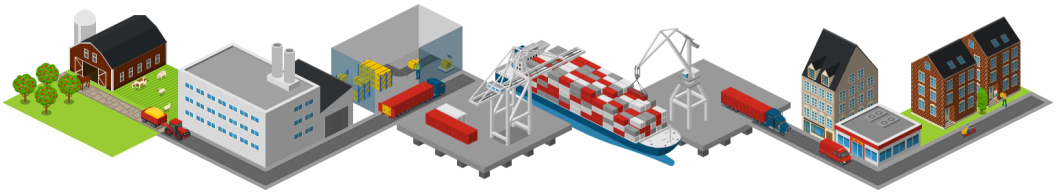

OPEN FOOD CHAIN

WHITEPAPER

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SUMMARY

Our food system is broken. We no longer trust labels, waste levels are around 40%, and obesity is bigger than hunger, to name a few symptoms. Consumer trust is at an all-time low, and businesses suffer billions in costs caused by inefficiencies, fraud, and recalls. While there are innovations, few see mass adoption, and the agrifood industry remains the least digitised industry on our planet. The significance of these issues is growing as the pressure on our food system increases with our expanding population. Therefore, 'radical transparency' is top of mind with industry players as a starting point for optimisation. However, few know how to establish this cost-efficiently.

Open Food Chain (OFC) is this cost-efficient transparent solution. OFC is an open public blockchain platform that connects the entire food industry from farm to fork. First, it offers clarity on the origin of products and provides credibility to claims like food safety and sustainability. This generates immediate cost savings for participants. Second, it kickstarts deep optimisation processes in supply chains. OFC is the basic interoperable infrastructure for safe and easy data sharing. Ultimately, it reconnects consumers to efficient supply chains, building a world where personalised nutrition is the norm. OFC pivots from a kilogram- to a nutrition-based food system. Open Food Chain is live. It is an operational solution for several multinationals with a collective turnover of 25+ billion euros. The first implementation of Open Food Chain is JuicyChain, currently uniting over 50 companies from the juice industry, from production to bottling. OFC implementation has also started in fish and soy.

Our architecture makes OFC very competitive. It is highly scalable, interoperable, and efficient. There are no transaction costs, so you can trace endless volumes without influencing the costs. Payments are made for the first connection to OFC and the maintenance of the system, depending on the service level. In addition to its technical innovation, OFC innovates on how industries govern digital solutions. Together with industry leaders like Refresco and Ahold Delhaize, renowned research organisations like Wageningen UR, tech experts from the blockchain space, and a strong and dedicated Amsterdam-based team, OFC is emerging as the new standard for a transparent and efficient food ecosystem. The FOOD token is designed to make the entire OFC ecosystem self-sustaining, without central authority: making it unstoppable.

1. WHY OPEN FOOD CHAIN?

Our food industry, worth 11 trillion euros, faces serious challenges that Open Food Chain (OFC) helps mitigate - if not solve. Here we discuss the most obvious ones: low consumer trust due to fraud, high levels of waste, and obesity overtaking hunger.

1.1 Problems in search of a solution

It is often said that Blockchain is a solution looking for a problem. Open Food Chain comes in from the other end. Working with farm data, Marieke de Ruyter de Wildt was looking for a way to increase the reliability of data and made the connection with Blockchain in 2016. This got further traction in 2017 with the first food and blockchain meetup, hosted in Amsterdam, attracting a global network of 2k+ people working in food and tech. Every month, we talked about a real case from the food industry. In 2018, this evolved into the first StrikeTwo Summit, where agrifood companies gathered to build the tech-powered future of food. StrikeTwo was co-financed by the Dutch Ministry of Agriculture, Ahold Delhaize, Deloitte, and IBM, to name a few. During StrikeTwo, real-world problems with clear problem owners took centre stage. The summit was split into the three parts of a food system: consumers, supply chains, and farmers. After five editions of Strike Two, it was clear that all parts of the food system suffer from dropping consumer trust, high levels of waste, and a focus on cheap food rather than nutritious food. Chapter two will show how Open Food Chain can help mitigate these challenges.

1.2 Low consumer trust as fraud increases

Consumer trust in the food industry is at an all-time low. According to the Food Marketing Institute, the key trend in the food industry is the rising demand for transparency: 94% of shoppers want to know more about the products they are buying. In the survey results, consumers emphasised the importance of transparency with regards to providing detailed information on food and how it is produced. This phenomenon is noted by other consumer research agencies from other countries, indicating a call for radical transparency. A key driver of transparency is fraud. Fraud in the food industry is extremely high, defined as any intentional manipulation of food, packaging, or labelling for monetary benefit. About one in five products are not what the label says it is. Food fraud has a significant financial impact on the global food business, with estimates ranging from $30 billion to $40 billion each year. Fraud results in

product safety concerns and product recalls. Food safety affects about 600 million people, nearly one in every ten individuals. Product recalls cost businesses an average of $10 million in direct expenses and are further harmed by indirect reputational damages. Overall, industries are increasingly forced, through regulation, to be transparent on origin and supply chain management, making fraud more difficult and increasing consumer trust.

1.3 One third of our food does not reach a plate

Every year, a staggering 1.3 billion tonnes of food is wasted, accounting for one-third of all food produced. Food waste is also believed to cause 8-10% of global greenhouse gas emissions. It has a significant financial impact, totalling around $1 trillion each year. Food waste occurs at all stages of the food supply chain: on producer's fields, during transportation to markets or storage facilities, in shops, restaurants, canteens and homes. It's a result of the inefficiency in food production and distribution systems. It is a global and multifaceted problem.

