to improve machine efficiency, quickly shift production in response to changing demand or goods shortages, and adapt products based on emerging consumer preferences.

### Sustainable Production

Food & drink manufacturers can achieve higher levels of sustainability and align with ESG standards by automating their production lines. Technologies such as IoT, AI, and robotics allow organizations to improve operational efficiency and reduce wastage of energy, resources, and materials. Intelligent manufacturing also minimizes losses due to error and, through predictive maintenance, prolongs the lifespan of machinery.

Over the next five years, the food & drink industry is expected to see the highest growth in smart factory solutions, increasing the quality and quantity of products manufactured and allowing for greater innovation.

[Source: Markets and Markets, 2021](#)



## How is it a Game Changer?

Projections show that companies that invest in implementing artificial intelligence in their manufacturing processes can see an increase in annual revenue of up to 18%. Many manufacturing companies have begun adopting technologies like IoT, analytics, AI-based digital platforms to minimize human interaction in response to the COVID-19 pandemic. In the future, Intelligent Manufacturing will be widely leveraged to stabilize the manufacturing process.



## Inspiration

[Aspire Food Group](#), a leader in advanced insect agriculture, is building the first fully-automated food-grade insect protein manufacturing facility. It will operate using IIoT (industrial internet of things) sensors, artificial intelligence, and machine learning. Integration of these technologies will improve productivity and resource efficiency, and, together with the low environmental footprint of insect protein, Aspire aims to support sustainable food security.

## HEALTH TECH & LIFE SCIENCES AGRICULTURE

# Precision Agriculture

Precision Agriculture is a management system that utilizes modern technologies to optimize the farming process. The technology-infused processes that fall under Precision Agriculture include drones for remote monitoring, digital field maps for detailed crop analysis, and fertilizer and irrigation systems that use variable-rate application. Precision Agriculture has proven to increase crop outputs, increasing profitability and assisting farmers in finding sustainable, net-positive farming solutions. Constraints of this technology include the cost of implementation and a lack of research on its long-term impact on the agricultural industry.



## Technology Ratings

### Scope



### Potential Impact



### Complexity

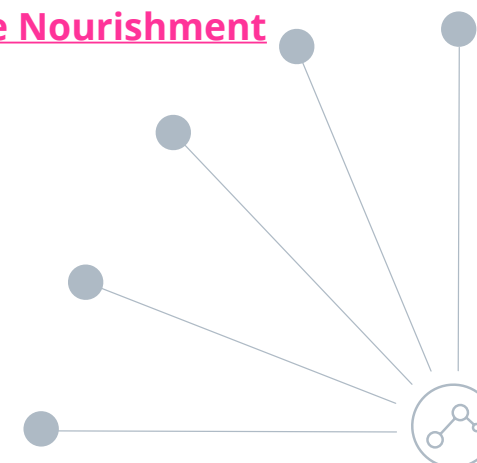


### Technology Readiness Level



## Related Trends

- [Automating a Greener World](#)
- [Bio Futures](#)
- [Future Farming](#)
- [Sustainable Nourishment](#)



## Industry Relevance

### Smart Weed Control

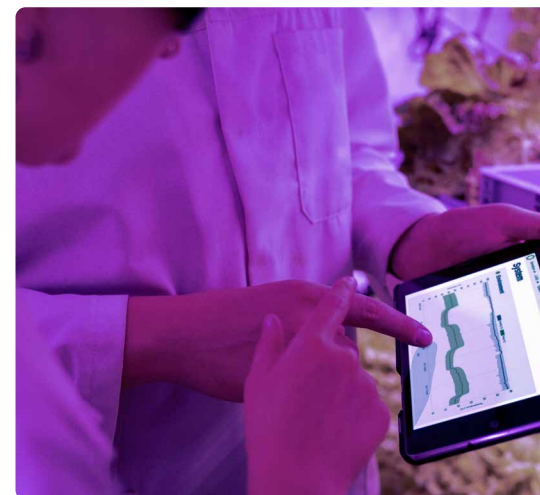
Agricultural robots and drones are the most optimal means of managing the growth of invasive weeds. These technologies are extremely accurate in weeding row crops, using 20 times less herbicide than conventional methods—which is far more economical and better for the environment. The integration of data analytics serves as an early warning system for the reemergence of weeds and efficacy of measures.

### Hybrid Analytics

Drone cameras and IoT devices acquire data that allow farmers to monitor various indicators like crop growth, soil conditions, weather patterns, etc. Facial recognition technology can also monitor livestock and individual animal behavior. Hybrid analytics—combining edge and cloud computing—allow real-time, local responses as well as more complex decision-making based on multiple data streams and predictive analytics.

### End-to-End Farm Management

As the technologies that enable precision agriculture advance and are more widely adopted, a new system of end-to-end farm management becomes possible. Built on remote monitoring and data analytics, this system is inherently digital and allows for greater transparency, automation, and overall efficiency. Farmers are empowered to take informed and pre-emptive action to ultimately increase productivity while lowering costs along the entire value chain.



