BLOCKCHAIN IN FOOD TRACEABILITY SYSTEMS

A qualitative study into perceived benefits from blockchain technology in food supply chains

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Perceived benefits from blockchain in food supply chains: a qualitative study outlining prospects

'*How can a blockchain food traceability system increase (perceived) transparency for consumers in the food supply chain*'

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Preface

My bachelor thesis about how blockchain technology can help end consumers in the food supply chain is presented in front of you. I wrote this bachelor thesis to finish the final part of the International Food Business program at Aeres University of Applied Sciences in Dronten and Dalhousie University's Agricultural Campus in Truro, Nova Scotia, Canada.

I also wrote this thesis for my genuine interest in the topic. After following a blockchain minor in the final year at the Hague University of Applied Sciences, I wanted to learn more about this specific topic. Furthermore, in combination with the term 'blockchain' being mentioned regularly during supply chain and food safety classes, I wanted to research possible integration in many more food supply chains, primarily to help consumers.

This paper is written for everyone interested in blockchain technology, the food industry, and traceability technology. As an average consumer, I am not getting enough information from the origin of a specific product mentioned on the label, such as transportation or packaging details. The only data point is the country of origin on many fresh products such as apples or tomatoes. Therefore, I wanted to determine whether it would be possible to integrate blockchain technology and its fantastic features into food supply chains to open the complicated food industry.

Blockchain technology is futuristic and relatively unknown, which caused a lot of research specific to the topics in this thesis to be unavailable or not exist yet. Therefore, many sources from the internet were used to explain the background of blockchain and traceability.

For now, I want to thank my university thesis coach Mr. Pat Burgess for guiding me through the lengthy process it took from the first idea to this final product. I underestimated the amount of work it took multiple times. Still, advice about what method to use or how to write a particular passage never stopped, so thank you for that. A thank you also goes to the second assessor from Aeres and Dalhousie for their feedback, which made me realize that most of the time, it is a good idea to read your product to someone else as you are likely to miss tiny but critical errors yourself. I also want to thank the participants who participated in the focus group discussion in June 2021 for their unique views on points that I imagined different in my head. I would also like to thank my internship company Vomar Voordeelmarkt and internship coach, for allowing me to work on my thesis for several hours while in the office I also want to thank my family for not giving up on me and to keep pushing to meet deadlines in the difficult COVID-19 times that confronted the Netherlands and the rest of the world.

Finally, I hope that you will enjoy reading my bachelor thesis and see the effort I have put into this paper to make it perfect. I also hope that blockchain in the food industry and food supply chains will significantly impact the end consumer can use it beneficially.

Christiaan de Jong

Dronten, August 2021

Summary

Blockchain technology has been rising in popularity since its introduction in 2008. Especially in the food industry and in food supply chains, blockchain could provide a guaranteed safe and reliable traceability system with as few errors as possible.

A small systematic literature review is conducted to find out how many articles describing the same keywords have been published to date and are used for further literature research. This research is followed by a mini focus group utilized to gain opinions from industry experts about the potential of blockchain in the food traceability system.

After inductive coding analysis, the perceived benefit for consumers as proposed in the research question is likely not to be reached due to the complexity of today's food supply chain and the ignorance of consumers when it comes to getting information about a food product.

It is recommended that consumers are educated about the true content of their food products and the reason behind the use of certain additives before access to data in the blockchain traceability system can be granted. Failing to educate consumers could result in mass protests or a severe distrust in the food industry, negatively impacting the entire world economy.

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1. Introduction

An increasing number of consumers is becoming involved in the process of tracing back their food products. More consumers want to know where their products come from, and more importantly, under what circumstances they have been produced (Walaszczyk & Galińska, 2020). Suppose the consumer can trace back the places the food product has been. In that case, it ensures that companies have a good food safety tracking system when a (push) notification is sent to users, including consumers and national regulators as soon as an unsafe product has been detected (Eufic, 2014). Legal requirements provide safe food products, together with traceable raw materials (Walaszczyk & Galińska, 2020). To prepare for a crisis such as a major recall or foodborne illness outbreak, the European Union (EU) has put the Rapid Alert System for Food and Feed (RASFF) in place for regulators, such as the Dutch regulator the 'Nederlandse Voedsel en Warenautoriteit' (NVWA; Dutch Food Safety Authority) to exchange information about 'serious risks concerning food or feed', covered in regulation EC/178/2002 (2002). According to the European Commission, when businesses report situations to national regulators, 'an alert is created in RASFF notifying others and decreasing human and animal health risks' (EC, 2007). Unfortunately, the RASFF notification rarely informs end consumers about bad products besides the legally required communication during a recall (Walaszczyk & Galińska, 2020). Research done by Walaszczyk & Galińska (2020) shows that there are multiple definitions possible for 'traceability' and that literature studies show that the international standard ISO 8402 mentions that traceability is the ability to 'trace the history, application, or location of a unit by way of an analysis of records allowing its identification' (Walaszczyk & Galińska, 2020).

The increased interest of consumers of where their food comes from presents opportunities for new technologies. One of those emerging technologies is blockchain. It was introduced with the launch of bitcoin in 2008 by an anonymous person or group named Satoshi Nakamoto. Distributed Ledger Technology (DLT) is part of the core infrastructure of any blockchain for several reasons; the main being that it is the technological infrastructure that allows 'simultaneous access, validation and record updating in an immutable manner' (Frankenfield, 2021). In addition, DLT also means that the ledger is spread across multiple entities or locations for maximum redundancy, as it is the top of a decentralized network (Frankenfield, 2021).

Furthermore, the environment is open and as said, immutable which provides an environment where data of any product can be stored (Nakamoto, 2008). This started by interrupting the financial market with bitcoin (Nakamoto, 2008). The crypto coin first appeared in 2008 and is the highest rated in value compared to the US dollar compared to other cryptocurrency coins such as Ethereum, Stellar and VeChain. Bitcoin's worth has increased relative to the US dollar since its existence because bitcoins are helpful as a form of money (Bitcoin, n.d.). Characteristics of money include durability, portability, scarcity, divisibility, recognizability, and fungibility (Potters, 2021). Bitcoin is based on these characteristics but uses mathematics rather than trusted central authorities such as (central) banks (Bitcoin, n.d.). A bitcoin gets its value when people want to pay with the crypto coin (Bitcoin, n.d.). Later in this paper a more comprehensive review of bitcoin and blockchain is given.

Several companies have already started implementing blockchain traceability in their supply chain in collaboration with other actors in the supply chain (van Rijmenam, 2019). An example is found in the Netherlands. Albert Heijn, the country's biggest supermarket chain, is working with local orange production companies in Brazil and a software company in the Netherlands to provide Dutch consumers information about the path of the orange juice from farm to bottle, incorporated in a blockchain (Albert Heijn, 2018). Consumers can see this route from the farm to the juice bottle in the supermarket by scanning a QR-code connected to the blockchain. This 'QR' or Quick Response code was invented in 1994 by a subsidiary company of Toyota, Denso Wave (Kaspersky, 2021). The code can store lots and great varieties of data, up to 7,089 characters (QRcode, 2021). The QR code can store more data than the regular bar code that can hold approximately 20 digits (QRcode, 2021). While

the initial invention was aimed at car production and trace components during production, in 2021, the code can be used for retail and for marketing or health and travel verification (Rijksoverheid, 2021). In the Netherlands, the CoronaCheck app is used after vaccination with Covid-19 or confirmation of a negative test, which allows the citizen to enter certain events or travel through Europe (Rijksoverheid, 2021).

This paper focuses on whether consumers are ready for more traceable products and if there are benefits for the consumer. A research plan is presented through a theoretical framework where more information is added to answer the main research question. Results from the used method are shown and discussed, followed by a conclusion and final recommendations.

1.1. Overview of emerging research; a systematic approach

In this paper, research for existing literature on the most important topics and keywords was conducted through a (small) Systematic Literature Review (SLR). This approach hoped to close the space between the existing literature and the main research question. Still, it was a little different from a 'standard' Systematic Literature Review as described by Liberati (2009) and Durach (2017), who mention that an SLR provides a reflection opportunity when answering a specific question in research (Liberati et al., 2009; Durach et al., 2017). Besides the reflection opportunity any SLR provides, it compares and discusses findings in previous years, which means that eventually, there is a different perspective and context (Pereira et al., 2021).

The main question in this paper is '*How can a blockchain food traceability system increase (perceived) transparency for consumers in the food supply chain'*? This question will be discussed later in this paper. The basis of this SLR was the three main keywords in the main question: ' blockchain', 'traceability', and 'food'. Searching for these keywords was defined by: {'blockchain' AND 'traceability' AND 'food'}. The general scholar databases ScienceDirect, Springer, Wiley, and Emerald Insight were used. Because this search only uncovered 260 unique scientific journal articles, it showed that the research in these areas has not been extensive yet, for many possible reasons. Additional criteria were therefore not used for that reason. In line with Pereira's (2021) description, the individual articles were organized with Mendeley® Desktop and exported to JabRef® and, in turn to Excel® for maximum sorting capability (Pereira et al., 2021). In Excel, articles were listed with different filters: authors, year of publication, title, and abstract. After a title read and classification session where every article was given a number from 1-3 to represent relevance to the main research question and keyword search mentioned earlier (one (1) for most relevant, two (2) for moderate relevance, and three (3) for non-relevant).