1.4 Nutritional values are lost

Another key symptom of our troubled food system is obesity. The worldwide obesity health crisis has surpassed hunger as the world's most serious nutritional problem today. Like hunger, obesity is unevenly distributed across the world. However, there are almost no countries that are not affected by the problem of obesity. According to the World Health Organization, obesity is a health problem that has reached pandemic proportions, with at least 2.8 million people dying each year due to being overweight or obese. Obesity is on the rise in all countries. This surge in obesity is attributed to an increase in cheap processed meals containing high levels of added sugar, fats, and salt, which are rich in calories but low in essential micronutrients. Not only do we have less nutrition in our food per kilogram, but the information about nutrients is also hard to find, and (health) claims are not backed by evidence.

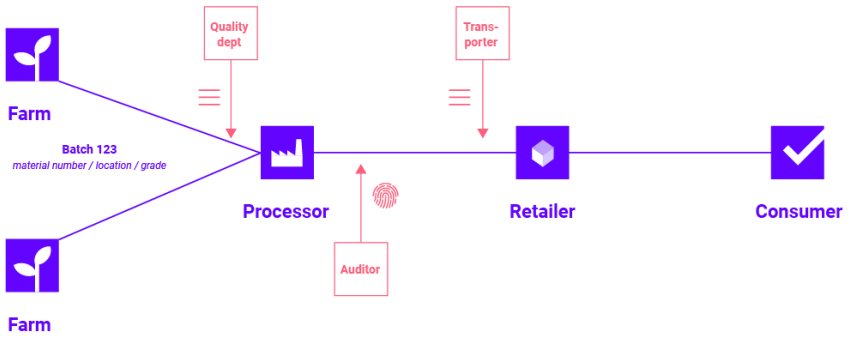
2. HOW DOES OPEN FOOD CHAIN WORK

Open Food Chain is built on a real and clear demand from agrifood companies. We illustrate how it addresses transparency, waste, and nutritional values in the juice industry. We also explain its very new - but tested - approach to governance to guarantee wide industry adoption. The roadmap shows how transparency is just the beginning for supply chain efficiency and a reconnection of consumers to the food system.

2.1 Case JuicyChain

An implementation of OFC is JuicyChain. JuicyChain is managed by the non-profit foundation JuicyChain Foundation, initiated by Refresco and Eckes Granini, and supported by the IDH Sustainable Trade Initiative. The goal of JuicyChain is to create a shared data infrastructure that transparently reports on progress made in sustainable juice production. Each participant of JuicyChain, from farm to retailer, shares volumes and concomitant sustainability claims. As shown in the figure below, participants add claims at different stages of the supply chain. Everybody, including consumers, can see where the product comes from, how it was handled, and its sustainability levels. Information on provenance and all the supply chain steps are available and can be verified by anyone. See a short video explanation **here**.

Figure 1: How JuicyChain works



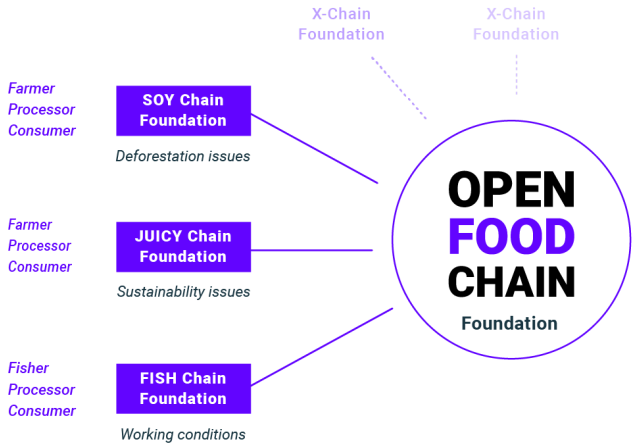
This transparency **creates consumer trust and reduces the propensity to fraud**. For example, if a false certificate is identified on JuicyChain, this will be visible to everybody in the network, and that participant will be excluded from further participation. As data on volumes is real-time, processors can see volumes coming with more accurate information, like lab results. This

reduces waste levels and optimises processing. Without JuicyChain, batches can only be assessed when they arrive at a collection point. With JuicyChain, they can be assessed with lab results when they are still within the farm gate. Any sort of claim can be shared in JuicyChain. Lab results include **information on micronutrients.** Therefore**,** product information shared with consumers can include that, so consumers see what nutrients come with an apple juice.

2.2 Governance structure

OFC has two levels of governing bodies. Governance issues (who initiates, who decides, who owns etc.) are critical to the successful growth of a blockchain network. OFC has OFC **foundation** that governs the main infrastructure. It includes autonomous, **industry-specific foundations**, like the JuicyChain foundation.

Figure 2: OFC Governance



Open Food Chain foundation

OFC foundation was founded in The Netherlands and is the governing body that sets the strategy and executes operations for OFC main net. The board meets at least four times a year to set strategic targets and discuss emerging issues. The board consists of key players within the food industry and were selected with the following criteria:

- Deep knowledge of innovation within the food industry
- Strong network to facilitate fast adoption
- Vision on the future of food

The first OFC board was set up in a centralised manner. However, future iterations will be voted in through a democratised process.

OFC foundation accelerates the adoption of industry chains in respective supply chains, with the following targets:

Year	Industry
2022 - Full implementation	Soy, Fish, Juice
2022 - Initial setup	Coffee, cacao, 10+ industries
2023 - Full implementation	Coffee, cacao, 10+industries
2023 - Initial setup	Industries X & Further ecosystem integration

Open Food Chain foundation facilitates the setup of these new industry foundations and their chains. It works together with different key industry partners.

