

A grayscale photograph of a grocery store aisle, viewed from the perspective of someone pushing a shopping cart. The cart is in the foreground, and the aisle stretches into the distance with shelves on both sides.

FOOD TRACEABILITY: A FRAMEWORK FOR TRANSPARENCY THROUGH COMPANY VALUES AND TECHNOLOGY

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EXECUTIVE SUMMARY

The importance of traceability in the food industry is increasingly recognized for its role in promoting sustainable food production. Traceability systems help address food safety concerns, combat fraud, ensure compliance with human rights and animal welfare standards, and build consumer trust.

Technologies such as blockchain, AI-powered and IoT devices are pivotal in enhancing transparency and accountability within food supply chains. However, challenges such as the digital divide, interoperability of systems, and the accuracy of data collection persist and reveal some of the limitations of technology.

This paper explores a selection of the leading technologies aiming to improve traceability in supply chains, and looks at leaders in other industries such as fashion to understand how to evaluate their traceability efforts and how to communicate these to consumers.

Successful traceability implementation requires a holistic approach that involves collaboration among businesses, governments, and NGOs to leverage technology effectively while addressing broader sustainability and ethical issues in food production.

Highlighting case studies and emerging technologies, the paper advocates for the integration of traceability as a core business strategy, emphasizing its role in promoting ethical sourcing, sustainability, and paving the way for a future where informed and responsible consumption is the norm.



CONSUMER INTEREST AND COMPETITOR DIFFERENTIATION DRIVING TRACEABILITY EFFORTS

Embracing transparency in supply chain and sourcing activities is crucial for companies aiming to distinguish themselves in competitive markets and achieve premium pricing in specialty sectors. This is particularly true for products like coffee, olive oil, and seafood, where traceability can be a key differentiator. Effective and transparent sourcing can become a cornerstone of a company's branding, enhancing its reputation and thus driving greater demand in specialty markets. Such strategic transparency not only sets companies apart, fostering a sustainable and trustworthy relationship with consumers.

While it's crucial for companies in specialty markets to embrace transparency to differentiate themselves and command premium pricing, the ultimate goal should be for all food products to achieve full supply-chain traceability. While current consumer interest and willingness to pay in the US may still be limited and traceability technologies may be driving some costs up, it is important to remember that most consumers purchase at lower price points. Consumer interest and demand can grow quickly (as in has in Europe, particularly in Scandinavia) as the result of effective marketing that highlights nutrition, human rights, animal welfare and environmental sustainability.

Food companies that start to build a framework for traceability across all products now can become leaders in a changing space, regardless of the price point at which they sell their products. They can spearhead the shift that is already underway towards more informed, health-conscious, and environmentally sustainable consumption patterns. This broader goal recognizes that all consumers, regardless of price sensitivity, merit insight into the food they consume.



REGULATION DRIVING TRACEABILITY EFFORTS

In the United States, it takes an average of 57 days to recall items after the FDA reports a risk⁽¹⁾. While this number is improving, such a long delay raises a variety of concerns for multiple players in the item supply-chain—including operational disruptions, financial loss, potential legal liabilities, dissatisfied consumers, and brand reputation damage.

FSMA Rule 204:

FSMA Rule 204 is the FDA's solution to this complex problem. Known formally as the Requirements for Additional Traceability Records for Certain Foods, FSMA Rule 204 is part of the FDA's Food Safety Modernization Act and will go into full effect in January 2026⁽²⁾. This regulation aims to create more visibility within food supply chains to enable better responses to foodborne illnesses and contamination incidents.

FSMA Rule 204 mandates that facilities holding, packing, manufacturing, or processing foods listed on the FDA's Food Traceability List must keep much more detailed records than what we have seen before.

Among other measures, to comply with FSMA Rule 204, brands will need to ensure that traceability records are easily accessible and can be provided to the FDA within 24 hours upon request. FSMA Rule 204 will thus attempt to reduce those 57 days to 24, and in order to comply with the new regulation, food companies will need to adapt and embrace new advances in traceability technologies.

