Supply Chain Transparency from Farm to Table

Establish a New Level of Trust for Healthy Living in the Food & Beverage Supply Chain with IoT and Blockchain

ARC White Paper
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The Supply Chain from farm to table continues to increase in complexity with pressures from changing customer interests, regulatory controls, and global competition. Companies can respond by adopting technologies – including IoT and blockchain to improve flexibility while increasing food trust and brand protection. This report covers the issues, technologies and solutions ready for adoption for improved food trust and brand protection.

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Executive Overview

The Supply Chain from farm to table continues to increase in complexity with pressures from changing customer interests, regulatory controls, and global competition. People are becoming increasingly interested in their food sources and look for more personalization, which leads to product proliferation and makes managing recipes across many geographies and cultures more challenging. Governments have a growing interest in food safety for their constituencies which results in new and more stringent regulatory requirements. A "shrinking world" with easier global access to markets increases the competitive intensity which drives margin pressures and capital expenditure constraints. These are some of the many factors driving adoption of digital technologies in the food and beverage supply chain.

An increasingly dynamic food and beverage market is driven by forces from changing customer interests, regulatory controls, and intense global completion. Users can respond by adopting technologies – including IoT and blockchain to improve flexibility while increasing food trust and brand protection.

To provide the necessary flexibility and transparency for high food trust, participants in the food and beverage supply chain should:

- Adopt a program to go from reactive (respond to illnesses) to a proactive food safety program (identify issues before complaints occur)

- Engage in proof-of-concept (POC) projects for the application of new technologies that can provide more proactive supply chain management, traceability and food safety including the Internet of things (IoT), global recipe management, and blockchain

- Consider the synergy across recipe management, track and trace, and blockchain for problem isolation and identification, and for obtaining consensus with regulatory bodies to reduce the scope of future recalls

- Consider using models or digital twins of the product, production equipment and process for dynamic formula optimization (optimize product quality and production) to improve operational performance (flexibility, margins and schedule), and to create new products using customer preferences extracted from the data

Healthy Living Needs Trusted Sources

People want to enjoy life and live longer which encourages healthy living including good eating habits. This rising consciousness motivates consumers to make a connection between their personal health and what they eat. This involves trends like the current adoption of gluten-free, dairy-free and vegetarian foods and beverages. Food is also becoming more personalized to fit an individual's interests and specific needs. People are becoming increasingly interested in their food sources and safety. This white paper focuses on the changes in eating habits, food safety concerns, and the impact on the food and beverage industry.

Dynamic and Complex Supply Chain from Farm to Table

The food and beverage industry has a fiercely competitive environment at each step in the supply chain with dynamic costs and prices, and regulatory compliance. Commodity product categories predominate with each one having multiple participants. Manufacturers compete with similar products that also have alternatives which could be substituted by consumers. Meanwhile, fierce competition forces the need for increasing speed and efficiency and companies must adapt to changing government regulations. How can a supplier survive in this challenging business environment?

Supply Chain Complexity

Industry concentration exists among the top suppliers like Associated British Foods, Coca-Cola, Danone, General Mills, Kellogg's, Mars, Mondelez, Nestlé, PepsiCo, and Unilever – each one having revenues exceeding $10 billion. These companies compete on a global basis across multiple product categories. However, the food manufacturing industry goes well beyond these participants with approximately 25,800[1] companies in the United States alone. With improvements in logistics and speed of delivery, companies are expanding their geographical coverage, further heating up the competitive

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[1] Census Bureau's 2012 Economic Census https://www.ers.usda.gov/topics/food-markets-prices/processing-marketing/manufacturing/

market dynamics. This expanded coverage drives food processors to consolidate through mergers and achieve economies of scale with lower costs.

Several forces drive growing supply chain complexity in the food and beverage industry. This starts with market demands and meeting customer buying behavior.

Divergent Consumer Interests Drive Product Proliferation

While many of the product categories in the food & beverage industry might appear to be mature and stable, this is certainly not the case. As a market matures, competitors tailor products to meet the needs of subsegments of the market to differentiate themselves and gain an advantage among a group of buyers. This product proliferation occurs for health interests, individual interests, regional tastes, and packaging alternatives.