Industry Chain Foundations

Endless side-chains run alongside the main OFC blockchain. These side-chains are each focused on a different food industry. JuicyChain focuses on the juice industry with its own foundation. SoyChain on soy, also with its own foundation. That separation serves the fact that each industry has different players and priorities. A collective industry challenge in juice is to show progress on sustainability, as defined in the juice covenant. For soy, current pressure is on deforestation

2.3 Competitive Analysis

One of the first blockchain implementations in the food industry dates back to 2016, with Walmart and IBM setting up a proof of concept to track the origin of mangos sold[1]. Throughout the years, different blockchain projects have attempted to create a solution for the food industry. These initiatives have had varying degrees of success. However, no industry standard has been set. OFC has several characteristics that can make it the industry standard.

Differentiators: We assessed the strengths and weaknesses of many different projects that attempted to make their way into the food industry. Some of the more prominent ones include Vechain, with their SaaS solution, ToolChain being adopted by Walmart[2], IBM Food Trust that offered a full-fledged platform based on Hyperledger[3], and Origintrail with adoption in the

[1] Hyperledger, 2016 (https://www.hyperledger.org/wp-content/uploads/2019/02/Hyperledger_CaseStudy_Walmart_Printable_V4.pdf)
[2] https://cointelegraph.com/news/walmart-china-subsidiary-teams-up-with-vechain-to-trace-food-products
[3] https://www.ibm.com/downloads/cas/8QABQBDR

South-European poultry market[4]. These are just some of the many Blockchain for the food industry initiatives considered when designing OFC. OFC sets itself apart based on three key differentiators:

Interoperability: The food industry is notoriously slow to adopt new technology[5]. Therefore, the onboarding experience had to be seamless and efficient. OFC is fully interoperable with existing data systems, and users can even do the onboarding on their own accounts. The ease of onboarding accelerates adoption. As we use the built-in UTXO model (Unspent Transaction Output) for administration, the model similar to Bitcoin, this means we do not make use of a virtual machine (like you find on Ethereum). UTXO's can be read and verified without consulting a virtual machine, which makes it possible for any software, app or dApp on any platform, to interoperate directly via our decentralised API's for blockchain and oracles. Any asset on OFC or one of the industry chains is bitcoin compatible and directly exchangeable for (wrapped) assets on other blockchain platforms such as Bitcoin, Ethereum, Polygon, Binance Smart Chain, Cosmos, etc. For this we utilise the open source third generation atomic swap protocol of AtomicDEX which is capable of handling 99% of public blockchain protocols.

No transaction costs on volumes: One of the bigger barriers to adopting Blockchain is transaction costs. We've seen that many supply chains that handle volumes cannot move beyond a pilot because of costs increasing with volume. OFC industry chains have been intentionally developed to work with no gas fees and with zero transaction costs.. We've implemented spam protection in a different way to secure our industry chains: Industry partners lock FOOD tokens on the main chain to gain access to the faucet of their industry blockchain as an active participant, a locked investment that Industry partners can cash out at any moment if they want to exit and which is slashed in case they misbehave. OFC and all industry chains do not have gas fees, as decentralised logic is processed within the consensus layer, there is no virtual machine. Industry partners run blockchain nodes decentralising and securing their industry blockchain. The costs to run these nodes are kept at a bare minimum and are not volume related..

Farm friendly: Farmers are critical in our food system and have the most valuable data on soils and crops. Hence, it is mission-critical to enable farmers to upload data. We developed something that we call autonomous onboarding, so any party - even smallholders - can connect to OFC on their own account. Our technology allows for mobile apps to directly interact with our

[4] https://origintrail.io/case-studies/food-traceability

[5] Foodsafetytech, 2018
https://foodsafetytech.com/column/how-a-history-of-slow-technology-adoption-across-food-supply-chains-nearly-broke-us/

blockchains using nSPV. Additionally, we developed strong ties with colleagues like AgUnity that work with smallholders.

We ate building with the Komodo tech stack because this tech stack best fits our needs. We are building an independent blockchain ecosystem with consumer trust, business efficiency and a healthy planet as goals. We need to move from data silos to shared (public) trusted transparent administrations which are optimised for the food supply chain. To be clear: we are not building on the Komodo blockchain, we are building with the Komodo tech stack. We are Open Food Chain like Polygon is Polygon, while they are built with the Ethereum tech stack.

Of course we looked at other platforms, let's discuss a few:
Ethereum: We would need our own industry 'shards' which are still far away (Eth2) and transaction costs and gas fees would make it far from optimal for food. Also the account based ledger and virtual machine setup serves another goal than that of a transparent and trustworthy administration. A workaround on Ethereum would mean data silos again…
Polygon: Polygon enables a Komodo style setup (many chains, secured by Polygon which on its turn secures on Ethereum) but would still lack transparency and trust of the shared administration (similar to Ethereum). Reporting would be resource intensive and hardware costs would be quite higher than in our current setup.
Polkadot: Also a Komodo style setup with many chains and it seemed interesting a few years ago. However, Polkadot was not close to be finished when we started and with its limitations and costs on parachains in hindsight it would have been a no go anyway. Same issue on being account and virtual machine based with effects on reporting.
Cosmos: This is an interesting project with lots of flexibility. However, it was not mature when we started (even now) and interoperability was non-existing at the time. The basis is still account and virtual machine based and you would need to secure your own chains. A Cosmos chain secured by Komodo dPow would be an option, but doesn't make sense as the administration is still not optimised for transparency and trust.
VeChain: We would make ourselves dependent on their tooling, setup and updates, while being exposed to their transaction cost taxation model. Costs are unpredictable and their setup is not food specific. A workaround on VeChain would mean data silos again…

