

## BlockBasket- Decentralization of Dairy Supply Chain: A Review

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**Abstract** - This review paper explores how blockchain technology can address some of the key challenges in the dairy supply chain, like improving transparency, traceability, and efficiency. It brings together studies that look at both the technical side—such as how blockchain can be integrated with IoT devices for data capture and how smart contracts can streamline processes—and the practical side, focusing on how these systems impact stakeholders like farmers, retailers, and consumers. We go over the main parts of the dairy supply chain where blockchain can make a difference, such as verifying product authenticity and ensuring fair pricing. We also look at how researchers assess the performance of these systems and review real-world examples that show how blockchain could work in practice. Lastly, the paper covers the hurdles that still stand in the way of blockchain adoption in the dairy industry and suggests future steps to improve supply chain operations.

CCS Concepts: •General and reference → Surveys and overviews; •Applied computing → Agriculture; Supply chain management; •Computer systems organization → Blockchain; Distributed ledgers; •Human-centered computing → User studies; Collaborative systems; •Computing methodologies → Decentralized algorithms; Smart contracts.

Additional Key Words and Phrases: blockchain, dairy supply chain, transparency, traceability, product authentication, fair pricing.

### INTRODUCTION

The dairy industry plays a crucial role in food production but faces some big challenges, like complex supply chains, lack of transparency, and inefficient pricing. With consumers increasingly wanting products that are high-quality, traceable, and fairly priced, there's a real need for innovative solutions to tackle these issues. BlockBasket, a blockchain based platform, is stepping in with a new approach that combines blockchain

technology, IoT devices, and smart contracts to bring transparency, traceability, and fairness to the dairy supply chain. The goal is to make the entire process—from the farm to the consumer—more efficient while also supporting key players like farmers, dairies, retailers, and consumers.

Traditional dairy supply chains often depend on centralized systems, which can lead to issues like inconsistent data, delays, and even fraud. With so many intermediaries involved, it's tough to keep data reliable and pricing fair. Blockchain technology offers a decentralized, tamper-proof solution that makes product information more secure and reliable, letting everyone in the chain access real-time, trustworthy data. BlockBasket's features, such as end-to-end traceability, automated quality checks, and fair payment processes through smart contracts, aim to build trust and tackle the current inefficiencies in the system.

### 1.1 Aims and Scope

This paper gives an in-depth look at BlockBasket, examining how blockchain and IoT technology can help solve key issues in the dairy supply chain, like transparency, traceability, and fair pricing. While studies in agriculture and supply chain management have highlighted the benefits of blockchain for improving data security, trust, and efficiency, there's been limited focus specifically on the dairy industry. This paper aims to fill that gap.

We review both technical studies, which focus on the design and performance of blockchain platforms, and user studies, which look at adoption rates, usability, and satisfaction among different stakeholders. Our analysis covers different scenarios where the platform is applied. For instance, in traceability scenarios, BlockBasket allows end-to-end tracking of products, and in pricing scenarios, smart contracts ensure that farmers are fairly compensated based on the quality and quantity of their products.

We employed multiple digital libraries and search engines, such as Google Scholar, IEEE Xplore, and Springer, using keywords like “blockchain,” “dairy supply chain,” “traceability,” “IoT,” and “smart contracts.” Articles were selected based on the following criteria: (i) studies describing blockchain or IoT implementations in supply chains that can enhance product traceability, transparency, and payment systems; and (ii) user studies exploring the adoption and effectiveness of such technologies in agriculture or dairy contexts.

Following an incremental development approach, BlockBasket starts with essential features like blockchain-based traceability and IoT-enabled monitoring, laying the groundwork for more advanced functions like predictive analytics. This step-by-step approach makes it easier for stakeholders to adopt the platform gradually and see benefits at each stage.

## DEFINITIONS AND TERMINOLOGY

**Blockchain** is a decentralized digital ledger technology that enables secure and transparent recording of transactions across multiple nodes within a network. This innovative technology eliminates the need for intermediaries by allowing participants to directly verify and record transactions in real-time. Each transaction is linked to the previous one, creating an immutable chain of data that enhances security and trust among participants. The transparency provided by blockchain ensures that all stakeholders can access the same information, fostering accountability and reducing the risk of fraud. In the context of the dairy supply chain, blockchain can facilitate traceability and product authentication, leading to greater consumer confidence and improved operational efficiencies.