Product proliferation and volatility are apparent across today's grocery stores. Consumers continue to demand tastier, healthier products, and more convenient products that fit their lifestyle.

Take milk for example. Domesticated cows started providing milk for human consumption approximately 9,000 years ago[2]. Not much changed until about 50 years ago, when skim (fat-free) milk made its way into the grocery store cooler, along with regular (whole), and chocolate-flavored. Fast forward to today, where, including the non-dairy milks, today's supermarkets have dozens of types, not including regional differences. After 9,000 years of stability worldwide, milk has become a complex and dynamic product category. Another category, bread, has an even longer history, and a look at the grocery aisle shows that it now has even more variety.

Product Proliferation in Cow's Milk from Dairy Council of California

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[2] Source: https://en.wikipedia.org/wiki/Milk#History

Product proliferation and volatility are apparent across much of the rest of the grocery store as well. Today's consumers demand more variety, and tastier and healthier products. This includes trends like low-sugar, locally grown, gluten-free, non-dairy, nut-free hypoallergenic foods, and more. They also choose products that offer increased convenience, usually via specific packaging and/or preparation that fits their lifestyle. These and other emerging consumer interests form new market segments that drive further product proliferation. Today's supermarkets carry as many as 50,000-plus stock keeping units (SKUs), giving consumers more choices than ever before.

Globalization with Increased Supply Chain Complexity

The global food supply continues to grow in distance, volume and complexity. This is driven by the need to lower labor and material costs, obtain seasonal availability (fruits from the southern hemisphere during winter in the north), and fulfill consumer demand for diversity in food and beverage products. Unfortunately, the supply chain needs protection from spoilage, adulteration (unintentional or intentional) and counterfeiting. Obtaining consistency, acceptable quality, availability and price are also concerns. Managing these issues requires visibility into the supply chain in real-time and for off-line analysis.

Multi-site Production Optimization

Each geography has a unique set of ingredient sources, customer tastes and government regulations. Products and packaging are tailored to accommodate local cultures. For example, Fanta provides an orange juice for each country it serves. Many companies have multiple manufacturing sites, and often have some internal competition to make specific products. Decisions made in one division of an organization will impact others and the broader supply chain. Optimizing production occurs across these dimensions:

- Within a plant for cost control and scheduling of locally available ingredients, product manufacturing, and packaging

- Across multiple plants with the best combination of manufacturing, supply chain, and transportation costs including currency exchange

- Risk management for supplies, production uptime, sustainability and other unpleasant surprises

- The growing interest in digital convenience for those who want to order products online or via phone call, and consume immediately

Global Recipe Management

When cooking a meal in your home kitchen, recipe management is simple - one recipe with locally sourced ingredients and a single, well-defined work flow. Now, scale this up to production on different lines and in multiple plants across several geographies. Variations among ingredients, equipment, and local tastes requires a means to manage a variety of recipes. Each recipe includes specifications for ingredients, equipment, quality, processing, health and safety requirements, and personnel certifications. Recipes can be segmented into types as follows:

- Master recipe from corporate product development that defines the product formula including ingredients, equations, processing steps, procedures and quality control.

- Region recipe is tailored for local tastes. India (spicy) and Japan (very mild) provide a stark contrast.

- Plant recipe is adapted to local ingredients. In Europe, beet sugar is a common sweetener. In North America, cane sugar is used. The sweeter taste of beet sugar significantly changes the recipe.

- Line recipe adopts the process variations to fit equipment deployed in a specific production line.

A lack of understanding of the suppliers' customs and differences in quality can become a major source of frustration. With recipe management, manufacturers are better able to consistently satisfy customers across geographies and cultures.