Bell Labs Consulting predicts that if 25% of all farms adopted precision agriculture by 2030, the annual global result would be:

- Increase in yield by 300 million tons
- Reduction of costs by \$200 billion
- Reduction of wastewater 150 billion m<sup>3</sup>

Source: Nokia, 2021



## How is it a Game Changer?

Precision Agriculture is set to redefine the relationship between technology and farming, interweaving the two to develop future-focused, innovative agricultural practices. Precision Farming is closely linked to the trend of Future Farming, driven by a need to develop sustainable farming methods and harness emergent technologies to increase crop yields to meet growing food demand. As technology costs drop and more Precision Agriculture technocrats emerge, using technologies such as the Internet of Things and drone-based monitoring in the agricultural sector may well become an industry standard.



## Inspiration

**Montana State University** researchers are collaborating with farmers across 15 states to improve the efficiency of their operations using technologies like yield monitors, protein sensors, and AI/ML platforms. The project will develop a user-friendly system for on-farm experimentation, data collection, and analysis, alongside a framework to help farmers make the most cost-effective and ecologically sustainable management decisions.

# Conclusion

## Closing Remarks

Innovation in the food & drink industry is often thought of in terms of new products, convenient formats, and customer experience. But this fails to acknowledge the complexity—and myriad opportunities and challenges—that exist in today's global food systems.

Meeting rising demands and achieving food security for all will require transformation of these systems. This starts with sustainable farm management and land use. **Precision Agriculture** will help optimize production practices and improve yields by employing drones, IoT, automation, and predictive analytics. Integrating other solutions like regenerative agriculture, hydroculture, pasture and crop rotation, and advanced seed coatings will also be essential in systems-level responses.

Along the value chain, **Intelligent Manufacturing** allows food & drink organizations to streamline operations, shorten time-to-market, and reduce materials wastage. IoT and AI/ML platforms generate real-time data and insights that manufacturers can use to dynamically adjust variables throughout the production line. While upfront costs of replacing or retrofitting legacy infrastructure can be high, the long-term savings in costs, energy, and resources make it possible to scale production more efficiently and sustainably.

Similarly, **Biomanufacturing** and **3D Printing** are promising alternative production methods for a more sustainable food & drink industry. As consumer preferences shift towards climate-friendly diets, the market for meat alternatives—e.g., plant- and insect-based proteins and “lab-grown” meat—grows. However, continued investment into improving and scaling these technologies is needed to reduce price and enhance palatability for consumers.

Organizations must also consider new distribution and retail strategies that address the rising dominance of e-commerce and direct-to-consumer services. Even as COVID-19 restrictions ease, food delivery is expected to thrive and

expand into less densely populated areas, made possible by technologies like **Unmanned Deliveries** and improved routing.

Meaningful food systems transformation will require the industry to strive for circularity in its value chain at each of the stages above, as well as at the point of disposal. This means introducing measures for minimizing food and packaging waste, like biodegradable and **Antimicrobial Packaging**.

Within this context of change, we provide a set of questions for organizations in food & drink to consider in the hope of nurturing fresh thinking about the future they wish to be a part of, and play an active role in helping to create.

- What if carbon labels become ubiquitous on food & drink products?
- What if more productive agricultural practices allow previously farmed land to regenerate and support natural ecosystems?
- What if plant-based protein and biomanufactured meat become viable and affordable alternatives to traditional meat in key markets?
- What if multinational food & drink organizations localize supply chains, taking into account seasonal availability?
- What if consumers gain the ability to trace products through the entire value chain to the origin of each ingredient?
- What if global flavors and functional ingredients can be synthetically reproduced and available to consumers on demand?

There are countless questions to be asked about what the future holds for food & drink. Finding possible answers to these questions requires a systematic approach and a structured innovation strategy.

## The Way Forward

*Create a future competitive advantage tomorrow by defining your strategic direction today.*

Making better decisions for tomorrow relies on an organization's ability to collect, understand, and act on innovation intelligence—the multitude of building blocks that make up an organization's innovation process.

Scouting the trends, technologies, startups, and other forces of change that are shaping your industry is a crucial first step in this process. But turning this information into innovation intelligence, and subsequently into action, requires additional steps and capabilities that fall within Foresight and Strategy.

## Taking Trends & Technologies to Opportunities



1. Discover ITONICS Trends



2. Build Internal Consensus



3. Develop Pictures of the Future

### 1. Discover ITONICS Trends

Supplement the insights gained in this industry-relevant technology report with an immersion into the trend landscape.

Get started by exploring the ITONICS [Teaser Trend Radar](#) displaying the elements that are most relevant to your industry.

For a full view of the trend landscape, our [Where to Play 2021+ Trend Report](#) contains the complete ITONICS Trend portfolio, presenting 90+ Trends with real-life inspirations and rich analysis.