Multiple articles in the original search list were left out because the primary language of the article was not English. A total of 146 articles were not relevant at all to this paper's keyword search. This left 114 articles with a title rank of either one or two. All articles were then analyzed by reading through the abstract. If the abstract was not present in the Excel file, it was attempted to retrieve it. For three articles, this was not possible, and they were therefore left out from the list. The abstract ranking left 37 articles most relevant for this paper in the first round, and after a final ranking round, only 17 articles were most relevant to the original search. This is less than 6% of the initial list of articles, which shows how low the number of written articles about something to do with the keyword search is.

A filter with articles was created to find out the number of articles published yearly relating to the three keywords search. It was set out to find articles from 2015 or before, and then for every year after that up to and including 2021. This graph can be seen in *Figure 1.* For example, the first articles written about blockchain, traceability, or food are not published until 2018. However, in 2018 two articles, or 12% of the 17 most relevant articles were published regarding the keywords used in this search. In 2019 this increased to five articles being published in total, which remained the same in 2020. This could be due to the COVID-19 pandemic and the inability to continue specific research. However, since the year 2021 started, five articles have been published until the date these articles

were retrieved, April 15. This, combined with generally quick technological advancements, most likely means that the number of articles published regarding blockchain, traceability, and food has increased in 2021 overall, compared to 2020 and 2019.

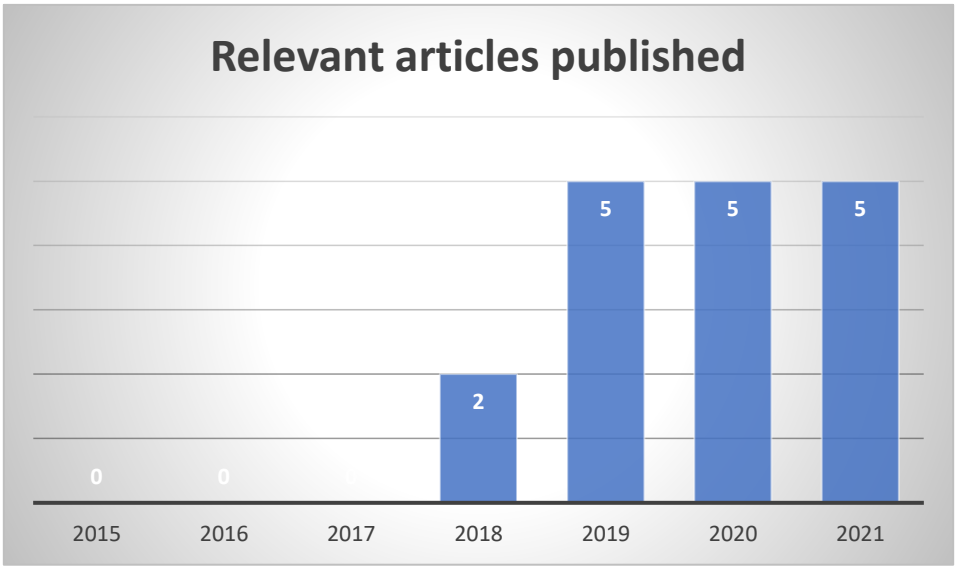

Figure 1: Articles with relevant keywords in databases from emerging research (de Jong, 2021)

This figure and information could mark growth in the scientific interest of blockchain technology combined with the food sector and revolutionary systems, such as an immutable traceability system based on blockchain technology. Because of this growth, more consumers are likely to get in contact with blockchain technology and traceability in several industries. Furthermore, the blockchain ledger is an excellent alternative to claims currently made by businesses about the use of child labor in a product, the level of care for animals, or something completely different; the amount of carbon dioxide offset achieved by that business in the supply chain. Claims can be checked and verified and influence consumer buying behavior simultaneously (Edwards, 2020).

1.2. Theoretical framework

This framework focuses on multiple essential minor research questions, which are important to understand before reading through the methodology and research section. A short introduction to a blockchain is given to help put the relatively new technology and possible use cases in practice. Food traceability is important, and thus a paragraph focuses on what food traceability is. For example, several Netherlands retailers use SIM Supply Chain to track and trace the food products and ingredients being used in products (SIM, 2021). Although SIM has started projects using blockchain to increase transparency in the food information, it is not a standard yet for users of the SIM database (SIM, 2021).

A food traceability system and its importance to consumers are discussed more profoundly and include trust, which is vital for consumers to trust. Without the trust of the consumer in the retailer, the integrity of the supply chain cannot be ensured (Chia, 2017).

A food traceability system is important to consumers and producers because it allows companies to monitor the production process at every stage, including transport, and allows spoilage or hazards to be identified quickly (AgriLinks, 2021). If concerns arise about a specific food product these can quickly be solved once the producer can provide evidence to support their claim of safety (Agrilinks, 2021). Implementation of a (food) traceability system within an organization often requires a lot of usable data (FMI, 2013). Data for internal traceability should be sufficient to track the product from when the product is received from the supplier (FMI, 2013). In most cases an Enterprise Resource

Planning (ERP) system is used to keep track of goods through the different processes before it ends up at the end consumer (FMI, 2013). External traceability requirements differ per country, in the European Union it is required to at least have information 'one step forwards and one step back', meaning the retailers must know where a product has come from and where it is going to (EC, 2007). This is also applicable in the United States (FMI, 2013). Currently it is not stipulated by law to share this information with consumers, but for business-to-business operations having access to information from others is very normal (FMI, 2013).

When a new traceability system is implemented based on blockchain, it means consumers will benefit through added awareness and the ability to see where the product has been on its journey from farm to fork (OpenLink, n.d.). This new system can result in fewer food safety incidents, and in case of a product recall, consumers can check whether they consumed the product involved through a quick QR-code scan (OpenLink, n.d.).

1.2.1. Blockchain basics

Blockchain is a decentralized and distributed digital ledger (Nakamoto, 2008). The technology was first introduced in 2008 when Satoshi Nakamoto introduced the peer-to-peer electronic cash system Bitcoin to the world (Nakamoto, 2008). The most significant incentive for this peer-to-peer system is to send online payments directly from one party to another, 'without going through a financial institution' (Nakamoto, 2008). Digital signatures verify transactions, but double spending is possible without further control over the ledger (Nakamoto, 2008). Fixed network timestamps are 'hashed' onto a growing blockchain chain of hash-based proof-of-work blocks, as seen in *Figure 2* (Nakamoto, 2008). The blocks provide the final step in removing the trusted third party from the transaction while making the Bitcoin transaction itself as safe as a regular monetary transaction (Nakamoto, 2008).

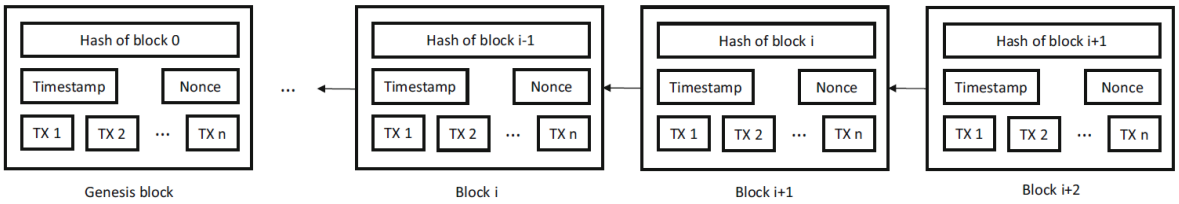

Figure 2: Example of a blockchain entry/transaction (Zheng et al., 2016, as cited in Nofer et al., 2017)

What this means is that people or computers connected in the same blockchain or bitcoin network, so-called 'nodes', check to see whether the digital signatures are correct and, if so, record this in the ledger by connecting the transaction to an existing chain of blocks of transactions (Nofer et al., 2017). This process is called 'mining' and requires great computational power, which in turn requires massive amounts of energy, consuming more power than the whole of the Netherlands, United Arab Emirates and Argentina combined (Gonzalez, 2021). According to Cambridge researchers, Bitcoin mining costs around 121.36 terawatt-hours (TWh) annually and is not expected to decrease unless the cryptocurrency's relative value does so too (Criddle, 2021).

Nodes in the network receive rewards for confirming transactions and storing copies and participation in building new blocks in the chain (Newman, 2021). New blocks are assigned to specific 'hashes', mathematical algorithms that have converted data to a fixed length string of text that is unique and can only be issued once (CrossTower, 2020) The first-ever block in the blockchain is called the 'genesis block' and has a hash value (Nofer et al., 2017). Other transactions and blocks have been created since, and for every one of them, a random hash has been generated based on the current position in the entire blockchain (Nofer et al., 2017). Therefore, if a hash would be changed, this would automatically alter every other hash in the blockchain (Nofer et al., 2017). This is prevented through a consensus mechanism. In this consensus, a majority of nodes in the blockchain network must agree

on the validity of the change or addition in hashes or blocks, and only after that has happened can an addition to the chain of blocks be made (Nofer et al., 2017).