Impact of Foodborne Illness and Recalls

Despite the growing complexity of the supply chain, corporations are under increasing pressure to manage foodborne illnesses. About 128,000 people are hospitalized, and 3,000 die each year in the US from foodborne diseases, according to data from the Centers for Disease Control and Prevention. A good

public relations campaign can mitigate some of the impact of food safety outbreaks where a contagion is identified, and users are unharmed. But, outbreaks that harm people can be devastating for both brand protection and unexpected costs for recalls, disposal, litigation and penalties.

Decline in Revenue and Shareholder Value

Companies face an average direct cost of $10 million (USD) for a product recall[3]. Additional business impact includes brand damage and lost sales. According to a Harris Interactive Poll, consumers indicated that "55 percent would switch brands temporarily following a food product recall, 21 percent would avoid purchasing any brand made by the manufacturer, and 15 percent would never purchase the recalled product again." Assessing these percentages leads to a significant reduction in a firm's revenue. The negative impact of a recall on shareholder value is long lasting.

Increasing Regulatory Involvement

Companies in the food and beverage industry can expect increasing scrutiny by government agencies both federal and state. Per an Ohio State University study[4], one out of every six people become ill every year from foodborne illness. In 2015, the total cost borne by individual states for 30 types of foodborne illnesses in the US was $93.2 billion. That kind of economic impact gets regulators' attention.

Hazard Analysis and Critical Control Points (HACCP) turns the approach to food safety around from reactive to proactive safety management. Reactive includes responding when people get sick with inspections. HACCP proactively avoids hazards with "principles" for good management practices. The ISO 22000 international standard augments HACCP and specifies the requirements for a food safety management system.

The FDA Food Safety Modernization Act (FSMA) passed by the US Congress on December 21, 2010 shifts the focus of federal regulators from responding

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[3] Food Marketing Institute and Grocery Manufacturing Association joint study
http://www.ironshore.com/blog/costly-food-contamination-recalls-unavoidable
[4] Ohio State University College of Food, Agricultural, and Environmental Sciences
https://cfaes.osu.edu/news/articles/high-cost-foodborne-illness-new-study-provides-state-by-state-breakdown

to contamination to preventing it. The FSMA gives FDA more authority and resources to ensure food safety. The bill focuses on several main areas:

· Increasing inspections of food manufacturing and processing facilities
· Requiring pre-emptive procedures to prevent contamination in these facilities
· Identifying foods at high risk for food borne illness outbreaks
· Increased inspections
· Developing a tracking system to follow food from the farm to table

FDA Authority	Expanded FDA Authority from Food Safety Law
Recall Products	Previously, the agency could only recommend voluntary recalls of food products resulting from possible outbreaks. The FDA would have to negotiate with the manufacturers and this delayed the process.
Conduct more inspections	Previously, the FDA did not have funding for initiating food safety inspections at processing plants. Added budget has been secured.
Increased produce surveillance	Previously, no federal standards for produce safety existed and safety relied on regional and local laws. Now, the FDA can inspect farms where foods are grown - particularly those known to be susceptible to contamination such as leafy green vegetables, berries and fruit. The new legislation includes provisions for inspecting larger produce farms.
Imported foods safety	Imported foods are inspected and subjected to the same standards in place for US foods. FDA now has the authority to block foods from facilities or countries that refuse FDA inspections. The agency also increased its inspection of foreign facilities that produce foods imported into the US.
Food safety collaboration	FSMA calls for better collaboration among food safety agencies: federal, state, local, territorial, tribal, or foreign.
Product Tracing System	FDA is required to establish, "within the Food and Drug Administration a product tracing system to receive information that improves the capacity to effectively and rapidly track and trace food that is in the United States or offered for import into the United States."

Food Safety Modernization Act Provisions

Gaining Control of the Supply Chain

Corporations in the food and beverage industries worldwide are experiencing increasing pressure to improve food safety from both a liability viewpoint and a regulatory compliance requirement. How can they gain the needed control of their supply chains?

Digital Disruption in Food and Beverage

Technology has had a transformative effect on most industries. Digital disruption has and continues to reshape how consumers become aware of products, engage with companies, and make purchases. Transparency has increased radically, particularly in the food & beverage sector. Bad reviews and commentary in social networks will damage the brand and reduce revenue. Digital disruption goes beyond communications and includes applying technology to reshape business processes to prevent problems in the first place and respond swiftly when they do occur.