As impactful as this change from 57 days to 24 hours may seem, it is important to consider the limitations of the rule that highlight the importance of companies continuing to focus on consumer interest and not solely regulation as a driver for change. For example, soft cheese is one of the items in the FDA's Food Traceability List, meaning all entities that handle the cheese are covered by FSMA 204.

(1) <https://www.npr.org/sections/thetwo-way/2017/12/28/573987023/fda-takes-too-long-to-recall-tainted-food-federal-investigators-say>

(2) <https://www.fda.gov/food/food-safety-modernization-act-fsma/fsma-final-rule-requirements-additional-traceability-records-certain-foods>

REGULATION DRIVING TRACEABILITY EFFORTS

However, given that milk and other ingredients needed to make soft cheese (salt, cultures, and rennet) are not in the FDA's Food Traceability List the farm that produces the milk and the supplier who provides the other ingredients are not covered by the rule and do not have to maintain any records under the rule. Similarly, in the case of wild-caught tuna, even though this is an item in the FDA's Food Traceability List, fishing vessels are largely except from the rule. In this case, traceability starts at the port where it is sold to a seafood company for processing. Given than the fishing industry in notorious for fishing in illegal waters and for rampant human-rights violations, this is a serious limitation of the rule, leaving a large grey area.

The limitations of regulatory frameworks like FSMA 204 underscore the critical need for companies to proactively enhance food traceability and transparency, driven not just by compliance, but by consumer demand for ethical sourcing and production practices. This consumer-driven approach, if paired with innovative traceability technologies can fill the gaps not covered by regulation, ensuring a fully transparent journey from farm (or ocean) to table, thus building trust and loyalty with increasingly conscious consumers.

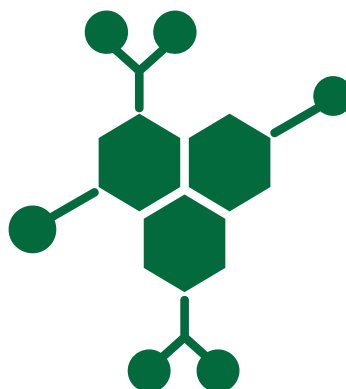
Items not in the Food Traceability List (FDA):



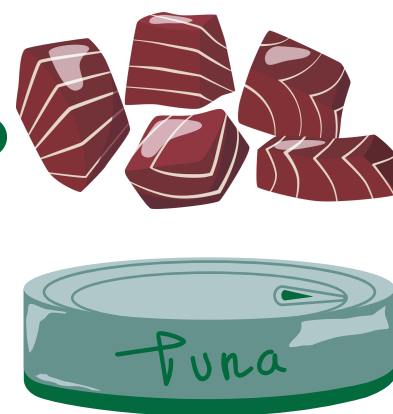
Milk



Salt



Rennet



Wild caught Tuna



TECHNOLOGIES FOR FOOD TRACEABILITY

A variety of technologies are already being used for food traceability, including blockchain for secure and unalterable records, the Internet of Things (IoT) devices for real-time monitoring, QR codes for consumer-level product tracking, and cloud computing for centralized data storage and access. Given the need for the many players in food supply chain to satisfy consumer pressures or to update their systems to comply with FSMA Rule 204, we are seeing great innovation and creativity from a variety of players.

Advancement in these technologies can help track the history, location, and state of food products throughout the supply chain, improving safety, reducing fraud, and increasing transparency for consumers and regulators. A variety of companies are pushing the frontier on traceability technologies, from giants such as IBM, SAP and Oracle to newer players such as Wiliot, with the mission to “make every single thing an agent of change,” (3) Authena with the mission to “help in the fight on anti-counterfeiting by protecting brands, manufacturers and consumers,” (4) and Blocktac with the mission to “end counterfeit and fraud,”(5)

Ambient IoT

Ambient IoT, describes a technology ecosystem where a vast number of objects are interconnected within a wireless sensor network through low-cost, self-powered sensor nodes. It represents an ambitious vision where individual items can communicate and operate intelligently within various environments.