Why are other projects working on Ethereum based or derived solutions? Mostly because the shared (public) trusted transparent administrations are not part of their goals. They are about

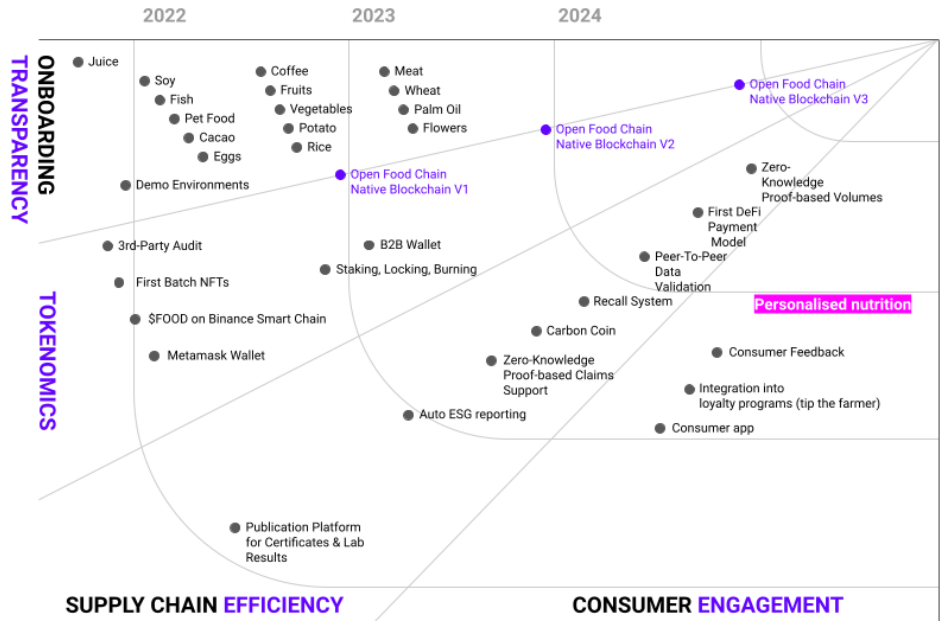
business efficiency and finance. Finance dapps and liquidity are for a large part on Ethereum. At this moment, the food projects are fine with shielded administrations (consortia data silos) and they share public blockchain proofs primarily for finance. We think that once the public wants to verify their claims (because of food safety for instance) the need for a transparent shared trusted administration will be there. We are ready, because we are interoperable with these Ethereum based or derived projects by design..

2.4 Roadmap

Below is the latest version of our roadmap, defining targets till 2025, split up into four categories. **Onboarding:** The onboarding swimming lane in the figure below indicates the planned OFC industry adoption for transparency, increasing consumer trust. The COVID-19 crisis has intensified digitisation in agrifood as never seen before. Most agrifood companies like Harvest House and Nature's Pride are implementing ERP systems for the first time. They also feel the pressure for transparency. Therefore, we estimate that we have two years to launch OFC in all key industries to enable OFC to become the new transparency standard. Based on running projects, we expect to onboard six new industry chains in 2022: Five have been tracks in StrikeTwo, and one was brought on by new board members. Of course, this is subject to change depending on new opportunities or pressures that arise. We know it looks ambitious, but we have been working on this for five years and have strong signals it is desirable and feasible. The main priority of OFC board is to assess the roadmap and capitalise on emerging opportunities.
Tokenomics: The roadmap defines several targets for the FOOD token. FOOD is central in OFC ecosystem, the growth of OFC and the design and development of new OFC features. We aim to list FOOD on decentralised exchanges as soon as possible and on centralised exchanges at the latest by mid-2022. The detailed usage of FOOD is described in chapter 4.
Supply chain Efficiency: This part of the roadmap is about the technical development of the OFC for efficiency gains or **optimisation in food industries**. It addresses the core challenges of waste (direct inefficiencies) and nutrition (indirect inefficiencies). The plotted features are suitable for all food industries.
Consumer engagement: The fourth part of the roadmap explains the inclusion of consumers into OFC ecosystem. While this is not the main priority right now, several targets are set to integrate consumers to play a big role in OFC ecosystem. The first consumer app is estimated

to be delivered early in 2023. The **end-game of OFC is to build a nutrition-centred food system that serves personalised needs and wants**.

Figure 3: Roadmap



3. WHAT IS OPEN FOOD CHAIN

Open Food Chain is a layer one blockchain solution designed specifically for the food industry. Here we explain the key design and development choices made when building OFC.

3.1 Why blockchain

A blockchain consensus mechanism decides how an agreement on the network's current state is reached. As this is native to a blockchain, it is a good solution for a group of loosely coupled participants to agree on a shared administration. No single participant can overpower the network, and no trusted party is needed. This is why public blockchains stand out and are the best option for agreeing on industry standards.

3.2 Public infrastructure for technical strength and adoption

One of the key principles of OFC is the public design of the protocol. Our focus is to build OFC as an open-source project that allows the ecosystem to thrive and encourage innovation through collaboration. Open Source software is often of higher quality, as the code is publicly available for reuse and review. This way, bugs and issues are exposed and addressed more quickly. The public nature of OFC protocol strengthens the adoption of OFC in the food industry. Stakeholders are often faced with closed-source or proprietary traceability platforms that rely on one central party for validation. A public solution is owned by no one, improving the trust for all stakeholders within the ecosystem. This is one of the most important considerations and serves as the foundation of OFC.