"Digital disruption is reshaping how consumers connect and communicate, buy products, and engage with companies. We are setting an agile course for the future."
Paul Bulcke, Chairman, and
U. Mark Schneider, CEO
Nestle Annual Report 2017

Digital disruption involves modularization, data exchange, and business process automation throughout manufacturing and the supply chain to improve overall operational performance for a company and its partners (the "extended enterprise"). The technologies start with industrial IoT (IIoT), cloud computing, analytics, machine learning, manufacturing operations management, and cyber-physical systems and extend to many other technologies. These range from drones to blockchain distributed databases to enhance execution and effectiveness.

Improving Execution and Compliance

The technologies associated with IIoT have been applied to improve operational performance in several areas including production and the supply chain. Improving execution has a few major themes:

- Reducing labor, materials, and energy costs by improving manufacturing orchestration
- Increased flexibility and flexibility to meet changing production schedules for on-time shipments with reduced inventory
- Monitor current conditions, identify emerging problems, and provide alerts so problems are resolved before mishaps occur

Preventing Unplanned Downtime in Production

Dreaded unplanned downtime, which interrupts production, has several compounding effects. First, the associated people are idle with lost productivity. Second, the work-in-process (WIP) inventory must often be scrapped

causing waste – particularly in the batch process area. Third, missed shipments cause both customer satisfaction issues and lost revenues. An IIoT strategy mitigates this by using equipment data and analytics for predictive maintenance. The equipment's condition is monitored, and early problem detection sends an alert well before failure. Maintenance and/or repairs are scheduled and made before a failure stops production.

Supply Chain Visibility and Improved Business Processes

Gaining better control of the supply chain starts with improving visibility in each step of the supply chain with tracking and tracing of the materials. This enables a well-managed prevention, detection, and response execution program throughout the supply chain. Implementation involves data acquisition, management, audit trail and governance for adherence to laws and regulations. This assures the manufacturers and consumers that its product's actual ingredients are consistent with the end product's labeling.

"A powerful megatrend impacting our business is the relentless pace of digital innovation. Internet-enabled services, automation across the value chain, the rise of Big Data, and pervasive social media–driven consumption are fundamentally transforming how all of us live, work, communicate, shop and do business."
Indra K. Nooyi, PepsiCo Chairman & CEO

Preventing Spoilage in the Supply Chain

Throughout the supply chain, goods can be damaged by temperature, shock, or long delays. The existing method to identify a problem has been to put a sensor and a data recording device in the truck with the goods. Only after the goods are received is the device checked. If the goods are damaged, the purpose of the recording is to determine who is at fault and liable for damages. Goods damaged in transit often result in missed production schedules, missed product deliveries, and/or lost revenues.

Cold Chain Management Source: Advantech

With an IoT approach, data from the sensor is continuously monitored with data acquisition via the cellular or LoRA network. The application uses analytics to generate an alert to warn someone who can take corrective action before damage occurs to the goods. Preventing damage avoids the negative impact to production and revenues which provides higher customer satisfaction with repeat orders.

Enhanced Track and Trace Requirements

Before the new FDA regulations, companies could track and monitor the products they purchase and ship using a paper trail. Different departments in the corporation or supply chain were responsible for different aspects of production and each party had its own methods of tracking the information. Determining the source of a problem or the downstream involvement using these inconsistent paper records was impractical. Paper records are not capable of becoming a systematic method to address food safety issues.

A provision of the FSMA requires companies to provide rapid tracing from where a product was received and tracking forwards to where it was sent. This creates massive amounts of information that is managed and integrated to provide complete traceability across the supply chain. The FDA is required to cover the entire supply chain, including farms and restaurants using electronic track and trace systems that can track the food genealogy throughout the supply chain. Per the FSMA, when the FDA finds evidence of contamination, it can ask the processor or grower to produce traceability records. The electronic records requirement is bringing more unified corporate and collaborative database or records systems, and suppliers developing new systems to meet the demand.

