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A Conceptual Prototype FrameWork for Blockchain in A2 milk Supply Chain Cluster

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ABSTRACT
The safety of consumers' health is critically dependent on the careful collection, processing, transportation, and storage of milk. Contaminated milk is responsible for millions of illnesses and over 40,000 deaths globally each year. Despite the rising demand for milk products, there is a concerning neglect of effective end-to-end traceability systems, particularly in India, where pure milk is scarce, and consumers struggle to verify the authenticity of local dairy products. The Indian government aims to support low-income cow farmers through cooperative processing and selling initiatives, exemplified by the Ministry of MSME's approval of the SFURTI cluster project to assist nearly a thousand farmers in Mahidharpur, Odisha. This study investigates the potential of blockchain technology to address food safety issues within the domestic milk cluster in India. Employing a mixed-methods research design that integrates qualitative and quantitative data, this research proposes a blockchain architecture tailored for indigenous breed cow dairy clusters. The proposed system aims to enhance traceability, ensure product authenticity, and empower farmers through improved market access, thereby contributing to public health and supporting the livelihoods of local farmers.

Objective: The objective of the paper is to ensure traceability of milk and ensure product authenticity and empower farmers through improved market access, thereby contributing to public health and supporting the livelihoods of local farmers.

Theoretical Framework: In this paper, introduction and literature review of the paper are presented. There are challenges and problems in dairy supply chain and blockchain helps to solve the problem.

Method: This study aims to identify the critical functions of blockchain technology in enhancing milk product traceability within the Mahidharpur milk cluster which involves 1000 dairy producers. Here blockchain is implemented in the dairy products to check tracability of the milk supply chain.

Results and Discussions: Blockchain technology should be implemented in milk sector industry to ensure its tracability and safety of all milk products.

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Research implications: Other than milk products, blockchain can be implemented in food industry to ensure tracability and quality of food products.
Originality/ Value: Nowadays the food have become contaminanted. Blockchain is one of the technologies for ensuring quality of food products and its tracability.

Keywords: Traceability, end to end , Blockchain

1. INTRODUCTION

Milk is considered as one of the consumable food items of the world. There are many milk products like cheese, paneer, cheena, ice cream, sweets etc. The daily food consumption by people relies on the confidence that the processes of manufacturing, processing, storage, inventory management, distribution, and marketing adhere to quality standards and comply with safety regulations [1]. A significant portion of data loss starts with adulteration, specifically the straightforward practice of adding water to milk. This extra water diminishes the nutritional quality of milk and has been associated with various health issues. In India, 68% of milk and milk products fail to comply with FSSAI regulations [2]. As the third most produced agricultural product globally, the dairy industry is valued at over $400 billion, contributing approximately 14% to the world's agricultural commerce [3]. In this context, transparency-driven supply chain traceability is essential, providing vital information about the source of raw materials, their journey through the supply chain, and the transformations they undergo to produce final products [4]. Tracking systems for food quality and safety have become indispensable. However, the increasing complexity of food fraud in many developing countries has revealed significant deficiencies in current dairy product traceability systems, which lag behind those in wealthier nations. Blockchain technology has emerged as a promising solution to this disparity, prompting researchers to explore innovative technologies to enhance traceability. Its unparalleled transparency makes it an effective tool for improving traceability beyond what traditional systems can offer. Globally, blockchain technology is being studied and implemented to address food safety issues affecting consumers and supply chain participants.
The objective of this research is to investigate the potential of blockchain technology in improving food safety and traceability within the dairy sector. Recognizing the critical role of traceability in food chains, the Indian government has initiated several programs aimed at enhancing the livelihoods of dairy farmers, with a particular focus on promoting indigenous cow breeds. Despite these breeds yielding lower milk volumes, they produce higher-quality products. However, consumer confidence in the purity of this milk remains low. This study aims to leverage blockchain technology to ensure the authenticity and traceability of milk from indigenous cows. The following sections provide a literature review, an analysis of the challenges in implementing blockchain in the dairy industry, an explanation of the research methodology, and a summary of the main conclusions.