**Traceability** refers to the ability to track the journey of a product from its origin, such as the farm, all the way to the final consumer. This capability is crucial for ensuring transparency at every stage of the supply chain, allowing stakeholders to monitor the product’s path, verify its quality, and ensure compliance with safety standards. Traceability can significantly enhance consumer trust, as it provides assurance regarding the authenticity and safety of dairy products. By implementing robust traceability systems, stakeholders can quickly identify and address issues related to product recalls or quality concerns, ultimately leading to improved food safety and enhanced brand reputation.

**Intermediaries** are entities or individuals that facilitate the movement and transactions of products between producers, processors, and retailers. While intermediaries can provide valuable services, they often add complexity and inefficiencies to the supply chain. In the dairy industry, multiple intermediaries may increase costs, delay product delivery, and obscure the origin of products. By leveraging blockchain technology, the need for certain intermediaries can be reduced, streamlining processes and ensuring that more value is passed directly from producers to consumers.

**Product Authentication** is the process of verifying the authenticity, quality, and safety of products to prevent fraud and ensure consumer trust. In the dairy supply chain, product authentication is critical for assuring consumers that the products they purchase are genuine and meet established quality standards. This process can involve various techniques, such as testing and certification, as well as the use of blockchain to provide a secure and transparent record of each product’s journey from farm to table. By implementing robust product authentication measures, stakeholders can protect their brands and enhance consumer confidence.

**Fair Pricing** mechanisms are designed to ensure that producers, particularly farmers, receive equitable payment for their products, reflecting true market value and production costs. In many cases, farmers may struggle to receive fair compensation due to the influence of intermediaries and fluctuating market prices. By adopting fair pricing practices and leveraging blockchain technology, dairy supply chains can enhance transparency and ensure that farmers receive a fair return on their investments. This not only benefits farmers but also contributes to the sustainability and resilience of the dairy industry as a whole.

## LITERATURE SURVEY

### **Blockchain-based framework for data management in IoT-based supply chain management. [1]**

In the paper, Kumar and Tripathi put forward the framework of blockchain technology targeted at achieving better data management systems in IoT-based supply chain. They come forward to study how IoT devices in supply chain create many data and how such huge volumes of data are secured and managed by blockchain technology and reduce the chances of data alteration so that the various interested parties will believe in one another. Thus, the proposed framework would permit real-time tracking and validation of goods and will preserve accuracy and reliability of the data as

well. An author elaborates clearly how the synergy between blockchain and IoT will make a chain more resilient; however, data volume, speed in processing, and the intensity of integrating IoT devices with blockchain pose potential issues.

This advantage lies in the fact that blockchain can grossly enhance the security and integrity of the data generated by IoT to be used in supply chains. Through this system, it is possible to ensure a chain offers reliable and real-time tracking and verification. With IoT integration into blockchain, it may be a disadvantage as it will challenge the processing speed in terms of data volume that slows down the execution process.

### **Blockchain technology adoption in the agrifood industry: Challenges and benefits. [2]**

Hashemi and Butcher's research paper is a thoughtful exploration of the applicability of blockchain technology in the agrifood industry: how its use can be applied to enhance transparency, traceability, and security in supply chains. Main challenges here would thus include technological complexity, high up-front costs, and standardization for wide industry implementation. From this study, it would be evident that blockchain can improve food safety with real-time immutable records to enable immediate identification and control of contamination or recalls. The authors would thus conclude that, while still promising much benefit, widescale adoption in agrifood is not without tremendous operational and structural barriers. Blockchain enhances traceability and transparency regarding information provided to consumers about food origins, thus enhancing trust and improving food safety.

Disadvantage: Those high initial investment costs and complicated integration with existing supply chains are scary tasks for most agrifood companies.

### **Food supply chain sustainability: A blockchain-based traceability approach. [3]**

Kamilaris and Prenafeta-Boldú, in 2018, discuss within their research the application of blockchain technology to ensure sustainability in food supply chains by raising transparent, trackable, and accountable processes. It discusses the potential offered by blockchain technology to reduce food waste, diminish fraud, and maintain sustainability standards in developing a cleaner production environment. By using blockchain-based traceability, argue the authors, all stakeholders—from farmers to consumers—can see every stage of production: improving resource efficiency and decreasing environmental impact. Yet the paper also identifies various problems, such as data privacy issues and

unavailability of technology for smaller stakeholders. Blockchain can make food supply chains more sustainable by offering accurate traceability, thus minimizing waste and improving environmental responsibility.

