Dairy Supply Chain System Based on Blockchain Technology

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Authors' contributions

The review work was carried out in collaboration among all the authors. The study was designed and drafted by all the authors. All authors read and approved the final manuscript.

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ABSTRACT

With the increase in the complexity of the dairy supply chain system, consumers know very less about the products produced or processed by producer or processor. Such information asymmetry present in the dairy industry has serious concern over human health, environmental sustainability, and welfare issues. In this context, we require the effective dairy supply chain system that not only fulfils the information requirement of the consumers but also increase the trust of the consumer on the dairy product they are consuming. The paper tries to present the application of Blockchain technology in the dairy sector. It focuses on the application of the Blockchain technology on improving the dairy supply chain system. This paper presents how this technology can be used in the dairy supply chain system and outlines the potential benefit of it to the different stakeholders and the whole dairy industry as a whole. This is a review article based on the secondary data and information that are obtained from various published articles.

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1. INTRODUCTION

Due to the presence of the various types of nutrients like carbohydrate, proteins, fat, minerals, vitamins, and other various essential components in milk, it is often claimed as the perfect food. However, in the present time due to the malpractices involved during the processing, handling and transportation of the milk, consumption of the milk available in the market can have deadly harm in human health. In the last decades, there is an increase in the occurrences of milk-related scandals all over the globe. Milk related incidences are higher in the developing countries like China, India, and Pakistan [1,2,3]. In China, milk scandal of 2008 has left more than 3 million victims and the death of six children. A study done by the Food Safety and Standard Authority of India (FSSAI) shows that 68.4% of the milk in the country is not as per the legal standard [4]. Milk related incidences are also high in developed countries like the USA. In the year 2018, there was a recall of 160 products in the USA due to undeclared allergens, in which one third was due to milk [5]. Such incidents have increased the concern for the traceability of the milk and milk products. However, concern for dairy traceability is not limited to public health safety. Other issues include environmental sustainability, animal and farm labour welfare.

Dairy traceability can be defined as the ability to trace the movement of the milk and milk products through different routes from its production until it reaches final consumption. Unlike past, there has been a decrease in the link between dairy farmers, processors/manufacturer, distributors and consumers, very few or no information passes to consumers from preceding members of the dairy supply chain. Although the various information is kept by the members of the dairy supply chain, they usually lack coordination among them. Such a lack of communication among the producers and consumers, along with the globalization of the dairy industry, has demanded a better traceability system for the milk and milk products. In the recent scientific literature, application of Blockchain technology and internet of things is presented as the potential solution to improve the traceability in the agri-food supply chain system. This paper tries to conceptualize the application of Blockchain technology in the dairy sector, with particular focus given to dairy supply chain management.

2. BLOCKCHAIN TECHNOLOGY

Blockchain technology often called "Distributed Ledger Technology (DLT)" is a technology behind the various cryptocurrencies like Bitcoin. It was first introduced by the pseudonym Satoshi Nakamoto [6]. This technology has been described as the most significant invention to humankind after internet and is claimed to have the potential to disrupt almost every industry. Blockchain is a digital database system in which a recorded data is shared among the computer networks at the same time. Unlike the existing traditional database system, it has no central authority controlling the system [7]. Devices connected to the Blockchain network are called nodes. Nodes are the participants of the network. When the nodes feed the information to the network, it gets digitally signed with the cryptographic keys. Then such information will be passed to other nodes, to check whether it is valid or not. This prevents fraudulent information to get stored. After authentication, this information will be added to the block. Such block has a unique code called hash. Such hash code adds the new blocks linking it to previous block and succeeding block will link itself back it making a chain. If someone tries to alter the information in the network, they need to crack the hash code, which requires an enormous amount of computing. This makes the Blockchain database immutable in nature [8], providing security to the information stored in the network. Similarly, one can easily trace back the history of information present in the network.

There are three different types of Blockchain network based on permission given to participant viz. public, private, and hybrid. In public Blockchain, anyone can be part of it (like Bitcoin), whereas in private Blockchain central body can restrict the participants. In hybrid Blockchain, it is managed such that some of the information and roles remain to some and limited to others. Such Blockchain is used in the banking and financial sector.