3.3 A strong, efficient consensus mechanism

One of the most important aspects for a blockchain to function as a public network is the consensus mechanism. For OFC, we decided on a structured consensus mechanism that combines Proof-of-Stake (PoS), Proof-of-Work (PoW,) and Delayed-Proof-of-Work (dPoW) for extra security. The blockchain consensus mechanism decides how an agreement on the network's current state is reached. When it comes to blockchain technology, reaching consensus means that at least 51% of the nodes on the network agree on the next global state of the network. The biggest blockchain network (Bitcoin) uses a Proof-of-Work (PoW)

consensus mechanism, which offers one of the highest levels of security of any network. Consensus can be achieved in multiple ways:

Proof-of-Stake: The PoS concept states that a person can mine or validate block transactions according to how many coins they hold. This means that the more tokens a miner owns, the more mining power they have. Stakers within this network put a number of coins/tokens at stake on their nodes and receive rewards after fair mining. Cheating puts their stake at risk. We use PoS because it is effective and works very energy efficiently. The drawback of using PoS, especially in a corporate setup, is centralisation. We counteract centralisation with the following two systems: Low difficulty PoW and DPoW.

Low difficulty Proof-of-Work: PoW is a common consensus algorithm used by cryptocurrency networks like Bitcoin and Litecoin. The participants' mine for a valid hash to be the first to serve a new valid block. However, the PoW mining mechanism can lead to high energy consumption. The base principle is that miners have ‘skin in the game’ by paying for energy. This keeps them honest because dishonesty will cost them (real) money. We use PoW because it is open to anyone regardless of their stake in the coin. It helps us counter the effect of centralisation we see with our use of PoS.

Delayed Proof-of-Work: Smaller blockchains are vulnerable to all kinds of attacks. For this reason, dPoW is a security mechanism invented by the Komodo team. This hybrid consensus method allows one blockchain to take advantage of the security provided through the hashing power of a secondary blockchain. dPoW is one of the key building blocks for OFC, allowing us to have a scalable multi-chain network of niche blockchains without compromising security. OFC has a notarisation process that cycles every ten minutes. The blockchain’s history is notarised into the Komodo main chain approximately every ten minutes, assuming constant activity. This notarisation will then be pushed through the notarisation process into the Litecoin blockchain, making the security complete. dPoW is being serviced by a network of Notary Nodes that are voted on by the Komodo community and supported by the Komodo team. The Notary Nodes create a notarisation of a digital fingerprint (a hash) of the concerned blockchain and write it into the Komodo main chain (KMD). These actions are then written into the blockchain itself. This allows the concerned blockchain to identify where its most recent notarisation can be found. We use dPoW to secure all our chains to the max, so we are sure data is and stays immutable, and the value of the ecosystem is protected.

3.4 UTXO-based tracking

Compared to other provenance blockchains, the main differentiator of our blockchain design is the irrefutable transparency that comes with UTXO logic or *unspent transaction outputs*. UTXO logic behaves like cash or notes and works similarly to fixed denomination notes that are cumulated. The logic kind of works like cash with a cash register. This means you calculate your balance by adding up the value of all your notes. And when you spend a certain amount, you can only spend notes you have and will get change back, if needed. The payments, settlement, and registration are all the same process, which means that the administration is always in line with the settlements, which everyone can see. In effect, the UTXO logic in a blockchain setup creates a fully working concept of transparent triple entry accounting.

Triple entry bookkeeping is often mentioned as the holy grail of all accountancy theories. It is regarded as an improvement to double-entry bookkeeping. A system in which all accounting entries are cryptographically sealed by a third entry (the blockchain). Thus, it works as a deterrent towards manipulations and financial fraud. In simple terms, the total balance of the blockchain's bookkeeping will always be in balance. As a result, all wallets in that blockchain can only be in balance as well. This is the accounting model that Bitcoin first implemented. The UTXO model makes Bitcoin more auditable, transparent, and efficient than traditional financial systems. A UTXO is uniquely referenced by its transaction ID and its index. We chose to design Open Food Chain with UTXO logic for several reasons, namely:

- Scalability (parallel transaction processing)
- Interoperability (one-time object simplicity)
- Predictable costs (no gas calculation)
- Security and privacy (one-time objects and condition-based logic

As our UTXO based foundational layer of transparent proofs and claims is interoperable with any platform using standard tooling, we consider this a strong starting point. If a connection with an Ethereum-based application needs to be made, this can easily be done by integrating UTXO-based proofs in their smart contract layer. This offers interoperability with other blockchain protocols while keeping a strong level of transparency.

3.5 Data model

The way data is structured is critical in a blockchain that interacts with large numbers of different stakeholders offering their secure data. OFC is designed with several steps for data processing, gathering, and structuring.

Data processing: Producers, suppliers, farmers, and other actors produce an enormous amount of data that needs to be structured in the blockchain. All this data is collected and processed in two different ways. First, “batching” allows grouped data to be exported from different ERP systems in report-form. This process is automated and results in a continuous flow of data. Second, unique data not included in the batch data can also directly be fed into Open Food Chain when timeliness is required. The batch data processing is handled through a script called block-notify. The task of block-notify is to create wallets for batch data, send transactions from representations of business artefacts, and publish the public data to the public-facing API. Our data model requires participants to share some essential data with the network. Batch matching is of great importance. Therefore, the Purchase Order (PO) number and position (if any) are of great importance.