However, while Bitcoin is one of the most significant users of the blockchain principle, its applicability extends much further than that (Williams, 2018). The essential and critical element of any blockchain is that there is a double verification in every step, which cannot be altered (Nakamoto, 2008). Also, because blockchain is based on Distributed Ledger Technology (DLT), some of the advantages over regular 'centralized' systems extend far beyond staying online when one node in the network breaks down, for this reason, it increases trust in people since the 'bank' is still open while the facility may be closed (Nofer et al., 2017).

The absence of third parties in the blockchain, such as central banks or authorities, decreases the risk of data theft or loss but poses a risk for cryptocurrency such as Bitcoin because a sudden value loss can occur due to the freedom and volatility of cryptocurrencies (Nofer et al., 2017). A bank keeps a person's data on file, making it possible to request a replacement card as soon as it is lost; personal Bitcoins become inaccessible once the private key to the online wallet is lost (Barber et al., 2012). Other weaknesses of this system include malware taking over computers and possibly shutting down the network, to scalability issues such as delays in confirmations, and more, as Barber et al. (2012) highlighted.

Looking at other sectors where blockchain is used, it is important to note that sometimes smart contracts are used to innovate a process (IBM, 2021). Smart contracts are programs that start to run once certain conditions are applicable, used mainly in workflows to trigger the following action or agree on terms and conditions to avoid losing time (IBM, 2021). Smart contracts can also be helpful in the housing market through increased transparency. Likewise, in the automotive industry, smart contracts can improve security for car-sharing technologies and insurance based on the use of the car (Gadam, 2018). In the next section, an analysis of food traceability is given, with an in-depth analysis of today's food traceability methods.

1.2.2. Food Traceability

Food traceability is the ability for consumers to track the origin of the food product that they are consuming. According to Olsen and Borit (2013), traceability is 'The ability to access any or all information regarding that which is under consideration, throughout its entire life cycle, using recorded identifications' (Badia-Melis et al., 2015). Traceability in food can also be described as 'the ability to maintain a credible custody of identification for animals or animal products through various steps within the food chain from the farm to the retailer' (McKean, 2001). For some consumers, traceability in food products might be as simple as looking at the label to find the origin country of that product. In contrast, others want to know what happened to that product in the production stage, how it was shipped, how long it took, and how many days the product has been at the distribution center or on the retailers' shelves (McKean, 2001).

Current traceability systems are unable to link the different food chain records and have inaccuracies and errors in existing records, which make it harder to obtain the essential data on time (Badia-Melis et al., 2015). These factors are critical in case of a food disease outbreak. Without the correct data present at the right time, it becomes challenging to identify which products are affected and that may pose a risk to consumer health and, if applicable, what batch of products is still safe for consumption (Badia-Melis et al., 2015). In short, traceability for consumers has different priorities than traceability is to producers of food products, who always need to ensure the quality and safety of their product meets the regulations (NVWA, 2018). In the next section, it is explained why a food traceability system is vital to consumers.

1.2.3. Importance of Food Traceability to consumers

A traceability system for food products where information is available to consumers is, according to Matzembacher et al. (2018), 'a solution to communicate safety practices' (Matzembacher et al., 2018). At the same time, consumer trust is increased if the company's or brand's communication is consistent and honest (Matzembacher et al., 2018). This includes food safety and an essential element where consumers pay increased attention to looking at ingredients and nutritional values in the product (Matzembacher et al., 2018). Genetically Modified Organisms (GMOs), additives, chemicals, and animal welfare are of greater importance to consumers nowadays (Matzembacher et al., 2018). With new technologies in food systems, retrieving this information has become harder, and 'separated the proximity with food producers, processors, plus it added an intense movement about increasing consumers' trust in food products' (Matzembacher et al., 2018). Food scandals have degraded that trust, and therefore traceability systems are critical in providing information about food safety and quality to consumers (Williamson, 2017). Besides the documented journey from farm to fork, location information and the environmental impact of the production of that food product could also be part of the traceability system designed for consumers (Matzembacher et al., 2018).

In the next section, it is explained why a food traceability system is essential to producers. For consumers, a traceability system is important because it provides them a ‘perceived’ benefit of additional product-related information and allows for much faster response times in food safety incidents, which helps to keep consumer level of trust in the product, company, or industry as a whole, high (Matzembacher et al., 2018). In the Netherlands, producers themselves are responsible for the food product's safety and are thus accountable in case of an incident, in compliance with EU regulations stipulating the brand owner is regarded ‘the food business operator’ and having to take appropriate action in case of an incident (FSA, 2007).

1.2.4. Importance of Food Traceability to producers

Traceability in the food system has become more important over the past few years. When a food product is traceable, it is possible to see where the product has been at any stage in the supply chain (Williamson, 2017). Around the 1980s, there were concerns about the safety and quality of food on consumer- and governmental levels (McKean, 2001). During that time, traceability systems were subdivided into four categories: country of origin, retail, processor, and farm-to-retail identity (McKean, 2001).

Over the years, traceability has become even more important and has already proved beneficial for several reasons, including continuous improvement, and maintaining efficiency without lots of waste in internal processes (Forcam, 2020). An innovation comes in the form of a distributed, decentralized ledger with tracing in every step of the product that will open a new dimension of product tracking for consumers resulting in more transparency from manufacturers to retailers (Forcam, 2020). As it happens, distributed ledger technology is the basis of blockchain and is therefore a basic but crucial element when companies want to implement blockchain in supply chains for added transparency (Nofer et al., 2017).

According to a study done in the Dutch Fish industry, only 30% of survey participants planned to integrate blockchain traceability in the next 5 years (Mors, 2020). However, over 50% believed that blockchain traceability ‘would eventually be widely adopted in the industry’ (Mors, 2020). When looking at the entire food industry, this would mean that in 5 years nearly all food products would be traceable through a blockchain. This would be a great achievement, as the study highlighted that although a few participants are using only digital traceability solutions, none is working with blockchain yet (Mors, 2020).

Several traceability components are important to producers, such as the physical location of a product anywhere in the chain (Ene, 2013). Knowing the location of a product important from a logistical point of view, in case of a recall a food producer or distributor must always know where the

affected products are, as also mentioned before (Ene, 2013). Furthermore, in a more digitalized ledger, producers need to know the conditions of different batches matched with ingredients that may differ slightly within the legal limits (Ene, 2013). Finally, it is important to realize that although the added data is useful, it does not mean anything until a system such as a blockchain is able to process the bits of data together for a comprehensive results (Ene, 2013).

Additional information capable of being stored in a blockchain and shared with consumers is something that is possible but costs the company a lot of money, which must come from somewhere. According to several studies, many consumers wanted more comprehensive information without the additional costs passed to them (Füzesi et al., 2020). Additional barriers are mentioned in the next section of this paper.

1.2.5. Barriers to Blockchain implementation

Besides positive effects on a traceability system, which include effective tracing of every food product (batch) from production to consumption as mentioned before, the implementation of a traceability system also comes with barriers. According to Biswas & Gupta (2019), the huge potential blockchain has for industries is most held back due to 'challenges in scalability and market-based risks' (Biswas & Gupta, 2019).

A literature review conducted by Vu et al. (2021) highlighted several other important barriers to adoption of blockchain in food supply chains, both internally and externally. A previously mentioned barrier is the high costs of implementation (Vu et al., 2021). Companies who want to switch to a blockchain system have to pay to keep using their existing system, and at the same time spend money for development of something new. However, this is not the root cause of the barrier, that is the complexity of blockchain and the possible requirement of a hired specialist for a perfect implementation (Vu et al., 2021). Firms with large financial resources are able to take on the project, but the implementation of a new system does not just effect retailers, it effects farmers and distributors too, which may not have the money for the project due to their low margins (Vu et al., 2021).

Another worry of retailers and a barrier to the implementation of a blockchain traceability system according to Sander et al. (2018) is privacy concerns (Sander et al., 2018, as cited in Vu et al., 2021). Information about prices and other competition-related data, even though being encrypted, is still easily retraceable to one specific producer (Zhao et al., 2019).

The literature review also identified barriers in the supply chain environment. For example, it is unclear whether the entire supply chain is ready for the switch to a blockchain system (Vu et al., 2021). If some of the entities in the supply chain decide not to join, results from sharing information are severely less usable and could make even more others hesitate to invest resources in this too (Vu et al., 2021). The risk of incorrect data entry is valued a high barrier too, because once faulty data is entered and confirmed in the blockchain, there is no going back or adjusting anything thanks to the immutability principle (Vu et al., 2021).

Finally, the scalability of the blockchain network is at risk when a lot of users try to get consensus on transactions and latencies start showing up, delaying the process of acceptance if the system is even adopted at all (Vu et al., 2021).