New Technologies for Track and Trace

New technologies are available for tracking food and adoption has already started. This includes coatings for seeds, DNA alterations in the food, and other taggants for uniquely encoded materials or chemistries that are nearly impossible to duplicate. These technologies are combined with authenticators such as smartphones, infrared, bar code readers, and RFID. With this data, software systems track and monitor the food chains.

Role of IoT and Cloud Platforms

Consumer IoT – including smartphones, apps, networking, cloud computing, analytics and security – created economies of scale and a robust infrastructure for IoT technologies. Now, industrial organizations are adapting proven IoT technologies for their industrial and supply chain applications. In this context, we essentially have an IIoT architecture that has smart industrial devices taking the place of consumer smartphones. Industrial applications obtain the needed real-time data through the internet and apply it for analytics and alerts when conditions warrant.
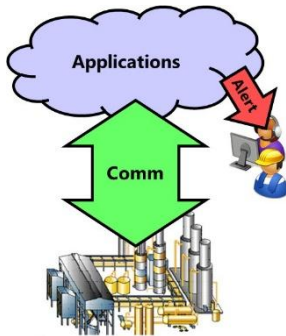
Basic IIoT Architecture

IoT cloud platforms provide data management, analytics, device management and many other services. Before cloud platforms, these functions had to developed as part of the software which caused high project costs and fragile applications. IoT lowers the development and support costs and extends the reach through the internet. This technology is consistent with the needs of supply chain track and trace applications.

By being an independent platform for bringing together data from multiple companies, cloud technology enables value chain digitalization. Since it is not within the premises and control of any one company, participants view it as an independent platform. This facilitates value building with participation among multiple companies across the supply chain i.e., a network affect where more participation provides higher value. Also, cloud enables further services like auditing, maintenance even provided by 3rd parties.

Blockchain Assures Supply Chain Transparency and Security

With Blockchain, each step in the supply chain adds to the accumulated data in a "block" that all participants can view. Blockchain is a distributed system that runs on multiple nodes across multiple data centers. Transactions are accumulated in an encrypted "block" with new entries added as they occur to make a "chain." Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. Copies of this block of transactions are stored in multiple nodes. These blocks are compared to determine if one has been tampered with, and only the consistent blocks continue to be used.

Each block provides a "single version of the truth" about transactions and activities occurring across complex supply chain ecosystems. Participants in a blockchain may access, inspect, and add to the data. But, encryption prevents them from altering or deleting existing data. The original information stays put, leaving a permanent and public information trail of transactions.

Hyperledger, hosted by The Linux Foundation, is emerging as the de-facto standard for enterprise blockchain platforms. Through open source and open governance, it obtained capabilities hardened for use by businesses with trust, transparency and accountability.

Blockchain technology can be applied and integrated into multiple types of applications. Today, the primary use of blockchains is a distributed ledger for cryptocurrencies, most notably bitcoin. Proof of concept trials are now in

progress to apply blockchain for authentication and security of a supply chain. If these trials are successful, blockchain will be used to assure the integrity of track and trace across the whole supply chain – from farm to table.

Where Blockchain Fits

Blockchain technology provides a secure distributed database (sometimes called a distributed ledger) and has many large companies experimenting with it. The IBM Food Trust consortium including Dole Food, Driscoll's, Golden State Foods, Kroger, McCormick and Co., McLane Company, Nestle, Unilever, and Tyson Foods has been examining blockchain technology for the food supply chain and secure traceability. Initial tests indicate blockchain could remake how the industry tracks food worldwide.

The Food Trust is beginning to scale. It has recorded over half a million transactions in total so far. This includes full end-to-end traceability for roughly 200 stock keeping units (SKUs).

The nodes are run by "trust anchors" which include some of the largest companies in this end-to-end supply chain. IBM, a blockchain technology supplier, believes that only a few dozen nodes are necessary to establish a trusted chain of data. Traceability appears to be a clear application for this technology. The Food Trust has recorded over half a million transactions in total so far. This includes full end-to-end traceability for roughly 200 stock-keeping units (SKUs).