GS1 global standard: GS1 is a neutral, not-for-profit, international organisation that governs a series of standards used for product identification. It is a widely used standard which means it can function as a common language for product-batch related identification where applicable. For OFC application, GS1 standards positively impact process efficiency by promising more clarity and fewer errors. Therefore, the use of GS1 standards is encouraged but is not mandatory for the functioning of OFC. The main GS1 standards to use within OFC are:

- GS1 Company Prefix: Company identifier (6 to 9 digits)
- GTIN-14: Identifier for wholesale shipments (14 digits)
- GLN: Location Reference (13 digits)

To avoid conflicts with duplicate PO numbers, we encode them to unique identifiers, preferably with the GS1 company prefix of the customer (the PO number issuer). The GS1 Company Prefix is a unique identification issued by GS1 US. The supplier and the customer must align on the exact company prefix used.

These data points are needed for the batch matching in Open Food Chain:

Purchase Order Number
Purchase Order Position
Customer GS1 prefix (or customer name)

Batch or lot number (can be GTIN)

Data is typically formatted with standard alphanumeric characters, and depending on the data cell, is of a particular type. Usually a string, integer, date or decimal. More complex types can be deconstructed into these primitive types and re-constructed as on-chain data via multi-send transactions.

Claim freedom: As seen in the data structure above, actors are free to add (unsanitised) claims with whatever data they feel is important to timestamp and store immutably for later proof. This can be, for instance, lab test results, audits or nutrients. As participants are running their own nodes, they have the freedom to decide whether or not to store any claims on the blockchain. The second advantage of these custom proofs is that any other platform, website or application can just look at the wallets and transactions (UTXOs) via the publicly available API. There is no restriction and no virtual machine to ask.

Data pipeline: The data pipeline determines how the batch data travels from the actor to the blockchain. The data pipelines are Open Food Chain “Customer Edge Services” (OFC-CES). This is the demarcation point where data from the organisation is migrated to the public blockchain data. The pipeline always remains private and in OFC-CES. Within Open Food Chain, multiple data pipelines are used:

- HTTP API pipeline: This pipeline is used when the ERP system can export the data into web-friendly formats or file uploads.
- Email pipeline: This is used when the customer has a more manual or spreadsheet-based internal process.
- FTP pipeline: This pipeline is used when the customer wants to push export files to our FTP servers or when the customer wants to push export files to their managed FTP servers and for OFC to pull the data.
- MQ pipeline: This pipeline is used when the customer has a more sophisticated infrastructure that is connected to their internal ERP systems or web applications that provide real-time data.

Pipeline documentation: The customer-facing CES are written in go-lang for their speed and efficiency with common libraries created for any data transformation requirement. Each pipeline has its specific implementation to carry out the underlying data transport technology. The starting point is the ingestion of customer data at the edge. The terminating point is at the end of the blocknotify finishing processing. All public data is stored in the blockchain and available by API of the explorers for building hosted services, like product journey applications.

Shielding private data: While our infrastructure is public, this does not mean that all the data is open to anyone. Stakeholders with sensitive data that is not chosen to be shared can be integrated through shielded chains utilising Zero Knowledge Proof technology. This effectively shields the sender, amount, and receiver while ensuring correct administration.
Decentralised Key Value: The decentralised key value (KV) store is useful for transmitting public data peer to peer and asynchronously. The data can be encrypted and remains encrypted whilst stored in the KV blockchain network. It is viewable in its encrypted form on the public blockchain. The KV is an inexpensive store for temporary data. Each participant is responsible for their own data entries. The data entries are used as an address book to signal to other participants where certain transactions can be sent.
Longer-lasting data: Data that is needed for a longer period of time, such as organisation type or organisational data, is stored on Open Food Chain using on-chain oracles. An oracle is managed within the full node and is also under the control of each participant. Oracles offer more flexibility than the simple KV store and will be implemented in future versions.

3.6 Interoperability

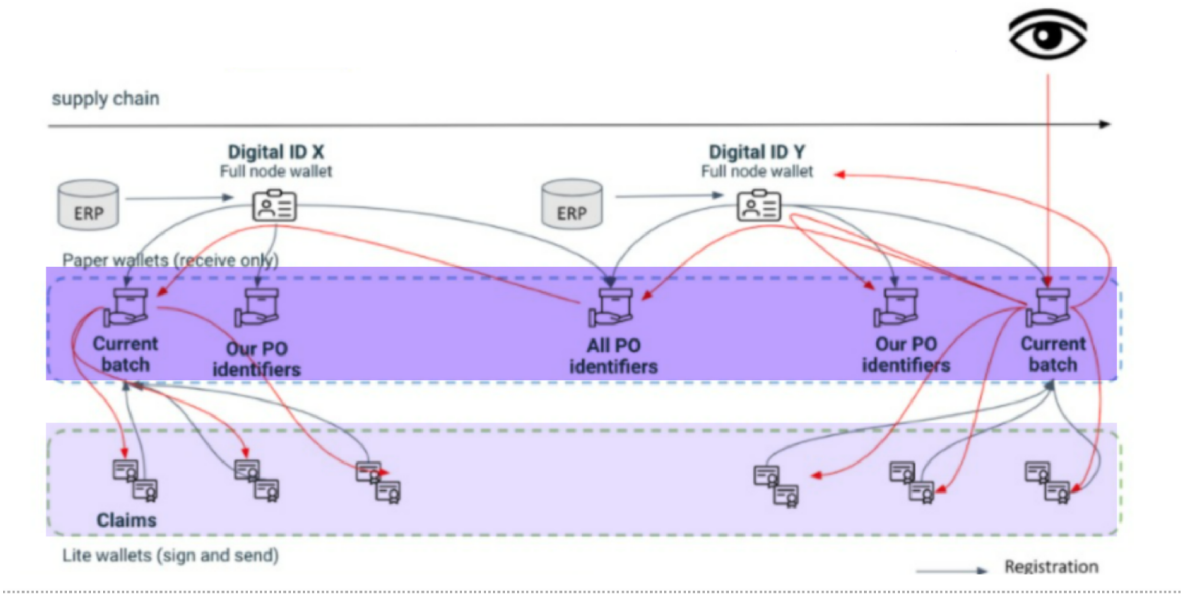
As previously discussed, one of the key issues with many traceability platforms is interoperability. OFC aims to be interoperable and backwards compatible with existing supply chain software infrastructure, from ERP systems to barcode scanning. Furthermore, OFC is interoperable by design with other blockchain platforms, generic wallets, DEXes, and exchanges. It is important to note that OFC is compatible with the AtomicDEX protocol built by the Komodo team. This means that OFC and all its industry-specific chains are able to exchange assets and data with nearly any public blockchain platform without requiring a broker.