Various technologies like bar-code, batch marks and RFIDs are used as an approach to apply the blockchain technology in supply chain system in various sectors including the dairy sector.

3. INTERNET OF THINGS (IOTS)

Internet of things can be defined as the interlinkage through the use of internet of various computing devices embedded in objects and

allowing them to share data. As the agriculture sector is time-sensitive and high risk-oriented, it is difficult to control the movement of the food products [9]. In this respect, innovation, development, and application of the internet of things is a must. Development of various sensors, GPS tracking systems, RFID devices, drones, etc. has provided us with multiple opportunities to be applied in the dairy sector.

With IoTs, the dairy industry can now handle lots of data and process information from it. Producer and other related stakeholders like certification agency, processors, exporters, etc. can know much more about the dairying operation efficiently and cost-effectively. They can monitor the animal health, disease pest occurrences, etc. which are useful in adjusting the dairying operation, and such information may be of value to the consumer. Similarly, IoTs enables management of the complete lifecycle of the dairy sector products, ranging from production to final sale until it reaches consumers' plate. In turn, it increases the trustworthiness of consumers to the dairy product they are consuming [10].

Radio Frequency Identification(RFID) is widely used technology for Identification. It is based on radio frequency waves as a form of wireless communication where a tag is attached to the object in the form of sensors and the information is transmitted to the system. This system do not require the visual contact like in barcodes while the information is passed wirelessly and can be placed inside the boxes and containers not requiring physical contact. This system can be used in monitoring various factors of food quality like freshness of milk, bacterial growth, etc. by using various sensors like chemical sensors, humidity sensors, gas sensors, etc. The tags can be used in intelligent/smart packaging systems providing the data about food quality, safety and history [9].

4. POTENTIAL APPLICATION OF BLOCKCHAIN TECHNOLOGY IN THE DAIRY SUPPLY CHAIN

Dairy sector has grown much more involved than other agri-food supply chain. In recent times, increased requirement of the dairy consumers has added much more complexity to the industry. Consumers are much more discerning, have a higher willingness to pay for food safety, sustainability, and ethically produced food. Such requirements demand for the transparency in the

dairy sector from its production activities to its consumption. Transparency and traceability are claimed as the most significant differentiator of food brands in the future food business [11]. Various studies show that Blockchain has the potential to transform the agri-food supply chain system [12,13,14]. Hua et al. [12] suggests that Blockchain system can be used in tracing food information including farm operations conducted. This can support in building a trust level among the various stakeholders in agri-food system. Tian 2017 mentions Hazard Analysis and Critical control points-based platform using IoTs and blockchain technology can be used in monitoring the foods physical conditions and food tracking.

Blockchain technology has great potential to transform the dairy sector as it can tackle various challenges that are preventing transparency and traceability in the dairy supply chain system. For this, all the related members should be registered in the Blockchain network; they will have a unique digital identity and profile in the network. As the milk and milk products get produced and move in the system, every member should update the relevant information in the network, which also can be automated by the use of IoTs. The automation can be achieved by using RFID tags, sensors and other devices to update the information along the system.

Farmers can update information about the location of farm, breed, vaccinations, medications, and special treatments, if any. Farmers can assign RFID devices or any other sensors to track the movement and health of the animals, which can be updated into the Blockchain network. Similarly, data can be captured and recorded during the milking of the animal, which can be done by sophisticated machines available. As the milk is milked, they are ready to be sent to chilling centers, milk collection center, processors, or food manufacturer.

During the transport of milk to any of successive place, it is crucial to maintain proper temperature to prevent spoilage of the milk and milk product. Different type of sensors can be used to do so during transportation at any part of the supply chain. Moreover, GPS can enable real-time tracking of the vehicle during transport. As the milk and milk products get delivered to successive units, they can update relevant information into the network. This may include the location of the unit, amount of delivery at particular lot, processing or manufacturing

environment (such as temperature, equipment used and sanitary practices), various additives and chemicals used, dietary health restrictions and any other information if that seems relevant for the business and managerial purpose. As the product leaves a particular place, it should be provided with a separate tag for its identification.