1.2.6. Benefits for consumers

The global scale of food supply chains creates serious opportunities for committing food fraud and for distribution of unsafe food through the chain (Pearson et al., 2019). Food fraud is 'an intentional act for economic gain', meaning the motivation for committing food fraud by counterfeiting or adulterating food products is purely sought for financial benefit with a public health risk as a

consequence (Spink & Moyer, 2011). Unsafe food on the other hand means that there has been exposure to bacteria or dirt, causing possible infections or diseases which can be life-threatening to people (FAO, n.d.).

According to the World Health Organization (WHO), approximately 420,000 annual deaths can be attributed to foodborne illnesses caused by 31 global food safety hazards, such as diarrheal diseases, salmonella, and hepatitis A (World Health Organization, 2015). Suppose the consumer is more aware of where a food product has been before purchasing it. In that case, the task of finding out whether there are any risks can be completed by checking the information stored on the ledger of the producer or retailer which is retrievable through multiple ways. It can be done with a QR-code as previously defined, or with a Radio Frequency Identification (RFID) tag. This tag works with radio waves to transfer data bits that can end up in a ledger for tracking inventory and assets purposes, including a blockchain ledger (AB&R, 2021).

Consumers can start to benefit from a blockchain traceability system once the retailer has implemented it. An interesting approach is described by Harvey et al. (2018), where marketing is used much more to attract consumers to interact with data on the blockchain, for example for extra promotions or small rewards (Harvey et al., 2018). This marketing can also include extra information about specific products and answer questions such as why the price of a product has gone up while another one went down. Marketing can also be used to deliver a personal message or price, if this is based on the buying behavior the blockchain could also start to suggest more sustainable products where farm workers are paid a fair wage, or something else the consumer is interested in (Harvey et al., 2018).

So far, there has been little research in finding out whether consumers want to pay more for products with blockchain tracing included. Still, a Chinese study found consumers more willing to pay a premium for products that have enhanced food safety information (Hou et al., 2019). This information includes supply chain traceability, a sound quality management system, and internal traceability for more control for the consumer and products that were bought (Hou et al., 2019).

In a research article that, at the time of writing, was over 20 years old, there was already a clear idea on consumer expectations regarding the traceability of products (McKean, 2001). Expectations that no matter the product's origin, it must comply with quality and safety standards (McKean, 2001). Ultimately, the consumer decides whether to buy the product (McKean, 2001). Commercial success for a retailer comes from meeting consumer expectations and eventually influencing consumers' buying behavior by the built-up collection of trust from safe products (McKean, 2001).

As mentioned above, it is not clear whether just blockchain technology has an extra effect on consumers' buying behavior. It is possible that when consumers see a QR-code or more information on the price cards about where their food comes from, they are more willing to buy those products. The range of suitable products to have enhanced (blockchain) tracing is hypothetically immense. It ranges from cocoa products to meat products, fresh salads and much more. For these products, traceability information on a blockchain could help consumers make a more environmentally friendly decisions by buying local instead of from the other side of the world to reduce CO2 emissions. Other parameters can also be monitored but depend on what information the consumer wants.

An example is meat products in the Netherlands which have a label from the Dierenbescherming (Dutch Society for the Protection of Animals) (Dierenbescherming, 2021). The 'Beter Leven' or Better Life label ranks these products on a scale of 1-3 based on factors influencing animal welfare, such as amount of free walking space, transport conditions, and use of types of animal feed (Dierenbescherming, 2021). This label has good accreditation and is monitored well; however, the only way to see 'proof' of the compliant product is with a sticker on the packaging (Dierenbescherming, 2021). Of course, potentially fraudulent companies could place a sticker on any

package to mislead consumers, but one look in a blockchain ledger would the true origin of the product and what certificates were obtained.

1.3. Research question

In short, this research paper hopes to close the knowledge gap of whether there is an advantage for consumers when products in the supermarket or any other point of sale are traceable through a blockchain with its integrated Distributed Ledger Technology (DLT). This blockchain traceability system allows for an increase in transparency throughout the food chain, and because it uses the principles of a blockchain correctly, consumers can access the real information. Therefore, the main question of this paper is: '*How can a blockchain food traceability system increase (perceived) transparency for consumers in the food supply chain?*'

Together with the main question, the following sub-questions (SQ) will be answered:

SQ1. What is blockchain?
SQ2. What is food traceability?
SQ3. Why is a food traceability system important to consumers?
SQ4. Why is a food traceability system important to producers?
SQ5. What are possible barriers to a (blockchain) traceability system?
SQ6. How will consumers profit from a blockchain food traceability system?

These questions will be answered using research objectives derived from research and from conducting a minor focus group discussion. The main objective of this paper is to find out what products are fit for being equipped with a blockchain traceability system that has more transparency for the consumer. This objective will be achieved through experts' opinions in the minor focus group discussion.

However, because this main objective has a large scope, a twofold breakdown is provided below:

Objective 1: Identify a list with max. ten products that are fit best for a blockchain traceability system with maximum transparency to consumers. This will be realized by asking the experts questions about what they think are the best options during the focus group discussion.

Objective 2: Analyze whether current (blockchain) traceability systems and online portals for consumers are easy to understand and use. This will be measured by conducting a small search before the focus group discussion and taking note of the website(s) to discuss this with experts. Ultimately the best experience is where the consumer can spot where the product comes from and where it has been in as few clicks as possible. For example, a popular but unofficial '3-click' rule mentions that a webpage or information page should be accessible in not more than three clicks. While this is not supported by scientific evidence, it is still important to pay attention to the interactions on a page and identify a thumb rule (Laubheimer, 2019).

2. Methodology

In line with the objective for this research laid out in the previous section of this paper, the main aim for this research was to collect experts' opinions about if and how a blockchain traceability system can provide benefits for the consumer in a food supply chain. This data was collected through a mini focus group discussion consisting of industry and educational experts in the food, supply chain, and blockchain sectors.

2.1. Research design

A mini focus group discussion and a 'regular' focus group discussion are similar to each other, but the number of participants is smaller in a mini focus group discussion, up to five, compared to six and more in the regular focus group (Fauvelle, 2021). Because these research methods serve a similar purpose and only differ in size, further mentioning of mini focus group in only this part of the paper is referred to as 'focus group', in other sections a reference to a mini focus group is used.

A focus group discussion (FGD) is a qualitative data collection approach widely used in conservation research (Ochieng et al., 2018). It is not only a cost-effective and promising alternative in participatory research as laid out by Morgan (1996, as cited in Ochieng et al., 2018). The FGD also emerged as a 'qualitative data collection approach and a bridging strategy for scientific research and local knowledge' (Cornwall & Jewkes, 1995, as cited in Ochieng et al., 2018). Simply put, this research method has been in use since the 1940s but has expanded in education, communication, media studies, and marketing research (Ochieng et al., 2018). In a focus group, it is essential to realize that the researcher adopts the role of moderator instead of being an investigator and asking questions to a single person (Ochieng et al., 2018). Therefore, most data will be gathered in the FGD when the experts have room for discussion instead of answering questions from the moderator (Ochieng et al., 2018).

According to Morgan et al. (1998), four major steps make up a good focus group discussion; the first step is research design, where the study's objective is defined, together with the recruitment of participants and selection of location (Morgan et al., 1998). In this paper, the site will be in an online Zoom® meeting room due to governmental restrictions on group gatherings regarding the COVID-19 pandemic. The online meeting posed a serious challenge because a typical, in-person focus group discussion facilitates broad discussion (Halliday, in press). It is uncertain what effect a digital meeting room will have on the debate between group participants (Halliday, in press). The recruitment of possible participants for this paper's focus group discussion will be done through social media platforms such as Facebook®, Twitter®, LinkedIn®, and through email with direct contacts at the researcher's disposal.

The second step in any focus group discussion, outlined by Morgan et al. (1998), is data collection, which includes preparation before the focus group session (Morgan et al., 1998). In case of an online meeting, preparation consists of testing equipment for all participants and making sure the recording software works to avoid precious data being lost in the process (Halliday, in press). Finally, during the focus group discussion, it is crucial to keep track of the questions that need to be asked to keep the conversation going (Krueger, 1994, as cited in Ochieng et al., 2018). While usually an assistant would be best to keep track of non-verbal communications, in an online environment this is less applicable as the recording can be replayed to focus on specific aspects of communication and retrieve details originally missed (Halliday, in press).

Non-verbal communication actively contributes to the interpretations of the verbal data and will be analyzed as much as possible in the online environment; however, only two out of four non-verbal communication means described by Gorden (1987) can be examined: the kinesics or behavior reflected by body displacements and postures, and paralinguistic variations (volume, pitch and possibly quality of voice) (Gorden, 1987). The other non-verbal data sources are harder to analyze.

