

Towards Traceable Flour: Digitizing the Grains & Cereals Supply Chain

What is Food Traceability?

Traceability is the ability to track the forward movement of food products through supply chain segments and the ability to trace backwards the history, application, and/or location of that product and raw ingredients. Historically, traceability is a business to business exchange of information that is largely focused on enabling rapid and complete product recalls. Today, both industry and the consumer base are seeing traceability as a way of increasing transparency, accountability and trust across the supply chain. Traceability systems are being piloted and implemented to address illegal and fraudulent product as well as providing consumers with increased knowledge on their food as a market differentiator.

Through IFT's research into effective traceability architecture, the concepts of **critical tracking events** (CTEs) and **key data elements** (KDEs)¹ were put forward as key system design elements. Critical Tracking Events (CTE), are defined as those events that must be recorded to allow for effective traceability of products in the supply chain, while Key Data Elements (KDE) are data inputs required to successfully trace a product and/or its ingredients through all relevant CTEs to achieve the traceability system use case(s). With variable technology adoption across geographies, supply chain segments, and food commodities, the framework advanced by IFT is invaluable as a technology agnostic approach to integrating systems in data capture, identification, and data sharing across a diverse set of supply chain actors.

Leveraging the CTE/KDE framework, the agriculture and food industries are moving towards building robust, interoperable traceability systems to achieve end-to-end traceability. Taking advantage of novel digital technologies, such as Internet-of-Things (IoT) and Blockchain, and anticipating the potential for Artificial Intelligence to transform decision making, food companies are driving adoption of common data standards and piloting early implementations of these new technologies. Standards setting processes utilizing the KDE/CTE framework enables technology providers to develop solutions that work across supply chain actors and streamlines data sharing arrangements among trading partners by having common best practices and verification. In this paper, we present a proposed mapping of the traceability framework to the **grains and cereals** supply chain, which can exploit technologies that have recently emerged and are commercially available.

Challenges for Grain Traceability

Grains and cereals represent the largest agriproduct category by volume, with about 2.7 billion metric tons harvested each year. The majority of this is handled and transported in bulk form, from the farm all the way to the final food processing stages (see Figure 1). This presents unique challenges for traceability. At the farm level, mandatory KDEs could include the geolocation of the actual field where a specific grain crop was grown, and the types of seeds, fertilizers, insecticides and irrigation water that were used in growing it. This data should accompany the crop's journey post-harvest, while various CTEs are created as the grain is transported and transformed downstream. For instance, a transformation event could be a blending operation at the level of a terminal elevator facility, where grain from different origins and quality grades is being mixed to achieve a 'target' grade. 'Tagging' the grain pre and post-mixing is a desirable, if not necessary, feature. Additionally, insect infestation levels and pest control

¹ McEntire et al., "[Traceability \(Product Tracing\) in Food Systems: An IFT Report Submitted to the FDA](#)", 2010.

records (e.g. fumigation treatments) should be recorded and added to the digital ‘tag’, as these may relate to allergies and certification requirements for certain identity-preserved foods (e.g. kosher).



Figure 1: Farm-to-Shelf Traceability Chain for Grains & Cereals

Enabling Technologies

The latest technology is now available to address these emerging requirements. We present some examples of solutions and innovations that can lead to the creation of a digital, automated, farm-to-shelf traceability chain:

- At the farm, **GPS** data from a combine harvester is mined in order to determine which particular field the grain was harvested from, and the geo-tag of the grain bin that it was loaded into. Level-monitoring sensors employing **microwave**, **ultrasound** or latest **LIDAR** technology can be used to record the loading event and provide real-time harvest volume data to operators.
- While grain is stored in on-farm bins, or further downstream in elevator silos, **monitoring sensors** report in real-time on grain temperature, moisture, CO₂ and other data that determine quality (Figure 2). Sensors transmit wirelessly to the cloud, where data analytics tools determine quality and predict spoilage conditions and expected ‘shelf life’ for stored grain. **5G communications** technology promises to enable increased speeds, bandwidth, and reduced latency providing a backbone for higher capability devices, increased data collection, and faster real-time data transmission. A **Quality Chain** is thus created, where a string of data and analytics accompanies a grain lot as it moves along the supply chain.
- Blending and mixing of bulk product may occur at a grain elevator, or at a train or barge terminal where shipments of grain are staged. Recording these CTEs is possible using ‘fingerprinting’



Figure 2: Monitoring of conditions with sensors in grain (available at centaur.ag)

methods based on **NIR spectrometry**. Portable spectrometers are now available that enable scanning and transmission of crop fingerprints. The same technology can be employed further downstream, say at a flour mill, to validate the provenance of incoming grain and propagate the chain of traceable CTEs.