OFC relies on interconnection with ERP systems to create a transparent supply chain record. The interconnection does not need to be online/active/hot. It can be achieved with batch processing triggered by, for instance, shipping or production. For each organisation, their full node is an integral part to process their data. The private key (passphrase) unlocks the capabilities to encode all data that will be processed, thereby creating new keys for subsequent transactions. Integration of farmers or smaller actors within the supply chain is more challenging, despite the data these actors offer being the most valuable. Integrating this into OFC onboards smaller actors through setting up a light node that can, for instance, run on a mobile phone.

3.7 Batch matching

Now that we have discussed all components, the following graphic visualises the entire batch flow within Open Food Chain. The black arrows show the data entry flow into the blockchain, and the red ones show the data lookup and batch matching.

Figure 4: Data model

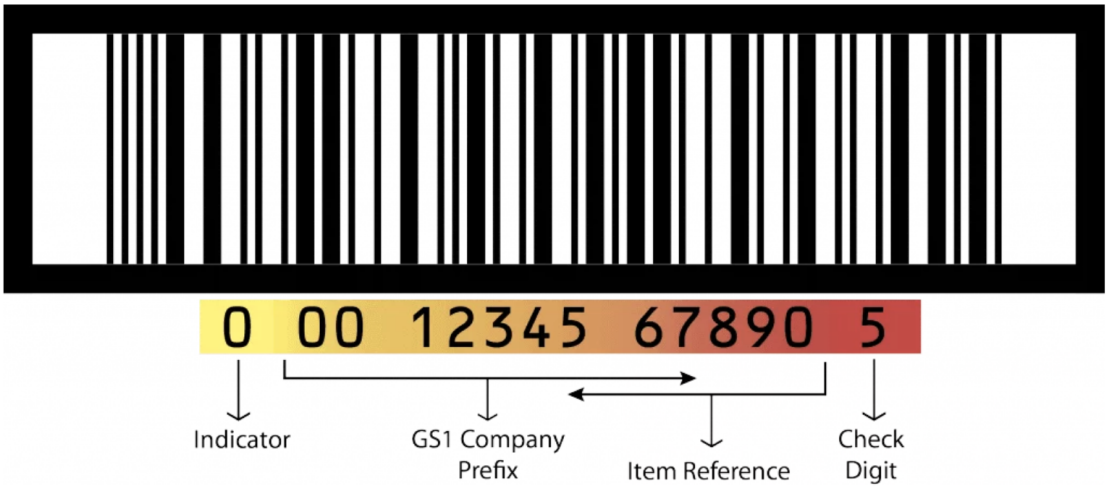


The essential part of batch matching is the PO identifier. The PO identifier is known by both the supplier as the principal and the customer. Independently from each other, they relate the PO identifier to their batches and their identity. An observer can precisely match batches as the PO identifier is unique. Therefore, if there is a match, they can only be related batches.

PO ID = H(PO, POS, GS1P)

PO ID: PO identifier
H: Hashlib function
PO: PO number
POS: PO position
GS1P: GS1 company prefix

This company prefix is the foundation of GS1 Standards and can be found in all of the GS1 Identification Numbers. The GTIN-14 is specifically meant for wholesale batches.



Example GTIN barcode

Example: An apple juice bottle refers to a bottler batch (current batch). The observer can see the identity of the bottler (ID Y), the connected claims, and the related PO identifiers. The observer can now look into the wallet of 'All PO identifiers' and see any matches. The found match is sent by ID X, and the accompanying transaction leads to the current batch of ID X. The observer can now also see all the claims attached to the connected batch(es) of ID X, which also apply to the bottle of apple juice. With the same logic, multiple batches can go into the 'current batch' of the bottler, and they will all be distinguishable in the same way.

3.8 Komodo infrastructure

The Komodo team originated from a decentralised finance project on the NXT blockchain from 2014 and onwards. The team learned that being dependent on the API controlled by another team creates unforeseen events which hurt your business. And so JL777 (architect developer Komodo) posted the Declaration of Independence - Atomic Cross-Chain Asset Standard on the Bitcointalk forum. This was the kickstart for technology enabling interoperable, autonomous yet secure blockchains and digital assets. Ultimately, it led to the Komodo tech stack that we used for OFC and all our industry-specific chains. As a result, we are independent, interoperable, and secure by design. It means we have a strong core supported by the Komodo team and building on Bitcoin architecture, Bitcoin script, Zcash shielding, Litecoin security, Interledger crypto conditions, and Komodo advancements. To be clear, OFC **does not run on the Komodo blockchain. It is a platform on its own powered by the tech, the security, the community, and the team of Komodo**. You can think of Komodo as Linux and OFC as an agrifood-specific distribution.