This is because the focus group is held in an online environment where only the front- or angled-facing camera provides a picture of the participants. Nevertheless, the amount of time reserved for this paper's focus group discussion is not more than 90 minutes and possibly less due to possible fatigue of participants caused by constantly staring at a monitor screen. Blockchain technology is widely applicable for many possibilities in the food sector and beyond, in the end, there might be areas or industries that are left unexplored but very much viable of being kicked into life.

The third step in the methodology thought out by Morgan et al. (1998) is the analysis; in the case of this particular focus group, qualitative analysis techniques that can be used to analyze focus group data against theory analysis, content analysis, and more analytic techniques recommended by Morgan (1997) since these 'afford the researcher an opportunity to obtain both qualitative and quantitative information' (Morgan, 1997). This opportunity is described by a framework that starts with data coding. This is an important step that begins with listing ideas, identifying keywords often used by participants, thus being called 'initial coding' (Charmaz, 2006, as cited in Ochieng et al., 2018). The next stage in coding is 'focused coding', where information from the initial code is further divided or combined to broader ideas or themes. Because this is a technique used primarily on comparison for studies with multiple focus groups, this step of coding is applied only if the initial phase has left too many relationships between ideas (Charmaz, 2006, as cited in Ochieng et al., 2018). Krippendorff (2013) described that 'ethnographic analysis' can be helpful in some instances to deeper interpret specific themes directly mentioned by focus group participants (Krippendorff, 2013). Since this technique identifies as being 'strictly qualitative', it will be used in this research paper to conduct a deeper content analysis of the coding results.

The fourth and final step in the focus group methodology, as described by Morgan et al. (1998), comes after analysis of all gathered data and is made to 'meet the needs of the target audience' in a narrative or pointwise format (Morgan et al., 1998). Before release, all results should be checked and confirmed with focus group participants to validate whether the participant, in their experience, is happy with the accuracy presented in the paper (Doyle, 2007). This will be done via email or the original way the participants were asked to join the focus group discussion, which at the same time ensures the privacy of participants, should they wish not to be associated directly with this paper's research.

According to Ochieng et al. (2018), there are several different focus group discussions, such as a single or two-way focus group, and a dual- and dueling moderator focus group, and a mini focus group (Ochieng et al., 2018). Even before the COVID-19 pandemic, online focus groups were mentioned, but as that also focused on the barriers such as poor connectivity or, as stated above, failure to capture non-verbal communication, it was and still is one of the less-preferred options due to these flaws (Halliday, in press).

In short, as options for an in-person focus group discussion were limited at the time of writing, an online mini focus group was the only feasible option to conduct research. A positive note to this is that according to Halliday (in press), dropout rates decrease dramatically in online (mini) focus groups, meaning fewer extra participants must be contacted in case one of the original participants cannot make the meeting time (Halliday, in press). Also, the participants will be informed before the online mini focus group session that they will be recorded for research purposes only. After the discussion ends, the recording and notes will also be stored securely on a password-protected hard drive. Finally, to overcome technical difficulties and keeping to Halliday's (in press) guidance, focus group participants were sent a short, user-friendly manual on how to use Zoom® software, combined with the moderator being available for any questions (Halliday, in press).

2.2. Expectations

During the focus group discussion, it was expected that the experts participating in the discussion had enough opportunities throughout the meeting to propose specific ideas that help to answer the sub-questions and ultimately the main question in this research, defined earlier. In the session, thoughts from one expert can be debated by other experts to see whether the suggestion would be good after all. Some ideas, views, or opinions hopefully focus on the food industry's main question and blockchain technology. Whether consumers would trust such a system and adopt it in their buying behavior is unknown but essential to implementing such systems. After analyzing the literature review, it became clear that this research is a relatively new topic. The more recent technological advancements stress that experts are the best people to be asking these questions to form the most objective statements and expectations through their professional experience in the relevant sectors. To help in this, the conversations in this focus group were coded and organized in different steps to identify specific popular categories and other areas of importance. Ultimately, these findings were expected to be sufficient to conclude and answer the main question of this paper.

3. Results

During the mini focus group session in June 2021, participants shared their views on different aspects of the research and research questions regarding blockchain and food traceability. In this part, the discussed topics and questions are highlighted, shortly introduced and the response is shown just as in the mini focus group*.

Quotes from the meeting were obtained from the transcript, of which a full version is attached as *Appendix 1.* To maintain participants' anonymity, they are identified with a number ranging from 1-4. In the table below the expertise of the participants is listed:

Table 1: Participant overview focus group discussion

#	Expertise
1	Supply Chain, Quality Management, Business
2	Food Quality Management & Food Ingredients
3	Blockchain Implementation Specialist
4	Food Safety & Circular Food Supply Chains

After a short general introduction where the expertise was mentioned to the other participants, the moderator of the mini focus group went over the code of conduct expected during the session. The session was scheduled to take place on a Friday afternoon, and due to other limitations, the intention was to finish the mini focus group session in 60 minutes. This resulted in an interesting and energized session as every participant was eager to use the precious time to share their opinions. The questions of the focus group were aimed at different areas of the research questions, split between blockchain at one end, and food and traceability at the other. In this section and as mentioned above, the different topics and questions that fit together are shown below.

Topic 1: Importance of traceability in food supply chains.

This was the first topic discussed in the mini focus group. The house rules of the discussion were discussed right before, so participants knew what was expected from them and allowed them to speak up about any topic. The first question was aimed at the food and business experts who have a lot of experience working at different food industry companies.

Q1: Why is or is it not important to have traceability in food supply chains?

This question was asked to find out if traceability affects every consumer who buys food products at any point of sale and to see if the participants had anything to add to that. Speaker 1 was the first and only one to answer this question, every other participant stayed silent upon additional questioning. The following was said:

Speaker 1: "OK, well the from a food safety perspective it is crucial to have traceability. Because our food chains are complex, but even in a simple one, if something goes wrong, it's easier to find the source and make sure that you can remove the product. And if you have the information from a food fraud perspective, again, identifying where things can go wrong. Traceability is crucial. That's from the food safety and the legal perspective, yes, otherwise you don't have any other tools to ensure consumer safety."

Speaker 1 mentions possible unsafe food as a crucial factor for having traceability information available. Not just from a food safety perspective, but also from a food fraud perspective. This code is put on a list and together with other codes counted during the mini focus group session.

*The responses from the participants are derived from the recording of the mini focus group. Due to use of automated transcript software inaccuracies in spelling or grammar can show up in the response section. Many errors were resolved but only when this did not alter the meaning of the input from the expert, otherwise it was left in. These inaccuracies may also be present in the full transcript.

Topic 2: Steps taken by (food) industry for more traceability

To see what the experts knew about achievements in terms of traceability in food supply chains, the following question was asked where, again, only Speaker 1 commented on.

Q2: Has the food industry already taken steps to increase traceability in supply chains?

Speaker 1: "Well, in general I think the GFSI level standards are increasing the effectiveness or the pressure on the actors of the food industry to have as accurate traceability system as effective as possible. That's the private law of the food industry itself. And as that pressure comes mostly from retailers, by the way, because GFSI standards are owned by retailers at the end of the day. And then the technology is catching up with it as well."

According to the Safe Food Alliance, the GFSI or Global Food Safety Initiative is a 'business-driven initiative for the development of food safety management systems to ensure food facilities are processing safe food for consumers' (Safe Food Alliance, n.d.). GFSI level standards include SQF2000 (Safe Quality Food), FSSC22000 (Food Safety Management system), BRC (British Retail Consortium Global Standard for Food Safety), IFS (International Featured Standard – Food) and Global GAP (Good Agricultural Practices) (Sansawat & Muliyil, 2011).

Speaker 1 highlighted the increased effectiveness of traceability systems who are using GFSI standards. It is true that GFSI itself is run by the Consumer Goods Forum, who consist of 400 retailers, manufacturers, service providers and others from 70 countries (The Consumer Goods Forum, 2021). The day-to-day operations of the GFSI coalition brings 38 retailers and manufacturers together from all over the world (GFSI, 2021).

The next question falls under the same topic but is focused on other industries that might have adopted traceability or blockchain in a way already. Speaker 3, expert in blockchain, among other things, had the main answer to this question which is shown below.

Q3: Are there other industries that have implemented traceability or blockchain?

Speaker 3: "In in the financial industry we see a lot of applications of blockchain. For example, in trade finance value chains or in logistics value chains where a lot of financial processes are intertwined with the operational processes. And mostly the goal is very similar, it's coming from a quality assurance perspective. It's coming from a risk management perspective and the focus is to have more control over the quality of the product that goes through a value chain and that is. Often mitigating problems of trust where a lot of participants along the value chain have small roles in the process, as at large and are very difficult to trust because there is this geographical distance. But there's also a regulatory distance because all these organizations often operate in different jurisdictions with very different cultures in regards to quality assurance and risk management. And it's very hard to, for example, ensure these transfers or transportations, and to gain more. High-quality data on these processes. Blockchain may help within these projects, but there's a there's not a lot of practical application. It's still in the exploratory phase where proofs of concepts are being built and there's no definitive implementation, as far as I know yet, only at a small scale."