IoT Pixels and Digital-Physical Seals

IoT Pixels, also called **Digital-Physical Seals** are self-powered (no need for batteries), miniaturized IoT devices following the product at unit-level across the entire value-chain & providing real-time data visibility & environmental conditions monitoring. By embedding these pixels into products during manufacturing, companies can receive detailed, item-level information such as product location, temperature, humidity, and carbon footprint without the need for human intervention. This technological advancement not only streamlines traceability and compliance with food safety regulations but also enhances data privacy and authenticity.

(3) <https://www.wiliot.com/company>

(4) <https://authena.io/technology-solution/>

(5) <https://www.blocktac.com/en/>



TECHNOLOGIES FOR FOOD TRACEABILITY

Digital Seals and Single-Use QR codes

Digital Seals and Single-Use QR codes are unique, single-use secure identifiers given to individual product unit. They are consumer-facing and can be easily scanned using a smartphone camera, enabling buyers to instantly confirm product authenticity at no cost and report counterfeits. This technology deters counterfeiters, as replicated seals are quickly identified as fake, removing the economic incentive for fraud and protecting the integrity of genuine products..

Digital Twins

Digital twins are dynamic virtual replicas of physical objects. They make any information on a product easily accessible and verifiable through smartphone.

Blockchain

A **blockchain** operates similarly as bookkeeping or a database, in which events are entered into blocks. Due to its features, the blockchain is transparent and safe, data cannot be manipulated after it is recorded and all events in the chain can be verified at any time.

Because the blockchain's sole purpose is to safely store data (whether the data is accurate or not), the integrity and quality of the data entered into the blockchain is critical for the technology's success.

CASE STUDY — ARLA FINLAND

Arla Finland

Arla Foods, a leader in the dairy industry, has embarked on an ambitious project to enhance the transparency of its milk production process. The initiative, named Arla Milkchain, employs blockchain technology to document the entire production chain of its Single Estate Organic Milk. This pioneering approach in the dairy industry aims to provide consumers with unparalleled insight into the journey of milk, from the farm to the final product.

In conjunction with this transparency effort, Arla Finland has launched the Arla Iris app, which represents a novel application of artificial intelligence in the sector. The app provides consumers with a wealth of real-time information regarding the welfare of cows. It is piloted on Tikka, an organic farm located in Kurikka, Finland, and focuses on enhancing consumer understanding of animal welfare conditions. The app collects and processes data on various aspects of the cows' lives, including cleanliness, nutrition, health, and outdoor activities, utilizing an AI-powered digital camera prototype specially designed for this purpose. This technology enables the detection of any deviations in animal welfare swiftly, ensuring that cows have a comfortable living environment.

The Arla Milkchain and Arla Iris app are part of Arla's broader commitment to animal welfare and sustainability. By offering such transparency, Arla not only meets consumer expectations but also supports dairy farms in improving their operations. This approach is seen as a step forward in bolstering the Finnish public's perception of dairy farms and the critical factors that contribute to the well-being of dairy cows.

These initiatives by Arla Foods illustrate the company's dedication to creating the most transparent milk origin journey and establishing new standards for consumer trust and animal welfare in the food industry.



LIMITATIONS OF TECHNOLOGY AND THE NEED FOR A HOLISTIC APPROACH TO FOOD TRACEABILITY

We have seen many cases in which traceability technologies are helping food companies get closer to their sustainability goals. In the context of animal welfare, Arla Foods in Finland is pioneering AI-powered monitoring technology and a consumer-facing app to champion their animal's welfare as a differentiator among competitors. Similarly, looking at environmental sustainability, satellite monitoring and GPS technologies are playing a key role for companies like Brazilian beef processing company Marfrig to ensure their animals never raised on deforested land.