From a transparency perspective, a **layer-one UTXO based setup like Bitcoin makes more sense than an EVM (Ethereum Virtual Machine)** based setup. A design principle for Bitcoin was to be a transparent, shared, immutable ledger. Ethereum's Turing complete smart contracts have a different focus (being the world computer) which even challenges that kind of transparency. The big volumes in agrifood and the need for a transparent, immutable administration made us prefer a Bitcoin type of ledger (UTXO based) in a secure multi-chain setup over any EVM based blockchain platform like Ethereum. The Komodo tech stack seems to fit that bill perfectly. The multi-chain setup provides industry flexibility and scalability while securing the simple design, clear partitioning, and interoperability.

Local API: The current version of Open Food Chain solution runs on an application server alongside the blockchain. To participate, an organisation will clone the app server source code and connect it to their locally installed node. By having their own node environment, each participant also runs their own local API. The processing of ERP data to transactions is executed within their own trusted environment.

Block explorer: The block explorers provide a decentralised API for applications and websites to pull data. Like the application server, the source code for the block explorer is available for download and to connect to any locally running blockchain node.

Apps: The first consumer app is web-based to be able to display the product journey transparently. It queries the saved blockchain data through a decentralised and open-source API,

then traces back the batch data along the supply chain. OFC is a solution that can be used for auditing. This can be performed by an organisation in scenarios like product recalls or by NGOs in specific industries for reporting purposes.

4. TOKEN MODEL

The FOOD Token (FOOD) is the native token of OFC that powers the entire ecosystem. The token plays a central role in both industry adoption of the solution as well as enabling a token-based economy within the food industry. The token is initially launched on Binance Smart Chain for the open side of the project, while industry-specific chains run on the Komodo infrastructure. We explain the role of FOOD within the ecosystem by looking at three different token value drivers: (1) industry spend, (2) token lock for industry access, and (3) third-party services on OFC.

4.1 Industry spend

OFC adoption within an industry improves operational efficiencies and transparency, leading to cost savings and increased value to the end-consumer, as seen with JuicyChain. The adoption creates buying power for FOOD in three different categories: spending on the setup of industry-specific chains, spending on the integration into existing (loyalty) programs, and spending on industry-specific services that run on OFC

4.2 Token lock for industry access

The second value driver of the FOOD token originates from locking tokens. Once industry chains are set up, actors that want to participate in the chain and benefit from the operational efficiency are required to lock FOOD tokens for the “ability to transact”. When the number of supply chain actors increases, the “buy” pressure simultaneously goes up. This lock is necessary from both a blockchain perspective and a food-industry perspective:

- **Blockchain-perspective:** Locking tokens aligns with our design to be a public blockchain with zero transaction costs. A zero transaction cost design introduces the possibility of a Sybil (creating a vast number of accounts) or spam (creating a vast number of transactions) attack, which we need to mitigate. With a lock of tokens, we enforce

participants to have skin in the game. Thus, a bad actor can be penalised because having a deposit incentivises no attacks on the chain.

- **Food-industry perspective:** The lock enforces responsible supply chain behaviour. If a supply chain actor displays bad behaviour, such as submitting fraudulent batches or incorrect sustainability proofs, the foundation of that industry will be able to penalise the staked part of the actor's FOOD tokens. This burns the supply permanently and provides pressure to the actor to act with the right intention.

The stake required for each participant is currently based on the annual industry revenue. With this in mind, we can estimate the “buy” pressure of the token. With the 2022 target at full implementations in the juice, soy, and fish industries and a 0.001% (low estimate) to 0.01% (high estimate) per industry:

Industry	**Target Market 2022**	**Required FOOD stake per industry (0.001-0.01%)**
Soy	€132B	€1,320,000 - €13,200,000
Fish	€88B	€1,000,000 - €10,000,000
Juice	€88B	€1,000,000 - €10,000,000

Other stakeholders are able to access and read the information on the chain without any required stake but will not be able to transact. This enables regulators, certification agencies, and other relevant stakeholders to be a part of the public blockchain and further verify data that is put on the blockchain. Tokens will be locked for the complete duration of the participant's use of the industry chain. Whenever they unlock, they lose the ability to transact on the industry chain. The result will be that tokens purchased for the lock deposit will be taken out of the liquid supply for years.

4.3 Service development on Open Food Chain

The third token value driver is the open side of OFC. OFC is an open-source and public platform on which people and companies can develop services and other utilities. We aim for Solidity developers to be able to use OFC proofs and assets in their Ethereum, Binance Smart Chain, etc., based smart contracts. Being a layer one solution, it allows for easy interaction with other blockchains, as well as with smart contracts on other blockchains.

For industry service providers, building with OFC has the benefit of being able to access the

biggest data infrastructure within the food industry. The industry has largely remained unstructured and with no real data standards. Open Food Chain connects the industry together and allows for new applications to be built using shared open data.

We foresee different applications built on OFC, such as finance (cross-platform, cross-blockchain), incentive programs, consumer loyalty (cross-industry), and independent data verification. Any service fee related to these services will be burned. This means it is sent to an unspendable address that is publicly verifiable. After burning, these coins are effectively out of circulation, which benefits the coin's value.

Figure 5: OFC Ecosystem