Speaker 3 mentions that the financial industry sees a lot of blockchain applications. The goal of this implementation of blockchain is highlighted to be coming from a quality assurance perspective. This approach is also realized according to Speaker 3 for 'mitigating problems of trust'. These problems arise on regulatory and geographical level. Transporting high-quality data is difficult, and although blockchain can assist in this process, the project is still in an exploratory phase with small scale concepts.

The next question was in response to the answer given by Speaker 3 above. This was done to identify if small scale concept versions of blockchains in the food industry would include free and open access of data to consumers.

Q4: Do these small-scale trials or concepts include free and open access for consumers?

Speaker 2: "If I may answer on that one, I would say. No, but I was. I was in the food ingredients as you know for more than 15 years, selling stabilizers, texturizers, emulsifiers & taste enhancers. That is something the consumer doesn't understand. Not at all, so. How to explain using an antioxidant? Or a coloring agent. For example, even in bread or in red meat products. If you tell consumers, for example, there will be a phosphate in a meat source and they start crying 'oh, this is a chemical product' but you need to have a phosphate to stabilize the proteins otherwise the pH. The acid degree. And you can never eat your meat, but how to explain this? That's far too difficult. So if you give an access to consumers to the data, I think that will be awful."

Speaker 3: "I really recognize what is being said here. I always approach blockchain implementation on a per case basis. We're now talking about this very broad idea of transparency in the food supply chain. But what do you want to make transparent? Is it about ingredients? Is it about the type of processing being done? We can't make everything transparent. As (Speaker 2) says you cause a lot of confusion and the excess amount of data that you will produce will not help anybody"

For the first time during the mini focus group session, two experts discussed with each other about a question. Speaker 2 mentions that a consumer does not understand why antioxidants or coloring agents are used in products. Many food additives are present in products without the consumer knowing it, such as stabilizers in meat products for optimized texture and juiciness (Hills, 2009). Consumers are not aware of additives present in their food nowadays, which is a focus point for Speaker 2. Speaker 3 reacts that the idea of transparency is broad and that boundaries of what to make transparent must be known to reduce confusion and the excess amount of data produced.

Topic 3: Interests and awareness of food under consumers

According to the mini focus group experts, to determine if consumers are interested in certain facts about the food product such as logistics or origin of food, the following questions were asked to obtain a possible answer.

An example used was a fresh product in a supermarket. In the Netherlands, using the term 'fresh product' is allowed for many products as it is only slightly protected by the Dutch commodity law (Voedingscentrum, n.d.). In this question, a fast-moving product was meant to stay in the supermarket for a very short time without turning bad.

Q5: Would consumers be interested in logistical facts or information about a fresh product in the supermarket?

Speaker 2: "Yeah, but also from your logistic part, uh? Uh, what was the temperature during the transport? Was it above the. Even from quality point of view, it was not allowed and if it was below the four degrees and the quality will. But on the other hand, maybe you have a map packaging, modified atmosphere, packaging in logistics. You have to tell them this. Transport is a cool transport at 4 degrees in a modified atmosphere. Packaging map packaging consumers doesn't understand. Again, this is such a difficult thing using blockchain using data from maybe your processing site of fuel. Uh. On one side, you want to be transparent, but on the commercial part you don't want to be transparent."

Speaker 2 identifies a potential issue for every innovation dreamt up by the industry, from Modified Air Packaging (MAP) to cooled transport for keeping products as short in the food chain as possible. Blockchain is difficult to use due to the large amount of data saved in the ledger. According to Speaker 2, 'you want to be transparent, but you don't want to be transparent on the commercial part.

Because Speaker 2 mentioned that consumers are often not aware of what is in their food products, and because according to research done in the United Kingdom suggesting 80% of consumers check the origin of their food, this was asked in the following question (Elementar, 2017).

Q6: Have consumers become more aware or concerned about the origins of their food?

Speaker 4: "I think we're seeing a growing development in the conscious consumer. Come in an awareness on country of origin. In an awareness of sourcing and factory location, an awareness of sustainability met. Tricks?

So much so that we're actually seeing now different domains of sustainability measurements on a package because a consumer is being more conscious about that. In the example of your fresh product, utilizing blockchain can have so many different outputs and it depends on what they want to see. So even if we think about logistics and you have the conscious consumer who is. More concerned about food miles and about greenhouse gas emissions, then that is the kind of information that they will be looking for. Yeah, so I think in the end the application is based on really what you want to achieve when you provide that decentralized ledger for access. In my experience that only goes as far as the level of the food broker or. Your B2B consumer, not your end customer."

Speaker 4 comes back to an earlier discussion point on what Speaker 3 noticed about what information should be listed in the (blockchain) traceability system. Speaker 4 mentions that using blockchain can have so many different outputs it depends on what consumers want to see, from food miles to greenhouse gas emissions. What the individual consumer wants can be visible in a blockchain and depends on the consumer itself, mostly reserved to the level of food broker or B2B customer, not the end consumer.

A follow-up question was asked next about whether the information that should be limited to only the food broker or B2B customer according to Speaker 4, would only be accessible for internal process and improvement of the processes. Speaker 1 and 3 reacted to this question.

Speaker 1: ''Keep that in mind that, uh, as. Is everybody said here before like the consumer doesn't really know what they want to know and I always. Argue that if the if the sustainable conscious. The consumers don't know what is sustainable because we don't know what is sustainable either yet, but that's a manager's job to find out in his PhD. By the way, uhm, I think blockchain is amazing from a regulatory point of view and within the industry and there is no like. It's not a coincidence that the finance industry started adopting it. Most rapidly because they are under the most community food industry is different, is perishable goods, not legislations, are still very young. Here in this in our food industry, consumers don't understand how the food industry works. They don't know anything about the products. They are too far from it, uhm? So. I think it's a. In that stage we are at the stage where you first have to figure out what kind of information the customer needs and can consume as well. So what can be provided about the food chain? I like the logistic idea. For example, footprint is always. Very fancy like you. You can go with that, but other. That we wouldn't touch anything else.''

Speaker 3: ''Yeah I would like to add to that because I totally agree. Uh, I think it's key to have a, uh. A tangible problem that you're trying to solve in the 1st place, uh, that needs to be more focused than the broad term of transparency in my opinion. And. If you want to use blockchain, you're not, you can't be sure about that from the get go, but if you want to use it, you should be really conscious about what a blockchain is for. It's not for anything related to data because it is not a very good database. It is an awfully bad database and databases. We have mean are going around since the 70s. We're pretty good at databases, so if your problem is data related you probably don't need a blockchain. The only reason that you. Could consider using a blockchain if you have a governance problem. Because the only real advantage of using blockchain is found in governance solutions. Not in data solution, not in transparency solutions. Of course there are some minor advantages to be found with blockchain technology in terms of transparency or some anonymity feature. There's, but there are. Better ways to achieve those goals. You don't need blockchain for that. If you want to use blockchain you should have a problem in the government space and then the. The first question you could ask is it a governance problem that is affecting? Retail industry is it affecting other parts of the value chain or is it actually affecting customers? If it is affecting the end customer and you want to solve the governance issue then a blockchain could be implemented and needed. But then, of course, if you want to solve a problem for the end consumer, that will also entail that the end user is becoming part of this network and a part of this solution, and that will. And undoubtedly put a lot of responsibility at the end of the end consumer. So I think using blockchain could be very interesting and could be very. Nice to have. Uh, but you should be aware that the only problem that you can solve is a trust issue related to governance issues.''

The two speakers identified that before information can be stored on a blockchain for a food product, it must first be identified what the needs of the consumers are to avoid having too much information in the immutable chain. To add to that, Speaker 3 mentions that blockchain overall is a bad database and should only be used for governance problems. In that case, if the governance is affecting the retail industry or other parts of the value chain, a blockchain could be used.

Topic 4: Governance, technology, and product examples

This topic continues where the previous stopped, at a possible governance issue for the retailer. It is important to know what a blockchain can do to make information in the supply chain more accessible to the consumer. Therefore, the first question in this topic has to do with what adaptation of technology equipment could make that there is more accessibility for consumers.

Q7: If a retailer has a governance issue, could technology adaptation such as blockchain make it more accessible to the consumer?

Speaker 4: "It's highly dependent on the boundary conditions that you want to look at and as much time right we said. In any food process industry, you can look at the business itself. You can look at supply chain processes. You can look at regulation. You can look at quality assurance and then you can also come down to look at traceability. All these are domains that you can enforce transparency. And each tool. Has certain parameters that may or may not work when you want to apply it. If you have a representative case study with a well defined boundary condition, then you can start looking at what are the options and how do you integrate blockchain technology or not. So it's not so easy and, uh, an answer to give, because there are no domains to work with them. It depends on what they're looking at, right? So if someone wants to have fair wages, then that's where you design the blockchain for and they go. They have access to it because they want to know right down at the ground level how much you're paying the producer, how much you're paying the workers. What is the effect of working conditions on the workers? What is your middleman getting? What is your retailer getting? Because that's all they're interested in. Is fair wages, so I think a consumer with an objective in mind, if given the right framework. Can be able to use it, but remember I think as we've all said, the end consumer. It's probably not the right person to access the information.''