How IoT and Blockchain Complement Each Other

Modern Industrial IoT platforms – like PTC ThingWorx, GE Predix, and Siemens Mindsphere – are cloud-based and provide a means to capture information from devices throughout the supply chain. Applications built on these IIoT platforms can support the implementation of specific track & trace uses cases. However, to gain acceptance, such solutions also need the trust provided with blockchain technology. The inclusion of blockchain allows companies to subscribe and contribute to the chain of custody. IoT and blockchain complement each other and combining them creates a trusted and scalable solution.

Siemens combines its Mindsphere platform, IoT, and private track and trace repositories to achieve a more complete solution. With the private track and trace repository and blockchain management applications, companies can select what information and to whom they want to share it along the supply chain. Sensitive information is kept private while exposing only "need to

know" information to other members of the supply chain. This allows supply chain participates securely trace ingredients and fully substantiate claims they make about their products – for example: organic, genuine, high quality, gluten-free, etc.
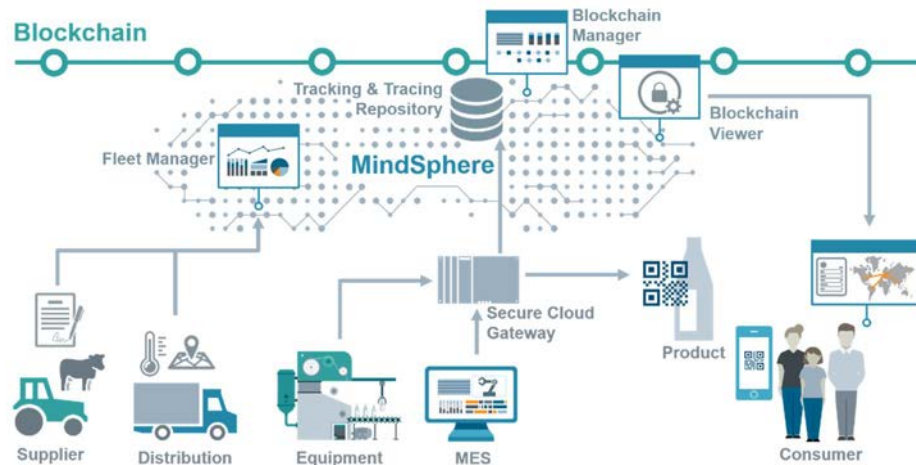
Blockchain Combined with Siemens Mindsphere for Supply Chain Trust

Gaining Food Trust

Brand management includes responding to issues in a manner that mitigates long-term damage to the image of the product and the company. Social networking and the short news cycle causes bad news to spread quickly, which drives the need for a fast and credible response to food safety or other sensitive issues. Having better visibility into the supply chain provides access to information that facilitates an appropriate and effective response. Applying monitoring and predictive measures goes a long way toward preventing the problem from occurring in the first place.

Using digital technologies - like IoT, cloud applications, analytics and blockchain - to provide new value-added revenue opportunities is the basis for digitalization. It can help boost both market response time and profitability by expanding production visibility, flexibility, and scalability. Digitalization supports continuous improvement and fosters continuous innovation to make food and beverage makers more productive, profitable and competitive. Input and output can now be integrated both for supply chain execution and closed-loop feedback across marketing, research and development, planning, procurement, manufacturing, sales and distribution.

Trust Selling

Trust is difficult to obtain and sustain. Healthy living and the origins of the food people eat have become more important to consumers. Studies of human psychology have shown that 20 positive experiences are needed to mitigate and overcome a failure. Having a consistently positive product experience provides the basis for being a trusted brand. Attaining trust will gain in importance for differentiation, revenue growth and premium pricing.

Track and trace provides the visibility needed to manage the supply chain and assure that the ingredients match the recipe requirements, and quality is consistently achieved. Blockchain adds security to assure the ingredients are what is documented. Combining these technologies with real-time alerts provides the means to obtain the needed control of the supply chain to fulfill the promise of a trusted brand.