2. LITERATURE REVIEW

Blockchain Applications in Milk Traceability

Successful supply chain management is essential to the success of the Indian dairy industry. By using appropriate supply chain management techniques, the dairy industry may successfully cut down on the waste of milk and its products, which helps dairy farmers and consumers by raising returns and bringing down prices. However, the SCM techniques of the Indian dairy industry are beset with a number of issues. If well executed, these strategies give an advantage, but if not, they may cause the business to fail. Information sharing [5][6]([7][8]Tue et al., 2021; Helo et al., 2019; Yeoh, 2017; Guan, 2020), inventory management [9][10][11][12](Cole et al., 2019; Atnafu et al., 2018; Li et al., 2005; Jonsson and Mattssonz, 2008), distribution management[13][14][15][16] (Lee, 2011; Kumar et al., 2020; Ulgen et al., 2015; Cigolini et al., 2004), and manufacturing practices (Wang and Hsu, 2020; Jun et al., 2007; Liu et al., 2020; Angrish et al., 2018; Lee et al., 2011) [17][18][19][20][21]are some examples of these SCM practices.(Pierro, 2017) [22]explains the concept of blockchain as "a table with three columns, where each row reflects a unique transaction; the first column records the timestamp of the transaction, the second column contains the transaction specifics, and the third column features a hash generated from both the current transaction and its details, along with the hash of the preceding transaction. By including a timestamp and referencing the previous transaction, individuals aiming to verify this information can access it at any time, and since it references the prior transaction, it facilitates tracking the transaction history quite effectively. There is some protective measure implemented to restrict those not involved in the transaction from accessing its details. The hash mentioned earlier in the third column, populated during the transaction process, is an encrypted code composed of letters and numbers designed to obscure details about the transaction.

Because each transaction's hash can subsequently be linked to the hash of the preceding transaction, it renders fraudulent activities extremely unlikely. With the inclusion of a record for each transaction that traces back to the previous one, it becomes effortless to track amounts all the way back to the very start. This characteristic would simplify the jobs of virtually all accountants, eliminating issues such as lost receipts or errors in calculations. Each transaction serves as a snapshot in time that anyone with the appropriate permissions can view while effectively remaining concealed. [22]

According to Robert Anascavage, since an anonymous programmer shared some code online with the intention of developing a new cryptocurrency platform, blockchain has become extremely popular in almost every sector, including healthcare, education, city planning, and finance. Finally, it seems that blockchain technology does not only make activities in existing sectors better, but they also have the ability to completely transform systems that record the history of artifacts by creating a transparent, far better ledger system.

Challenges in the Dairy Supply Chain

Figure 1 illustrates Mahidharpur's traditional milk supply chain prior to the incorporation of blockchain technology. Seasonal variations affect milk production, leading to fluctuations in supply throughout the year. Dairy farms serve as the starting point of the supply chain, where cows are milked and raw milk is initially stored before being sent to processing plants. A cooperative collects milk at predetermined collection stations, acting as an intermediary between farmers and processing centers. The raw milk is then transported to a processing factory, where it undergoes various processing steps, such as homogenization and pasteurization, to create different dairy products that are packaged and distributed.

One of the key challenges facing the dairy supply chain is the seasonality of milk production, which results in variations in supply and demand, complicating inventory control, transportation logistics, and production scheduling. The dairy industry also frequently encounters issues related to packaging management, delivery accuracy, visibility, and route optimization—particularly with milk, which must be transported swiftly due to its perishable nature.

Additional challenges include managing product returns, reconciliation processes, and determining responsibility for damaged milk—whether it falls on the dairy, transporter, retailer, or customer. Assessing the quality of milk at the source poses significant challenges, as it raises accountability questions when low-quality milk is detected later in the supply chain. The lack of quality control complicates matters for merchants, transporters, and dairy farmers. Furthermore, the absence of visibility into the quality and shelf life of raw materials during transit presents an urgent challenge. Accurately identifying suppliers' locations and determining optimal transportation routes are crucial, especially when tanker routes become difficult to trace due to potential weight and height restrictions.

Transitioning from the current supply chain management system to a blockchain-based framework presents a substantial opportunity to enhance safety and security, thereby alleviating these challenges.