Speaker 4 comes back to the point where boundary conditions are important to determine the scope of the soon-to-be-implemented blockchain. For the end consumer, this can vary depending on the priorities of the individual consumer. Ranging from gaining insight in the wages paid to workers on the plantations, to what share of the payment ends up at the retailer or point of sale after all. Speaker 3 added that the offer to consumer depends on whether the blockchain is part of the product itself, or put in own words:

Speaker 3: ''And it also depends if your blockchain solution is a part of the product itself. So if you're implementing a broad scale network of trusted party that are enforced using blockchain technology and are therefore better trusted and that is for example part of a specific brand or identity or logo that you put on the product and that's something that directly interacts with the end consumer. That's completely different than an implementation where basically the blockchain is invisible for the end consumer and the trust is being. Monetized by the retail aspects of the value chain.''

Speaker 3 highlights a very important split in use of blockchain. The first is where it is actively monitored and marketed as a Unique Selling Point for the retailer, so it can attract more consumers based on the marketing alone, whereas the other type of use is less visible for the end consumer but at least as important to keep track of products moving through the supply chain. Speaker 3 puts it as 'trust being monetized by the retail aspects of the value chain', which is different from the visible, marketed blockchain where trust needs to build at the level of the consumer.

To get an answer to one of the previously defined objectives of what products are best suited for implementation with blockchain technology, the following final question for this mini focus group was asked to the participants:

Q8: What are products that might be suitable for an easily traceable blockchain initiative?

Speaker 3: ''From my experience the focus right now is on products that have a lot of turnover, so that are very cheap to produce and can be sold very expensive. For example, coffee or cacao for chocolate, in combination with industries where a lot of things go wrong. For example, child labor or for example a lot of fake products or difficulties in in the transparency of the food supply chain, but it right now there is no come off the shelf blockchain solution for anything.''

Of the products mentioned by Speaker 3, according to the Dutch Nutrition Center (Voedingscentrum) over 50% of all coffee sold in the Netherlands already has a UTZ certificate which means the product is traceable and farmers in the production country are encouraged to use as little pesticide and fertilizer as possible (Voedingscentrum, n.d.). However, there is no control over the amount of guaranteed extra revenue the farmer gets for the certified batch of coffee (Voedingscentrum, n.d.).

Afterwards, Speaker 2 had a final remark deemed relevant for this section, about blockchain implementation in medical products.

Speaker 2: ''Do you also want to implement blockchain for medical point of view? Because if this is for medical reasons a consumer wants to know if there are allergens in it. A specific type of fats or oil used because of sugar for diabetes, et cetera. Then it's a whole different story. Then you can interact with consumers and involve the consumers, but this is then hopefully done by medical research. And that the consumer gets access to the database given by a specialist, somebody from hospital or anyhow not free to everybody.''

When a retailer chooses to include blockchain on pharmaceutical products, not just stand apart from the competition, but also have greater access and control over the allergen information. This can save lives from impacted consumers if the allergens present are not clearly labelled on the product. According to Speaker 2, this information should remain confidential to whomever is not authorized to retrieve the information in the database. Otherwise known as a need-to-know basis for that information instead of want-to-know that many consumers are like.

Coding chart

The coding process was conducted inductively based on the conversation transcript of the mini focus group. Important words or passages that repeatedly came back in conversations with experts were highlighted and placed in the table below.

Every code point corresponds with a sub-question, and for extra clarity a color has been added which is different for every sub-question. The number or ranking given to the specific code has to do with how many times the code, not the words itself, were mentioned during the mini focus group session. From this table many codes correspond with the fifth sub-question: 'What are possible barriers to a blockchain traceability system?'. An unclear desired area of transparency was mentioned most often, followed by that the consumer 'does not understand'. Although this is not perfect English, what is meant is that the consumer, according to the experts, cannot understand certain parts of the food supply chain. This might seem a lot like consumer confusion, but consumer confusion means the difficulty for consumers to understand the data present in food supply chains, as mentioned by several experts.

Further investigation to the meaning of the assigned numbers and what this entails for the research is discussed in the next part of this paper.

Table 2: Coding results

Sub-question	Code	Topic 1	Topic 2	Topic 3	Topic 4	Total
5	Consumer does not understand		1	3	1	5
5	Unclear desired area of transparency		1	4	1	6
3	Unsafe food	1	1			2
2	Effectiveness of traceability system		2		1	3
1	Goal of blockchain implementation		2	1	1	4
4	Quality assurance		2		1	3
4	Risk management		2			2
1	No open access		1			1
4	Find source of bad product	1				1
6	Consumer does understand			1	1	2
5	Consumer confusion		2	1	1	4
3	Problems of trust					0
5	Exploratory phase		1		1	2
6	Governance problem			2	1	3
6	Insight in industries with problems				1	1
	Total	2	15	12	10	39

Table 3: Total codes per sub-question

1: What is blockchain?	5
2: What is food traceability?	3
3: Why is a food traceability system important to consumers?	2
4: Why is a food traceability system important to producers?	6
5: What are possible barriers to a blockchain traceability system?	17
6: How will consumers profit from a blockchain food traceability system?	7

4. Discussion

This paper started with a complicated research question: *'How can a blockchain food traceability system increase (perceived) transparency for consumers in the food supply chain?'*, broken down into six sub-questions:

1. What is blockchain?
2. What is food traceability?
3. Why is a food traceability system important to consumers?
4. Why is a food traceability system important to producers?
5. What are possible barriers to a (blockchain) traceability system?
6. How will consumers profit from a blockchain food traceability system?

Reflection on research

These questions were first researched through a small systematic literature review to see how many relatable articles were published up to the point of analysis, in this case, in early April 2021. Looking at that and the date of publication of this entire paper, four months have passed in which many articles that are of similar relevance could have been published but not be included with the search results. There was no issue with the research itself, but since such a low number of articles was found to be relevant, the assumption that the food industry was remarkably more interested in blockchain seemed to be incorrect.

After the small systematic literature review, a literature search was conducted to find theory applications to the sub-question in this paper. Information was widely available in scientific databases and on the internet, where many blockchain experts have created their own websites to explain certain topics regarding blockchain.

Originally this paper's research method intended to hold a focus group with up to 8 participants, as described by Central Connecticut State University (n.d.) who mention that the ideal size of a focus group is 8-10 subjects with additional moderators and notetakers, to have a more lively group of people excited to talk about a topic they are interested in (CCSU, n.d.). However, just before the focus group was about to start, two contacts were not able to join anymore, and as a result, only 4 experts were left to participate in the focus group session. According to Fauvelle (2021) a mini focus group serves a similar purpose, with number of participants often being a maximum of four to have more intimacy and openness during the session (Fauvelle, 2021).

Leading the conversation as moderator was difficult for several reasons. First, the setting where the moderator is the one to ask questions instead of having experts ask questions was a somewhat strange experience. Nevertheless, the conversation which started sort of stiff because no expert would answer the first question immediately. After a few questions, every expert said something and was now beginning discussions with each other, based on responses given. To try and retrieve as much information as possible, one or two questions may have been asked out of the context of the research scope, such as a question about EU labelling. Overall though, the conversation generally followed the pre-defined script in an attempt to get opinions on how to answer the research question.

After the mini focus group ended, the coding process was complicated as there was no reference point to look at, so codes had to be thought of depending on the importance as mentioned by the experts in the session. These codes are seen in *Table 2*, and have a number in the column next to the description, indicating how much the code was mentioned in the different topics outlined in the results section. In *Table 3* it is shown which codes connect to the different sub-questions. The connection to the sub-questions is further defined in every sub-question below.

SQ1: What is blockchain?

This direct question was not asked at the mini focus group, after an initial question it was assumed every expert knew what blockchain was and roughly how the system works. According to the experts in the mini focus group, the financial industry has implemented many blockchain applications already, mainly focusing on quality assurance to reduce risk in the chain and have more control over the quality of the product that passes through a value chain. Furthermore, blockchains can open up investments to anyone, facilitating trade in the traditional market (Consultancy.eu, 2021).

Blockchain is a decentralized, distributed ledger based on Distributed Ledger Technology (DLT) (Nakamoto, 2008). This technology allows computers from around the world to be connected simultaneously and to receive an update to a block at virtually the same time (Frankenfield, 2021). The basis of blockchain is also based on this, it depends on the decentralization of the ledger, which is done through the earlier mentioned computers or 'nodes' that are all connected to the network (Frankenfield, 2021).

SQ2: What is food traceability?

The mini focus group session participants identified the importance and urgency of good traceability information for both producers and consumers. This is because food chains are complex and when something goes wrong it is easier to find the source with good traceability information and make sure no more affected products can be consumed. This is also seen from a food safety and legal perspective, because apart from traceability, there are no more tools to ensure consumer safety in the food supply chain.