Supply Chain Flexibility to Respond to Change

Consumer interests continually change – sometimes rapidly. For example, "fat free" was in vogue with wide adoption. Recently this approach to dieting was debunked, and then "fat-free" rapidly disappeared from grocery shelves. Obviously, this had huge impact on recipe management and the supply chain from farm to table. Digitalization provides flexibility with real-time supply chain visibility to respond and control costs. As food and beverage products become more personalized, we can expect continued product proliferation and the need for visibility to manage rapid change.

A more intelligent supply chain means finding ways to better track raw materials, product, and finished goods as they travel through the supply chain. Access to production and supply chain data with IoT analytics have enabled end-to-end supply chain visibility and optimization. Manufacturers have focused efforts for supply chain efficiency by monitoring logistics. Now, supply chain leaders are beginning to take supply chain visibility to the next step by leveraging digital technologies and digitalization.

Enterprises can build algorithmic decision making and automated execution to deliver highly optimized supply chains. With adoption of digitalization, we are now seeing manufacturers integrating the broader value chain across physical, information, and financial flows. With new kinds of data being generated, it is possible to drive better outcomes in planning, inventory optimization, revenue, and brand management.

Growing Demand for Fresh Vegetables
Source: Kroger announcement of "Produce Mom" Partnership

Recall Cost Containment

The vast majority of recalls are far more expensive and damaging to the brand than necessary. Without the tools to identify, isolate and mitigate the problem, companies often purge everything in the supply chain. Costs across all of the parties involved over a wide geography multiply rapidly. Brand damage deepens as news outlets spread the warning messages.

In the past, a relatively large number of very sick people were needed to gain attention and action due to the availability of rudimentary techniques for data collection and analysis. Now, the FDA has access to large data sets and analytics. The bar has been raised and a very small percentage of defects have already obtained attention. Expect recalls to continue to increase in quantity and scope.

Management of a recall has a multifaceted set of objectives including quick response, contain costs to only the defective materials, and visibility for others to validate and support the activities. Achieving these objectives requires accurate determination of where things went wrong, and the specific downstream products affected. As products move through the supply chain, track and trace solutions capture relationships between raw ingredients and finished goods. This information provides the basis for meeting the objectives for minimizing costs and brand damage. Track & trace provides the ability to clearly identify the source of a problem (backwards tracing), focus the recall on only the defective products (forward tracing), and contain the impact on revenue and costs while complying with food safety regulations.

Financial Justification

For the business case for a digital investment, some drill into the specifics of the process being digitized to gain confidence that it will work, and the results will be achieved. Then, the proposal connects these details to financial benefits. This detailed operational approach often drives the business case into a comprehensive analysis with a focus on details beyond the interest of the executives that provide funding.

How can you obtain and sustain executive attention? Executive metrics are public and contained in the financial reports including the P&L statement and balance sheet. Connecting the benefits of a supply chain digitalization project to executive metrics for revenue, margin, asset management, and risk mitigation that improves shareholder value gets their attention.

- Revenue and the P&L statement: The enhanced customer engagement and visibility provided through digitalization improves brand management and enables a more agile supply chain. The company is more responsive to changing customer needs and better serves the market for improved revenue and margin.

- Asset management and the balance sheet: Reduction in inventory improves the balance sheet and metrics used by financial analysts to evaluate the company.

- Risk and cost management: This takes two forms. One is the previously mentioned recall management. Another is reducing shrinkage by knowing where materials are and when they go missing.

Project by the European Institute of Innovation & Technology (EIT)

EIT Food is a pan-European partnership including over 50 of Europe's leading food companies, research and educational institutions. It covers the whole agri-food value chain for consumer centric and trusted food production and supply. A major innovation goal of EIT Food is solutions for the digitalization of food value chains to improve trust and transparency of food supply and to leverage new business using the available information in digital twins of both products and production equipment.