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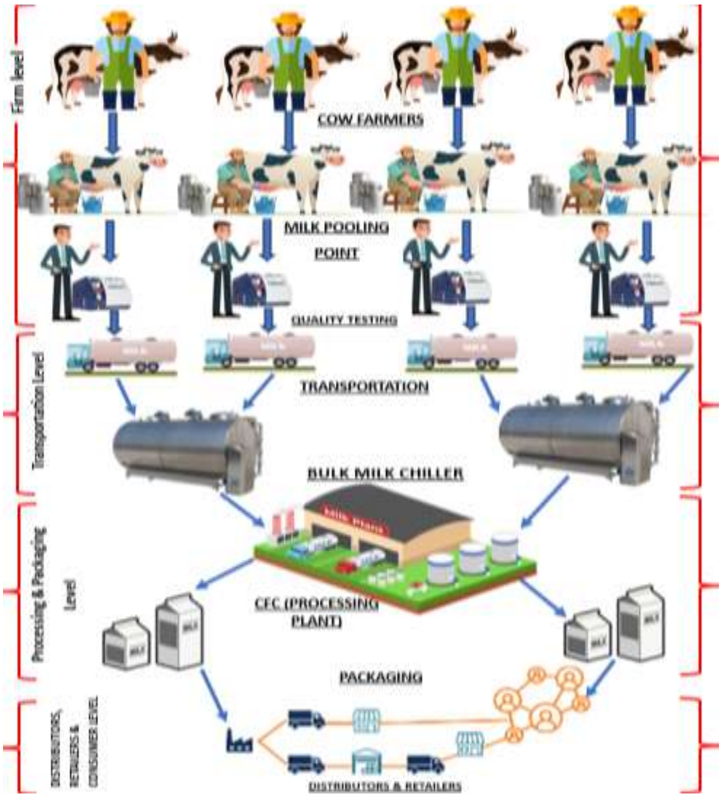


FIGURE 1. THE EXISTING MILK SUPPLY CHAIN SYSTEM IN MAHIDHARPUR MILK CLUSTER

III.Methodology

This study aims to identify the critical functions of blockchain technology in enhancing milk product traceability within the Mahidharpur milk cluster. The cluster on the case study is involving a group of 1,000 dairy producers, each raising an average of four indigenous breed cows, resulting in a total dairy harvest of approximately 5,000 liters. The existing supply chain is characterized by its complexity and lack of structured systems. To address these challenges, the following methodology will be implemented:

A. Study Population and Technology Implementation

1 **Participants**:

1.1 A total of 1,000 dairy farmers will be involved, each managing an average of four milking cows.

2 **Technology Provision**:

2.1 Each farmer will be equipped with a 4G smart phone loaded with a blockchain application for data input and management.

3 **TRAINING**:

3.1 Farmers will undergo training sessions to ensure proficiency in using the application effectively.

B. Data Collection Process

[1] QR Code Creation:

AT THE FARM LEVEL, A QR CODE WILL BE GENERATED CONTAINING ESSENTIAL INFORMATION ABOUT THE FARMER, THEIR COWS, AND THE MILKING PROCESS. THIS WILL OCCUR IN THE INITIAL PHASES OF BLOCKCHAIN IMPLEMENTATION.

[2] Milking System:
Twenty units, each capable of processing milk from groups of fifty cows belonging to ten farmers, will be established.
Four milk collectors will be responsible for collecting, weighing, and testing the milk from these groups. They will compile relevant data and upload it via the mobile app to the blockchain, which will initially generate QR1 codes. The data will include:

- Cattle breed
- Immunization records
- Diet and health status
- Milking records
- Transportation details to the Common Facility Center (CFC)

[3] Milk Sampling:
Individual milk samples will be collected, tested, and analyzed at the farm level. The test results will be recorded, resulting in an upgraded QR code (QR2).
C. Supply Chain Stages
Bulk Milk Cooler (BMC):
Milk will be collected after examination and temporarily stored before transportation. The QR code will contain critical data such as:

- Timestamps
- Temperature readings
- Quality assessments of the milk

3.2 Upon uploading this data to the blockchain, the QR2 code will be replaced with a new QR3 code.
Transportation:
RAW MILK WILL BE TRANSPORTED BY TANKERS FROM THE BMC TO THE CFC.
Upon arrival at the CFC, temperature and analytical reports will be entered into the QR3 code, which will be upgraded to QR4.
Processing at the Common Facility Center (CFC):
Raw milk will be processed into various dairy products through several processing steps.
[1]Sensors integrated within the blockchain system will provide accurate information about individual milking cows, milk collectors, and processing details.
[2]The upgraded QR4 code will change to QR5, ensuring transparency for end-users.
Packaging:
During the packaging process, the QR5 code will be converted to a QR6 code, which will include a timestamp, offering consumers comprehensive traceability information.
Distribution:
At the distribution stage, packaged and bottled milk products will have QR6 codes attached.
Smart contracts will facilitate efficient transactions between the milk cluster and wholesalers/retailers, updating shipment information such as:
Temperature
HUMIDITY

- Shelf life
- Order deadlines

Customer Engagement:
Customers can verify the product's identity and origin by scanning the QR6 code using the smartphone app, scanning the QR6 code will provide detailed traceability information, including:

- Type of milk (e.g., specific cow breed)
- Cow identification number
- Origin location
- Processing information
- Safety precautions
- Expiration date

Figure 2.Proposed Framework for a blockchain traceability system for milk supply chain cluster

QR CODE

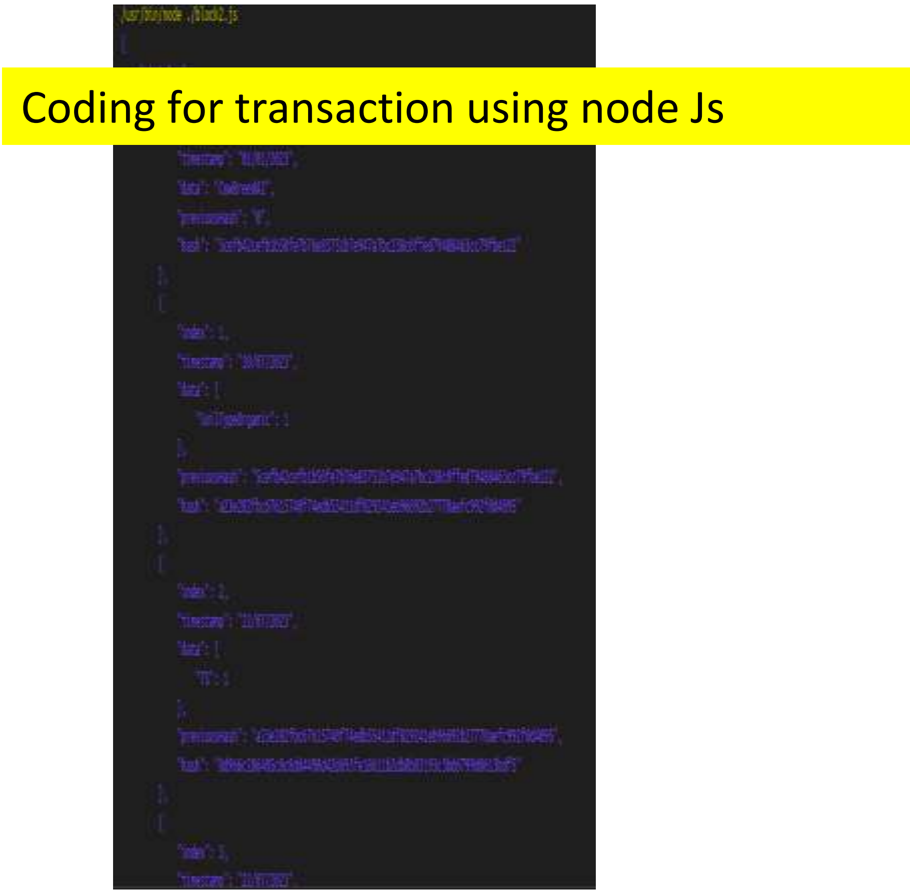
TEXT- A2 MILK COLLECTED AT 5:30 AM ON 22NDMARCH,2021 FROM TAG 45, REACHED INDUSTRY AT 6:12 AM, CLEARED QUALITY CHECK AND PROCESSED AT INDUSTRY AND PACKED AT 8:15 AM, REACHED AT RETAIL STORE WHILE MAINTAINING A MINIMUM TEMPERATURE OF 38 DEGREE F AT 8: 50 AM.