**DOWNLOAD NOW**

## 2. Build Internal Consensus

In establishing **Where to Play**, it is essential to gain consensus and raise alignment within your organization. This can be achieved through a process of collaborative evaluation. Invite internal stakeholders and experts to participate in rating elements—trends, technologies, scenarios, opportunities, etc.—based on unique industry- and company-specific parameters.

When undertaken in the environmental scanning stage, an internal rating exercise helps empower teams with the consensus needed to ensure strategic relevance, strengthen buy-in, and act decisively.

**ITONICS has provided the following internal rating criteria for organizations to consider for trends and technologies:**

### Technologies

- Technology Attractiveness: How high is the potential value of the technology?
- Internal Know-How: How much internal know-how does your business possess with regard to this element?
- Need for Action: How important is it that your organization take action with regard to this element?

### Trends

- Business Relevance: How relevant is this element to your business?
- Strategic Fit: How well does this element fit into your organization's overall strategy?
- Need for Action: How important is it that your organization take action with regard to this element?

The ratings above are pre-set in the ITONICS Showroom. However, organizations can tailor rating criteria to align with their own set of needs and workflows.

## 3. Develop Pictures of the Future

It's not enough to identify the trends, technologies, disruptive startups, and other drivers of change that are relevant to your industry and organization. To develop an innovation strategy that remains effective beyond the time horizon of key drivers, organizations need to develop realistic and plausible pictures of the future in which these various drivers will unfold. This is done through a process of **scenario planning** and is the basis for discovering future opportunities upon which to act.

Scenario planning is a strategic tool commonly used by key decision-makers, innovation leads, and strategists to find focused foresight, grounded in dependable analysis. This equips them to anticipate exposures appropriately, evaluate innovation opportunities, and inform proactive responses.

### What is a scenario?

In the context of business planning and strategy, a scenario is a postulated sequence or combination of events projected to take place that could hold relevance to an organization's future state.

Developing plausible, actionable scenarios requires a systematic approach and organizational participation. It builds on the internal rating exercise, which serves to identify those trends and technologies that hold the greatest strategic relevance and potential. From here, your organization must derive the underlying drivers that are influencing its business environment and extrapolate the different trajectories each driver could take.

Plotting these trajectories against one another and engaging your team's collective and creative input reveals multiple scenario narratives. While each narrative represents a possible future for which your organization may need to prepare, internal consistency and strategic objectives point to those scenarios that should be prioritized.

Your team should prioritize the scenarios they feel hold the most strategic relevance by asking the following two questions:

- Is this a future we hope to play an integral role in creating and shaping?
- Is this a future we hope to mitigate and avoid through thoughtful tactics?

The selected scenarios form a foundational springboard from which your organization can best derive and define clear opportunities—i.e., possible solutions or responses to the various scenario narratives. Use the **ITONICS Roadmap** to plot critical scenario events and develop a timeline of innovation activities required to explore the various opportunities ahead of the horizon in which they are set to occur.

In this way, scenario planning provides organizations with the information required to act on opportunities timeously—as well as the evidence needed to develop appropriate capabilities and assets, actively shape our world, and influence outcomes as they steer towards the future.

To further your innovation journey, all the Trends, Technologies, and Inspirations selected as most relevant to food & drink can be found on the ITONICS Innovation Platform using the saved filter: [Food & Drink](#).

The ITONICS solution supports end2end innovation management, from environmental scanning and trend and technology management to building internal consensus and roadmapping.

**REGISTER**



## About ITONICS

### We build AI-powered SaaS to innovate, grow, and disrupt.

Our data-driven software platform helps organizations around the globe to identify emerging technologies, trends, and market potentials and translate them into powerful growth strategies.

Supported by artificial intelligence, companies can manage their entire innovation process in a modular software suite to efficiently achieve their business goals and remain future-proof.

Working with global teams to innovate new products, services, and business models, ITONICS professional services inspire, guide, and accompany organizations on their innovation journey. With more than 115 experts on four continents, we support innovation leaders such as adidas, AUDI, CISCO, Intel, Johnson & Johnson, and SAP.

*As a strategic partner to key market players across all industries, we systematically advance the topics of innovation, strategy, and digitalization.*



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# What's Next

## Turn Innovation Intelligence into Action

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## You can find us around the globe



ITONICS is a leading SaaS provider of systematic innovation management. The ITONICS Innovation OS combined with a systematic framework to steer innovation efforts helps companies to identify emerging technologies, trends, and market potential and to translate them into customized growth strategies.

With more than 150 experts worldwide, we support innovation leaders such as adidas, AUDI, BMW, CISCO, Intel, Johnson & Johnson, and KPMG.

Get a Demo

Let's Chat

Discover more at [www.itonics-innovation.com](http://www.itonics-innovation.com)



# EMPOWER EVERYBODY TO INNOVATE



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