Food traceability has a lot of different definitions in analyzed studies, but according to YourDictionary (n.d.) traceability is 'the ability to trace (identify and measure) all the stages that led to a particular point in a process that consists of a chain of interrelated events' (YourDictionary, n.d.). This fits quite well with the definition from EFSA where businesses must keep track of where food products are 'one step forwards and one step back in the supply chain' (EC, 2007).

Food manufacturers or producers have often implemented traceability systems where the entire supply chain is visible for maximum control (AgriLinks, 2021). However, before such a system can be implemented, a significant amount of usable data has to be processed (FMI, 2013). Often this is stored in an ERP system, mostly designed for internal use (FMI, 2013).

SQ3: Why is a food traceability system important to consumers?

This question was not literally asked in the mini focus group. Instead, experts reacted to the question of whether consumers woul be interested in logistical facts or information about fresh produce in supermarkets. The experts quickly indicated that even though a food traceability system is made to protect consumers, this information would lead to even more questions, such as the temperature during the transport and why it was lower or higher than usual.

More consumers have become aware of the origins of their foods, experts highlighted in the session but that does not mean that they are all interested in the same information. For example, some want to know more about sustainability and greenhouse gas emissions during transport, others are more interested in the wages of workers at the farms if it concerns a low-income country of origin.

This increased awareness is in line with a study from Williamson (2017), and originates from a degration of trust due to food scandals over the past 20 to 30 years, such as the EU horse meat scandal (Williamson, 2017). However, the most important reason to have a traceability system is to ensure food safety and provide information to consumers (Matzembacher et al., 2018).

SQ4: Why is a food traceability system important to producers?

According to the experts, traceability is important because more retailers are increasing pressure on actors in the food supply chain to get the traceability system as accurate as possible. Also, because

more retailers are relying upon GFSI standards that are implemented almost industry-wide the technology behind the traceability system also innovates at the same time.

The GFSI is indeed a 'business-driven' initiative to develop food safety management systems to ensure 'food facilities are processing safe food for consumers' (Safe Food Alliance, n.d.). The GFSI in turn is run by the Consumer Goods Forum as described earlier, consisting of over 70 countries and 400 food industry companies to work together on improving the effectiveness of a traceability system (The Consumer Goods Forum, 2021).

Another reason why a food traceability system is important to producers is the ingredients of different product batches (Ene, 2013). If the production process is automated, data can show the various ingredients that enter the mix, and in case of errors, either act immediately or make a digital note for the future, to 'know' where to look, shoud something go wrong with the product (Ene, 2013).

SQ5: What are possible barriers to a (blockchain) traceability system?

Before implementing blockchain in a traceability system, parameters need to be defined on which the system can operate. Implementing a blockchain system will not work if there are no parameters or domains of data to work with. This is where the consumer is the negative factor because the 'conscious consumer' will have other expectations from a traceability system than a regular consumer interested in looking at the products. Another aspect mentioned in the mini focus group is that retailers and other providers of blockchain traceability solutions should think hard about allowing end consumer access to the database or not. The suggestion that came back from analyzing the mini focus group transcript revealed that all experts thought it would be a bad idea to share a lot of food data with end consumer, simply because they are not ready for it.

Risks in the scalability and other market-based risks were defined by Biswas & Gupta (2019) mainly due to the huge potential blockchain implementation has (Biswas & Gupta, 2019). Other barriers similar to reactions from the experts are that the entire supply chain must be ready to receive the amount of data processed and transmitted in the blockchain, including the end consumer who is an important final entity in the supply chain (Vu et al., 2021).

Something the experts did not discuss was the likelihood of incorrect data entering the blockchain. Once this happens, the core function of the blockchain is built in a way that does not support a way back (Vu et al., 2021). Therefore, careful attention should be given when entering data in the blockchain to overcome this barrier.

SQ6: How will consumers profit from a blockchain food traceability system?

As described by the mini focus group participants, current small-scale trials are often tested to see whether the organization likes working with a new system, but often does not include free and open access for consumers. The experts mention that this is because consumers cannot understand what extra substances have been present in food products. After all, they do not understand the food industry. This was expressed multiple times in the mini focus group and one of the key codes of the results section in this paper.

For example, Hills (2009) described that stabilizers and phosphates are added to meat products constantly to improve 'texture and juiciness' (Hills, 2009). According to the experts, consumers generally do not know about this but once they find out about it, protests could start, one expert warned. All of this does not help consumers to profit from a food traceability system.

Besides the very little effect from extra transparency the blockchain offers, the consumers, according to the experts, should be broken down into two groups; 'need to know' and 'want to know'. Need to know consumers include people with diabetes, allergies, or other intolerancies that precisely need to know what ingredients are in the product they were about to purchase. This information is

reliable once entered correctly in a blockchain and that is why the experts mentioned this during the mini focus group.

'Want to know' consumers are the 'conscious consumers' who are spread out from consumers who want to know more about the origin of the food product, to the transportation data, or to specific data on workers' wages. Although sharing information would be the goal with blockchain, experts expect that it will do more harm than good to the industry.

Limitations of research method

During this research, the biggest encountered limitation was the low number of participants in the (mini) focus group. Initially more experts would join, but one did not show up at the last minute and another had suddenly made plans at the exact time the meeting time and day were set in everyone's agendas. This was very disappointing but the discussion itself was very interesting and resulted in some interesting changes in the perception of both the average consumer and the food industry. Another limitation was the ability to keep to the line of previously defined questions. On two occasions a follow-up question was asked that was not in the script. However, it turned out that these questions have added a large contribution to the overall data from the mini focus group.

Another limitation was the relatively new topic of this paper, meaning that there were not a lot of literature articles available in the scientific databases. However, there are a lot of blockchain experts around the world who had very useful information on their websites.

The final limitation has been the time of writing and conducting the focus group. Since later deadlines were still available, the writing process was pushed repeatedly, resulting in the focus group only being conducted with only a few days or weeks left in the school year.

Recommendations

For a next (mini) focus group session, taking notes with important or recurring is a good idea so analyzing data later is made more accessible. It is also recommended that the meeting with participants is held in a real office or meeting room, instead of virtual. Although, the response rate might have been reasonable, there is not as much discussion going on as when there are people around a table talking about them. It also becomes much harder to read other body signals such as hand gestures in an online environment, because most camera's only focus on the head and neck, not on the upper body as a whole (Gorden, 1987).

5. Conclusion & recommendation

This research paper aimed to determine whether the consumer would benefit from supply chain and product information laid out in an open blockchain. Through a mini focus group discussion with experts from both the blockchain and food industry, it can be concluded that the average consumer is not ready to receive the enormous amount of data about food products stored in a blockchain.

Only when consumers start becoming aware of the regular practices of the industry and the processes and ingredients present in food products already, then, sharing the information in a blockchain is justified. The mini focus group participants identified this as a critical point in the decision-making process for producers and other providers of food product information. If information is shared too early or without complete knowledge about the supply chain, protests may arise, significantly affecting the entire food sector.

By EU law, food producers and retailers are required to present data, tracing ingredients from food products back in the supply chain. Regulators in countries ensure the quality and safety meet the regulation. Inaccuracies between supply chain systems could cause essential data to be lost in case of a recall. Blockchain is an immutable ledger making it impossible for data to be lost and thus having a safer product for the end consumer.

A food traceability system for consumers is very important for trust in the food product concerned. For example, if bacteria are found in a consumed product it sets off a chain of actions for the involved entities in the supply chain. The mini focus group highlighted that these consumers could use the information in the blockchain to look up information relevant for their searches, such as working conditions or worker compensation, but only after a clear path has been laid out about what specific data is shown to consumers.

Possible barriers to adopting blockchain technology in food supply chains are high introduction costs, complexity of blockchain, privacy of company data, and the question of when one party wants to implement blockchain, others have the financial means to upgrade to this type of system.

Benefits for consumers from a blockchain traceability system are slim.

Sharing the sensitive ingredient information does the industry more harm than good. Consumers need to learn about the internal working methods of the food industry before they can process more data. Because the blockchain is open and accessible to anyone, fraudulent companies are discovered quickly and will dramatically prevent possible public health risks.

Recommendations

Before adopting a blockchain traceability system, the food industry's first recommendation is to carefully consider what data will be shared in the blockchain.

'Is it worth it to have every detail about a food product out in the open?' is the question that a producer must ask before making a decision.

The second recommendation to consumers is that they must understand the data presented to them to fully profit from the added transparency in the blockchain traceability system.

If consumers see the data in the blockchain and do not understand what is going on, this could lead to distrust in the sector and should be avoided to keep (fake) news from spreading quickly on social media (Dizikes, 2018).

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Appendix 1: Full transcript mini focus group

The full transcript of the mini focus group is located on Google® Drive and is accessible through this link:

https://docs.google.com/document/d/1AFqASEPTC3g8xjaJHANV054yurBZmR8m/edit?usp=sharing&ouid=115621390777221632157&rtpof=true&sd=true

In this document, a link to the audio recording of the mini focus group is attached.