Programs

```
const SHA256 = require('crypto-js/sha256');
class Block{
constructor(index, timestamp, data, previousHash = ''){
this.index = index;
this.timestamp = timestamp;
this.data = data;
this.previousHash = previousHash;
this.hash = this.calculateHash();
}
```

```
calculateHash(){
return SHA256(this.index + this.previousHash + this.timestamp + JSON.stringify(this.data)).toString();
}
}
class Blockchain {
constructor(){
this.chain = [this.createGenesisBlock()];
//  this.difficulty = 2;
//this.pendingTransactions = [];
//this.miningReward = 100;
}
CREATEGENESISBLOCK(){
return new Block(0, "01/01/2023", "CowBreedA2", "0");
}

getLatestBlock(){
return this.chain[this.chain.length - 1];
}
addBlock(newBlock){
newBlock.previousHash = this.getLatestBlock().hash;
newBlock.hash = newBlock.calculateHash();
this.chain.push(newBlock);
}
}
let savjeeCoin = new Blockchain();

savjeeCoin.addBlock(new Block(1, "10/07/2023", { SoilTypeOrganic: 1 }));


savjeeCoin.addBlock(new Block(2, "22/07/2023", { TS: 1 }));


savjeeCoin.addBlock(new Block(3, "22/07/2023", { SolidNotFat: 11 }));

savjeeCoin.addBlock(new Block(4, "22/07/2023", { Lactose: 4 }));

savjeeCoin.addBlock(new Block(5, "22/07/2023", { TotalSolid: 19 }));

savjeeCoin.addBlock(new Block(6, "22/07/2023", { Protein: 5 }));
console.log(JSON.stringify(savjeeCoin, null, 4));
```

Output



IV. Conclusions:

The proposed conceptual framework for implementing blockchain technology in milk supply chain traceability presents several significant advantages for stakeholders throughout the supply chain.

Automated Payments for Farmers: Farmers within the cluster will benefit from guaranteed, automated payments that occur upon the transparent fulfillment of all conditions specified in smart contracts. This will enhance financial stability and streamline transactions.

Reduction of Human Error: By minimizing human involvement in critical operations, the framework aims to reduce the likelihood of errors, thereby improving overall efficiency in the milk production and distribution process.

Consumer Trust: The integration of blockchain technology will provide consumers with access to a platform that validates the purity and authenticity of dairy products. This transparency fosters greater trust in the quality of the products they purchase.

Cost and Time Savings: Incorporating sensors and smart contracts into the system will allow businesses to significantly cut down on the time and costs associated with human resources and intermediaries, leading to more efficient operations.

Enhanced Compliance Assurance: The ability to track specific batches of milk sourced from designated groups of cows will provide manufacturers with increased confidence in farmers' adherence to established quality protocols.'

Minimized Milk Waste: The traceability system is designed to significantly reduce waste associated with the perishability of both raw and finished milk, contributing to more sustainable practices within the industry.

Economic Benefits: Improved authenticity and traceability can lead to increased prices for milk and its derived products, ultimately resulting in better economic outcomes for all members of the supply chain.

In conclusion, the implementation of a blockchain-based traceability system has the potential to revolutionize the dairy supply chain by enhancing transparency, efficiency, and trust, thereby benefiting farmers, consumers, and the industry as a whole.