However, while technologies such as blockchain, AI-powered cameras, IoT devices and single-use digital seals, can enhance transparency and accountability in food supply chains, it alone cannot solve the complex systemic issues that give rise to human rights, animal welfare standards, and fraud violations.

A particularly pronounced limitation of technology is data authenticity. As Tomi Sirén, Head of Digital and Technological Innovation at Arla, aptly observes, “The thing about blockchain is that it doesn’t help with the quality of the data. If you put garbage in, you get garbage out. It keeps the data exactly as it is.” (7) The integrity of the data entered into the blockchain is critical—while the blockchain is adept at preserving the state of data but does not enhance its quality. Incorrect or poor-quality data input will lead to unreliable outputs, and can mislead consumers just as easily as fraudulent marketing.

Overall, there needs to be a concerted effort where businesses form partnerships with governments and human rights organizations across all countries in their supply chain. It is essential to keep in mind that technology is not a panacea when it comes to traceability and its role is limited. Its purpose is to diminish the margin of error and reduce opportunities for bad actors. By doing so, technology can strengthen consumer's confidence in the quality and authenticity of food products. They can be comfortable making a purchase with the understanding that the product is authentic and are not supporting human rights, animal welfare, or environmental violations.

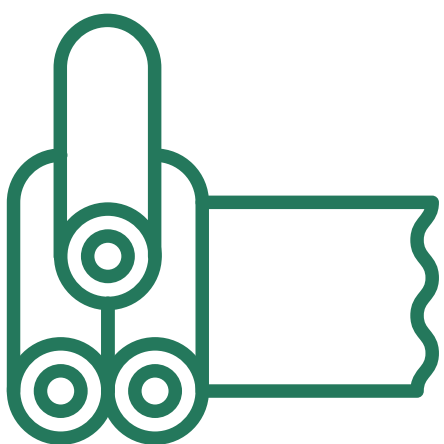
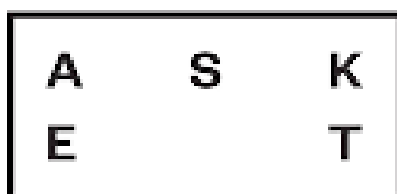
Currently significant obstacles prevent the implementation of sustainable policies. One example is traditional farms making the transition to organic and regenerative practices. The hurdles of education and the costs associated with adoption are non-trivial. There's a clear need for a shift in government subsidies to support the integration of new technologies and the development of climate-resilient crops, which are essential for the advancement of sustainable agriculture.

(7) Driving transparency in the dairy value chain, Tomi Sirén of Arla. (2021, February 16). TX – Tomorrow Explored podcast. <https://tx.company/blog/tx-podcast-transparency-in-dairy-value-chain-arla/>

LEARNINGS FROM THE FASHION INDUSTRY: ASKET'S FULL TRANSPARENCY EFFORTS

Food companies can also look at other industries such as fashion to understand how to improve supply-chain traceability and how to communicate their traceability efforts to consumers as a key differentiator among competitors.

Asket is a Stockholm-based clothing company with a mission to create the perfect wardrobe—a permanent collection of high-quality, essential garments that invite consumers to keep garments in use for longer and reduce overconsumption. Asket's philosophy on traceability is rooted in the belief that conventional "Made in.." labels oversimplify the truth about garments origins(8). To address this, Asket meticulously traces each step of a garment's creation, from the source of raw materials to the finished product. The process includes visiting facilities, issuing questionnaires, collecting certificates, and sharing detailed findings on their website and product labels.



Raw material



Finished product

(8) <https://www.asket.com/us/transparency/traceability>



A FRAMEWORK FOR RESPONSIBLE TRACEABILITY PRACTICES IN FOOD SUPPLY CHAINS

In their push towards 100% traceability, Asket has created a framework that can be adopted by companies in other industries to 1) develop a better understanding of complexities of their unique supply-chain, 2) turn traceability, transparency and sustainability into key values for the company and 3) communicate these values to consumers.