For one of the first projects, Strauss, Givaudan, Fraunhofer, Technical Univ. Munich and Siemens are developing a solution for exchanging information on products between business partners, authorities and consumers. The solution includes Siemens' MindSphere IoT cloud platform for hosting digital twins of products, production processes and production equipment. The solution will integrate data and information from all relevant data sources encompassing ERP, MES, SCADA systems, and other cloud solutions for farm management. To help assess Blockchain, this technology is also part of the solution.

Siemens' MindSphere is an IoT platform that helps users apply IoT data to create digitalized solutions including supply chain track and trace. Siemens offers a range of applications that provide structured approaches for feeding data to the MindSphere platform and integration for supply chain management and optimization.
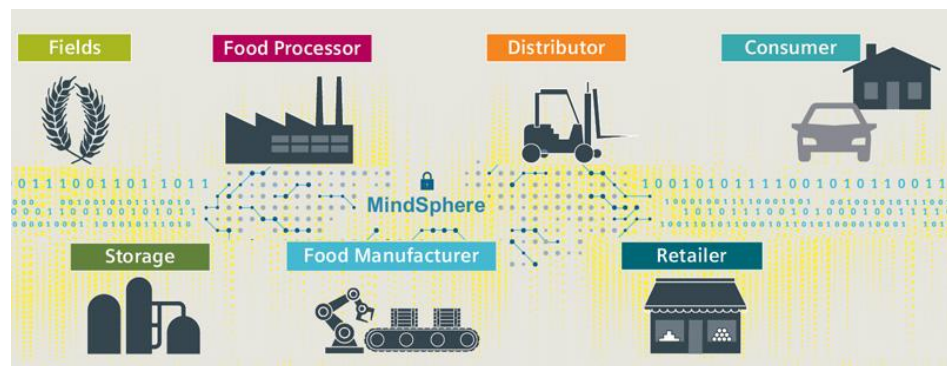
Food & Beverage Supply Chain Management - Source: Siemens

Recommendations

There are many factors driving adoption of digital technologies in the food and beverage supply chain. Some provide flexibility to manage the increasingly dynamic market environment like product proliferation and changing consumer interests. Others are driven by internal issues including margin pressures, capital expenditure constraints, and managing recipes across many geographies and cultures. A third aspect involves governments' growing interest in food safety for its constituencies which has resulted in new regulatory requirements including the associated track and trace initiatives. To assure margins and quality, and mitigate risks, participants in the food and beverage supply chain should:

Factors driving adoption of digital technologies in food and beverage:
- *Flexibility for dynamic customer interests*
- *Operating performance including global recipe management*
- *Government regulations including track and trace compliance*

- Use the HACCP program across the supply chain to go from reactive (respond to illnesses) to a proactive food safety program (identify processing and quality problems before illnesses occur)
- Engage in proof-of-concept (POC) projects for the application of new technologies including:
    - IoT for track and trace compliance
    - Global recipe management for improved flexibility and operations
    - Blockchain for governance of food trust and supply chain integrity
- Consider the synergy across recipe management, track and trace, and blockchain for problem isolation and identification, and for obtaining consensus with regulatory bodies to reduce the scope of future recalls
- Recognize that improving data acquisition and management by government and consumer advocacy groups increases the probability that a relatively small issue will be identified, and your need for brand protection will drive a recall. Containing the risk and scope of these recalls will continue to be a growing concern
- Consider using models or digital twins of the product, production equipment and process for dynamic formula optimization (optimize product quality and production) to improve operational performance (flexibility, margins and schedule)

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Editor: Sharada Prahladrao

Acronym Reference:

FDA	US Food and Drug Administration	PLC	Programmable Logic Controller
FSMA	Food Safety Modernization Act	POC	Proof of Concept
HACCP	Hazard Analysis and Critical Control Points	RFID	Radio Frequency Identification
IIoT	Industrial IoT	ROA	Return on Assets
IoT	Internet of Things	SCADA	Supervisory Control and Data Acquisition
IT	Information Technology	SKU	Stock Keeping Units
LoRA	Alliance for Low Power Wide Area Networks (LPWAN)	SCM	Supply Chain Management
MES	Manufacturing Execution System	WIP	Work-in-Progress
P&L	Profit and Loss statement		

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