V. REFERENCES

1. Tan, A. and Ngan, P.T. (2020), “A proposed framework model for dairy supply chain traceability”,Sustainable Futures, Vol. 2, 100034.
2. Economic survey (2022), available at: https://www.thehindubusinessline.com/economy/agri-business/economic-survey-indias-per-capita-milk-availability-rises-to-427-grams/article64959774.ece(accessed 15 March 2023).
3. Wang X, D Li (2006) Value Added on Food Traceability: A Supply Chain Management Approach. In 2006 IEEE International Conference on Service Operations and Logistics, and Informatics, 493-498.
4. 4.Zhang P, White J, Schmidt DC, Lenz G (2017) Applying Software Patterns to Address Interoperability Challenges in Blockchain-Based Healthcare Apps. In ArXiv Preprint.
5. Teodorescu, M. and Korchagina, E. (2021), “Applying blockchain in the modern supply chain management: its implication on open innovation”, Journal of Open Innovation: Technology, Market, and Complexity, Vol. 7 No. 1, p. 80, doi: 10.3390/joitmc7010080.
6. Helo, P. and Hao, Y. (2019), “Blockchains in operations and supply chains: a model and reference implementation”, Computers and Industrial Engineering, Vol. 136, pp. 242-251.
7. Yeoh, P. (2017), “Regulatory issues in blockchain technology”, Journal of Financial Regulation and Compliance, Vol. 25 No. 2, pp. 196-208.
8. Guan, Z., Zhang, X., Zhou, M. and Dan, Y. (2020), “Demand information sharing in competing supply chains with manufacturer-provided service”, International Journal of Production Economics,Vol. 220, 107450.
9. Cole, R., Stevenson, M. and Aitken, J. (2019), “Blockchain technology: implications for operations and supply chain management”, Supply Chain Management: An International Journal, Vol. 24 No. 4, pp. 469-483.
10. Atnafu, D. and Balda, A. (2018), “The impact of inventory management practice on h1s’competitiveness and organizational performance: empirical evidence from micro and small enterprises in Ethiopia”, Cogent Business and Management, Vol. 5 No. 1, 1503219.
11. Li, S., Rao, S.S., Ragu-Nathan, T.S. and Ragu-Nathan, B. (2005), “Development and validation of a measurement instrument for studying supply chain management practices”, Journal of Operations Management, Vol. 23 No. 6, pp. 618-641.
12. Jonsson, P. and Mattsson, S.A. (2008), “Inventory management practices and their implications on perceived planning performance”, International Journal of Production Research, Vol. 46 No. 7, pp. 1787-1812.
13. Lee, C., Leem, C.S. and Hwang, I. (2011), “PDM and ERP integration methodology using digital manufacturing to support global manufacturing”, The International Journal of Advanced Manufacturing Technology, Vol. 53 No. 1, pp. 399-409.

14. Kumar, A., Singh, R.K. and Modgil, S. (2020), "Influence of data-driven supply chain quality management on organizational performance: evidences from retail industry", The TQM Journal, Vol. 35 No. 1, pp. 24-50, doi: 10.1108/TQM-06-2020-0146.
15. Ulgen, V.S. and Forslund, H. (2015), "Logistics performance management in textiles supply chains: best-practice and barriers", International Journal of Productivity and Performance Management, Vol. 64 No. 1, pp. 52-75.
16. Cigolini, R., Cozzi, M. and Perona, M. (2004), "A new framework for supply chain management:conceptual model and empirical test", International Journal of Operations and Production Management, Vol. 24 No. 1, pp. 7-41.
17. Wang, J. and Hsu, C.C. (2020), "A topic-based patent analytics approach for exploring technological trends in smart manufacturing", Journal of Manufacturing Technology Management, Vol. 32No. 1, pp. 110-135.
18. Jun, H.B., Shin, J.H., Kiritsis, D. and Xirouchakis, P. (2007), "System architecture for closed-loop PLM", International Journal of Computer Integrated Manufacturing, Vol. 20 No. 7, pp. 684-698.
19. Liu, X.L., Wang, W.M., Guo, H., Barenji, A.V., Li, Z. and Huang, G.Q. (2020), "Industrial Blockchain based framework for product lifecycle management in industry 4.0", Robotics and Computer-Integrated Manufacturing, Vol. 63, 101897.
20. Angrish, A., Craver, B., Hasan, M. and Starly, B. (2018), "A case study for Blockchain in manufacturing: 'FabRec': a prototype for peer-to-peer network of manufacturing nodes", Procedia Manufacturing, Vol. 26, pp. 1180-1192.
21. Lee, C., Leem, C.S. and Hwang, I. (2011), "PDM and ERP integration methodology using digital manufacturing to support global manufacturing", The International Journal of Advanced Manufacturing Technology, Vol. 53 No. 1, pp. 399-409.
22. Pierro, M. D. (2017). What is the blockchain? Computing in Science & Engineering, 19 (5), 92-95.

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