1) *Understanding the complexities of each unique supply-chain*

Asket's framework starts by breaking each garment into different components based on their manufacturing tier: Raw Material, Milling, Manufacturing, and Trims. Each facility within these tiers is scored based on the level of detail known about it—fully traced (exact legal name and location), two-thirds traced (city known), or one-third traced (only country known).

Based on the scores from all facilities involved in creating a garments components, Asket weighs each tier's scores relative to its environmental and human impact, and ultimately gives each individual garment an overall traceability score. This score reflects the degree of transparency and knowledge Asket has about the production of each item, ensuring customers are informed about the origins of product they purchase.

Using the example of olive oil, a product that is known to have an opaque supply-chain and where consumers often fall victim to counterfeit products, we can apply Asket's framework, following a similar tiered format. By starting with doing this investigative work, the olive oil company would understand of complexities of their unique supply-chain and would be able to remedy any issues they may find.



A FRAMEWORK FOR RESPONSIBLE TRACEABILITY PRACTICES IN FOOD SUPPLY CHAINS

Tier 1: Harvesting

Olives are picked by machine or hand during the harvesting season, in the fall.

Full traceability would capture information about the olive groves, their geographic locations, cultivation practices, and the olive varieties grown.

Tier 2: Processing

This part of the process typically includes milling, malaxation and extraction. The olives are transported to a milling facility, often on the same day of harvest to maintain quality. At the milling facility, the olives are separated from leaves and branches, and then crushed into pulp by machines and milled into a thick paste. During the malaxation process, water is added to the paste made of olives and pits to thin out the consistency of the mixture. The mixture is then churned slowly to help the olive oil droplets separate from the rest of the mixture.

Full traceability at this step would detail the mill's location and processing methods, capturing information from the moment the olives arrive to the facility.

Tier 3: Pressing

Typically done in a decanting facility, the oil is separated from the paste, often using a centrifuge. The oil is then clarified to remove water and impurities, which can be done at the same extraction facility or a separate processing plant.

Full traceability would capture information about the decanting facility's location and processing methods, and if applicable information about separate processing plants used for clarification.



A FRAMEWORK FOR RESPONSIBLE TRACEABILITY PRACTICES IN FOOD SUPPLY CHAINS

Tier 4: Refining

In this optional step, heat, chemicals and other processes are used to change the taste, color and other characteristics of the oil. This is generally only done to lower quality olive oils. Higher quality olive oils, such as extra virgin olive oil, are not refined before consumer use.

Given what has been the opaque nature of the olive oil supply chain, this is a critical step in traceability in order to ensure that the oil is not adulterated or mislabeled. Once again, full traceability at this step would detail the facility's location and refining methods, including any changes made to the characteristics of the oil.

Tier 5: Storage and Bottling

The olive oil is stored in stainless steel containers at a storage facility to prevent oxidation, and then bottled, packaged and shipped to either the consumer or the distributor.

This is another key step that requires careful monitoring to ensure lesser quality oil is not bottled as premium. Full traceability at this step would detail the storage facility and the bottling facility's location and methods used.



A FRAMEWORK FOR RESPONSIBLE TRACEABILITY PRACTICES IN FOOD SUPPLY CHAINS

2) Turn traceability, transparency and sustainability into key values for the company

As discussed earlier, effective and transparent sourcing can become a cornerstone of a company's branding, shaping its reputation and building a niche in specialty markets. As August Bard Bringéus, Co-Founder of Asket explains, when the company was starting, transparency was “a means to manifest quality... we had to open up our factories and show what it actually takes to create this garment to give a sense of that craftsmanship and the quality. (9)” Such strategic transparency can set companies apart from competitors who do not position themselves as patterns eager to educate their consumers about the intricacies that make their product unique. Furthermore, when strategic transparency becomes part of a company's mission, it serves to foster a long-term relationship with consumers.