- Pathogens in grain and related toxins are often a cause for food recalls. Their presence in grain (or preferably, absence thereof) can be captured and recorded as a KDE. **Polymerase Chain Reaction (PCR)** based methods are an example for detection or quantification of pathogens (e.g. *Fusarium* species). With PCR, copies of DNA sequences are exponentially ‘amplified’ to generate thousands to millions of more copies of that particular DNA segment. Compact PCR instruments and bioinformatics methods make their application feasible in the field.
- **DNA ‘barcoding’** is a known molecular-based method which can identify biological specimens and is used for the identification of both raw materials and processed food. Anywhere in the supply chain, a commodity lot can be tagged with a safe, edible, odorless, tasteless substance carrying complete traceability information across the industrial pipeline.
- Ultimately, **blockchain** technology is employed for creating online, distributed ledgers of traceability data collected with any combination of the technologies described above, bringing the essential properties of immutability, openness and authenticity of data records. Open source software frameworks such as **Hyperledger Sawtooth**², hosted by the Linux foundation, are promising broad adoption and standardization. Additional layers of functionality and novel

² <https://www.hyperledger.org/projects/sawtooth>

workflows become possible in a blockchain-enabled supply chain. For instance, digital ‘smart contracts’ which build upon the existence of traceability ledgers, automate commercial transactions without the burden and friction caused by paper contracts, bills of lading and inspection certificates.

What Comes Next?

Even though there is still much to be done to fully implement end-to-end chain of custody traceability solutions, this space is quickly evolving. More and more companies are committing to using traceability for a variety of purposes including underpinning sustainability initiatives and providing consumer facing traceability information. Consumers desire more insight into sourcing, growing, production and quality of the products they purchase and consume. The benefits that accrue for food companies are multiple:

- **Compliance** to food safety requirements is more streamlined. The costs of obtaining and maintaining certifications is better managed, by leveraging the effects of automation and global connectivity.
- **Brand loyalty** is enhanced, once consumers are offered access to transparent traceability data and are able to engage better with the products they consume, understand and trust their provenance and quality.
- **Supply chain management** cost structures become leaner; e.g. grain buyers can leverage data to make better purchase decisions, just-in-time inventory management becomes feasible, and root cause analysis for quality problems is timely and broad, costly recalls are avoided.

IFT GFTC sees a rapid movement towards further digitizing the food supply chain, with grains, cereals and baking goods being among the verticals that stand to benefit. Building on the established CTE/KDE framework, the ability is there to track and communicate a full complement of consumer facing parameters (e.g. provenance, sustainability metrics, production methods, and quality metrics). Hardware and software technologies are advancing quickly with revolutionary solutions constantly coming to market. Previously, the ability to trace and track products on a real-time basis was limited by device capabilities, cost, and network limitations. With the roll-out of inexpensive IoT devices, 5G telecommunications, and traceability IT solutions, the industry is incubating a new digital frontier where accountability and transparency are key aspects of a consumer’s decision-making process.

About the IFT (www.ift.org): The Institute of Food Technologists’ Global Food Traceability Center is a global authority and resource on food traceability with a focus on interoperable data sharing architectures in food operations. The IFT GFTC convenes experts, provides advice, researches novel traceability schema, facilitates data standards development, and communicates research findings to industry and the wider public. Food traceability encompasses the entire value chain and requires an interdisciplinary skillset in the domains of food operations, IoT, logistics, information technology, and regulations.

About Centaur (www.centaur.ag): Centaur Analytics Inc., founded in 2016, provides its award-winning Internet-of-Crops™ software platform, digital twin technology and smart sensors to transform agriproduct supply chains into a global, trusted Quality Chain. Centaur empowers CPG companies, commodity traders, logistics providers and growers with advanced digital tools to enable pristine product quality, waste prevention and sustainability across global supply chains.