Disadvantage: Blockchain implementation will create potential issues with data privacy due to the fact that so much of that information will be accessible to parties within a chain.

### **Improved milk distribution and quality control using blockchain and IoT. [4]**

In the year 2021, Sharma and Kalra proposed a hybrid blockchain-IoT framework for the betterment of milk distribution and quality control. Sharma and Kalra further expanded that a new approach could target challenges when moving milk products, including integrity during transport and transparency in the supply chain process. This will thus make it possible to monitor parameters such as temperature and pH constantly through IoT sensors while recording the data safely in blockchain that will eliminate the chances of such data being tampered with. All this will help stakeholders to verify the quality of milk coming into their stores and trace its source. The system will thus increase consumer trust in the milk product because it gives real-time information regarding the freshness and safety of milk. Blockchain and IoT create more efficient quality control and transparency concerning the milk from point of production to consumption to enhance the qualitative advantage for consumers. It is expensive, particularly on the side of small suppliers, because it requires not only IoT infrastructure but also blockchain integration.

### **Supply Chain Traceability Using Blockchain. [5]**

In "Supply Chain Traceability Using Blockchain," Perboli, Xu, and Dobrovnik (2023) explore how blockchain technology can enhance traceability and transparency across complex supply chains. The paper discusses the potential of blockchain in the creation of immutably recorded origin, processing, distribution, etc., which makes it possible to trace in real-time as well, so data integrity would be ensured. Of course, traceability in this sense holds much value for authentication of products and protection against frauds. Technical skills are the main challenges it faced in its implementation. Private data might also raise a challenge for companies that hold them. There is also a need for the participants in the supply chain to reach a consensus for effective traceability. According to the authors, this depends on collaboration and technical adaptability all through the supply chain while taking its achievements on some

promising blockchain. Blockchain can achieve dramatic improvements in traceability with lower risks of fraud by making secure, tamper-proof records of every stage in the supply chain. The wide-scale implementation of blockchain in supply chains is a difficult task to contemplate, mainly because technical know-how and cooperation by all participants are necessary to build such a system, which could be highly complex and expensive.

### Blockchain Technology Implementation in Supply Chain Management: A Literature Review [6]

In "Blockchain Technology Implementation in Supply Chain Management: A Literature Review," Sharabati and Jreisat (2024) summarize the existing body of research on the application of blockchain technology in supply chain management. The paper investigates whether blockchain technology has improved the transparency, traceability, efficiency, and security of the supply chain. It emphasizes key advantages associated with fraud elimination efficacy, data integrity improvement, and operation streamlining in discussing the major challenges: high costs, scalability issues, and standards that require regulatory development. The authors point out that while blockchain promises transformative possibilities, successful implementation will still be based on overcoming technical, organizational, and regulatory hurdles. The main advantage of blockchain is about its capacity to enhance transparency and security across supply chains because errors cannot be made concerning data, and fraud would be impossible. One of the big obstacles for widespread adoption in supply chain management, blockchain's cost overhead and scalability drawback.