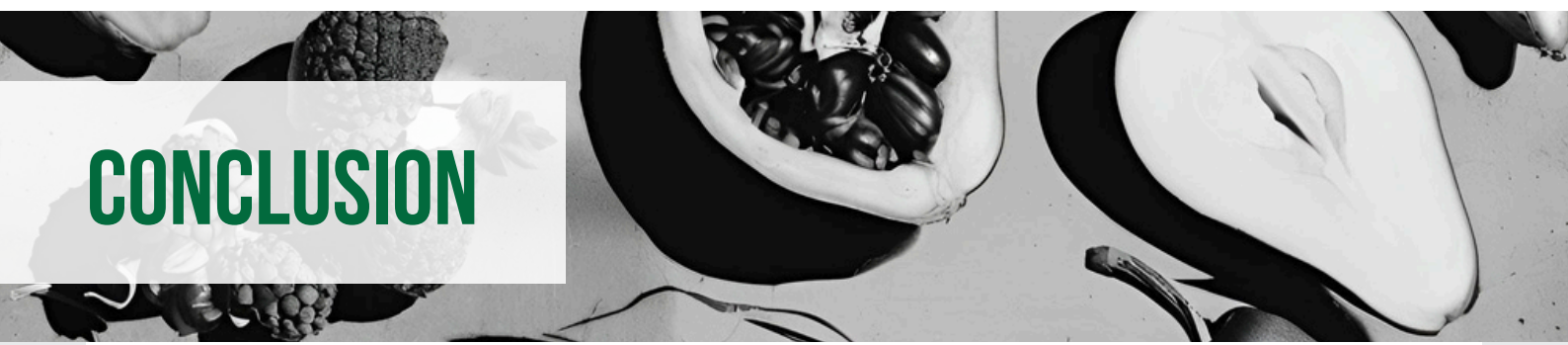
3) Communicate these values to consumers

Following the Asket model, it is essential that companies consider how to deliver information about their product's traceability to consumers. What is revolutionary about Asket's approach is that their traceability efforts are not only available but clear and highly visible to consumers on their website and clothing tags. As they state in their “Asket Principles” report, which offers a framework for responsible business practices in apparel, “No matter how far we've traced a garment, we provide everything we know (and, importantly, what we don't know - otherwise, it's not full transparency but a half-truth) on [asket.com](https://www.asket.com), as well as in the Full Traceability label sewn on every garment.”

While food products sold through retailers may have more limited opportunities to provide consumers with all the information they wish to, if the values of traceability, transparency and sustainability become truly embedded in the company's mission, they will still become visible to consumers. An example of a company operating in the complex space of olive oil and succeeding at telling their story is Brightland. Their dedication to providing detailed information about the harvest, the specific olive varieties used, and the production methods on their packaging and website. This level of detail empowers consumers with knowledge about what they are consuming and the environmental impact of their choices. Brightland's traceability efforts are showcased through QR codes on their products, leading customers to more information about the origin and journey of the item they've purchased, reinforcing the bond between the farm and the kitchen table.

(9) <https://podcast.menswearstyle.co.uk/1068124/3724124-august-bard-bringeus-co-founder-of-asket-zero-compromise-garments>

(10) <https://brightland.co/>



CONCLUSION

In the evolving landscape of the food industry, the imperative for comprehensive traceability has never been more acute. The combination of consumer demand for ethical sourcing, regulatory pressures for enhanced food safety, and the technological advancements enabling granular tracking, marks the start of a period of transformation. As companies stride towards embedding traceability into their DNA, they're not merely complying with regulations but are also elevating their brand ethos, fostering consumer trust, and setting new benchmarks for transparency. This convergence of values, technology, and regulation underscores a pivotal shift towards a future where food traceability is not just a compliance requirement but a core business strategy, promising a more informed, ethical, and sustainable consumption paradigm.