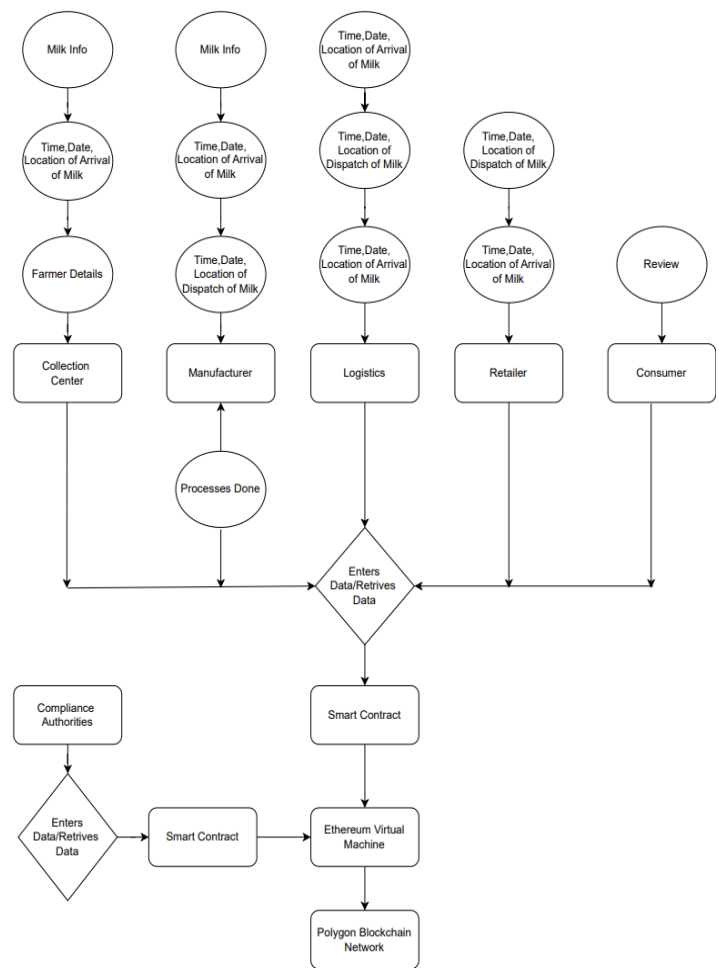


Figure 1: ER Diagram of Proposed Solution

### APPLICATIONS AND SCENARIOS

The blockchain-enabled platform offers various applications to enhance supply chain management. Target applications in System Studies include product authentication, supply chain efficiency, quality monitoring, and regulatory compliance. **Product Authentication** ensures that dairy products are genuine and meet quality standards at every stage of the supply chain, building consumer trust and reducing the risk of fraud. **Supply Chain Efficiency** is achieved by automating processes, minimizing intermediary involvement, and reducing delays, ensuring that products reach consumers quickly and in optimal condition. **Quality Monitoring** involves real-time tracking of product conditions (such as temperature and humidity) using IoT sensors, ensuring compliance with safety standards, preventing spoilage, and maintaining product quality. **Regulatory Compliance** ensures that stakeholders meet legal and safety requirements through blockchain-based records, enabling seamless audits by authorities. The platform also supports several practical

scenarios in **User Studies**. **Traceability-based Scenarios** involve tracking the entire journey of dairy products from the farm to retail shelves, using blockchain records to provide consumers with detailed product histories. This transparency allows consumers to view essential information such as production dates, storage conditions, transport details, and certifications, fostering trust and confidence in the products they purchase. **Pricing-based Scenarios** automate the payment process through smart contracts, ensuring fair compensation for farmers based on the quality and quantity of their products. By eliminating manual pricing negotiations and implementing predefined models, the platform reduces delays in payment settlements and ensures equitable transactions. Additionally, **Recall Management Scenarios** enable quick identification and removal of defective or unsafe products by tracing their origin and distribution path. This minimizes public health risks and protects brand reputation. **Incentive-based Scenarios** could reward farmers and logistics providers for maintaining high-quality standards and meeting delivery targets, driving better performance across the supply chain.

### FUTURE WORK

Future enhancements for BlockBasket could focus on improving scalability, ensuring data privacy, enabling seamless interoperability with legacy systems, and establishing incentive structures for all stakeholders. Adding privacy-preserving techniques like zero-knowledge proofs can secure sensitive information, while predictive analytics based on blockchain data could help prevent supply chain disruptions. Additionally, incorporating environmentally sustainable practices and measuring their impact would further strengthen the platform's role in creating a resilient, eco-friendly dairy supply chain.

### CONCLUSION

BlockBasket has the potential to transform the dairy supply chain by providing transparency, traceability, and fair pricing through blockchain, IoT, and smart contracts. By decentralizing data management, it improves trust and accountability, benefiting farmers, retailers, and consumers alike. Although challenges around cost, integration, and scalability remain, BlockBasket's tamper-proof and decentralized framework offers practical solutions that could streamline dairy operations. This approach aligns with the industry's push for digital transformation, paving the way for a more efficient and consumer-centered supply chain.

### Acknowledgments

This work was supported by PES Modern College of Engineering. Special thanks to Prof. Aboli Deoli for their valuable insights and support throughout this project.

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