Certification agencies and regulatory bodies can also be added to the supply chain system. These agencies are given digital profiles in the system. They can check and control the various information provided by the farmers and dairy industries. They can visit those members and check whether the required condition is fulfilled or not. Moreover, they can verify the various claims done by farmers and food processor or manufacturer regarding the product such as organic certificate, chemicals used, welfare status of the farm, and many more, whatever required. All the findings after verification are published in the system.

Consumers are the final participant in the food supply chain system. Consumers can use their Android or iOS devices to scan the code attached to the food item. Being based on the information provided, now consumers can make an informed choice of dairy food available to them.

5. BENEFIT OF USING BLOCKCHAIN-BASED DAIRY SUPPLY CHAIN TO DIFFERENT DAIRY-RELATED STAKE HOLDERS

Blockchain technology-based dairy supply chain system has various benefits to every participant of the dairy supply chain. The benefits of this to various participants are as follows:

5.1 Producers

Using the Blockchain platform, producers can more efficiently communicate with the other participants of the dairy supply chain system. On the one hand, the producer can maintain his identity; on the other, the producer can supervise the movement of dairy items in the market. If in case, someone mishandles, one can be easily pinpointed and prevent it from reaching to consumers. Producers can also maintain the reputation of the industry from the geographical indications, improved food production practices, sustainability and welfare practices, as Blockchain can help to disseminate such

information in the market. Moreover, ultimately, the producer can have a better return on his produce and maintain the goodwill of the farm.

5.2 Certification Agencies and Regulatory Bodies

In the present time, there are various issues like local production, GM/ Non-GM, environmental footprint, animal welfare, and fair working condition revolving around the food industry [15]. The agencies certify such attributes of food production. Application of Blockchain technology will make the certification process more manageable. Other regulatory bodies, if needed, can track the location, their ecological footprint, working condition, and welfare condition of farm. Moreover, certification information can be disseminated through this platform to consumers. This makes, on the one hand, the certification process more manageable and, on the other hand, helps the farm to stand out among its competitors.

5.3 Food Processing and Manufacturing Industries

Application of Blockchain technology seems promising for the food processing industries. By using Blockchain technology, food processing, and manufacturing industries now can better communicate with the consumers. They can disseminate the correct information about the food ingredients, handling instructions, expiry dates, consumption instructions, and other beneficial information to the consumers. They can maintain their reputation in the market-beating the unfair competition prevalent in current food industries. Similarly, if the industry has to recall the product, they can easily do this using the same platform provided by Blockchain technology [16].

5.4 Logistic Agencies

In the present time, food produced in a place travels to distant places, and this has increased the importance of the logistics service companies in the food industry [17]. A fault in the proper transfer of food items by such companies leads to spoilage of food items due to the perishable nature of food commodity. Similarly, on the other hand, logistics companies involved in food transportation has to maintain its reputation in the market. Both of the above challenges can be solved by using Blockchain technology.

Integration of internet of things with the Blockchain platform helps to gather the information needed during the transfer of good from one place to another, and they can be easily traced. Indirectly, the performance of logistics companies can be measured based on the information, which can help them to make a reputation among their competitors in the market.

5.5 Wholesalers and Retailers

Wholesalers and retailers are vital members of the food supply chain. They handle the food before it gets into the consumer's plate. By using Blockchain technology, they have increased the sale of particular food items by focusing on attributes of it. If hazardous food product gets into their shelves, they can be easily identified and removed. Similarly, it can also be advantageous in making a profile of consumers [18].

5.6 Consumer

With the application of Blockchain technology, traceability, accountability and quality assurance can be improved to such a level that food industries can react to the food safety issues with great speed preventing others from having a food-related illness [19]. According to Yiannas [19], Blockchain technology can be used in tracking the food products easily and timely than conventional methods. This technology in food tracking platform is just a thought away. This will give enough confidence to consumers on the food they purchase because they will know every detail of the food right from its site of production until it reaches to his/her hand.
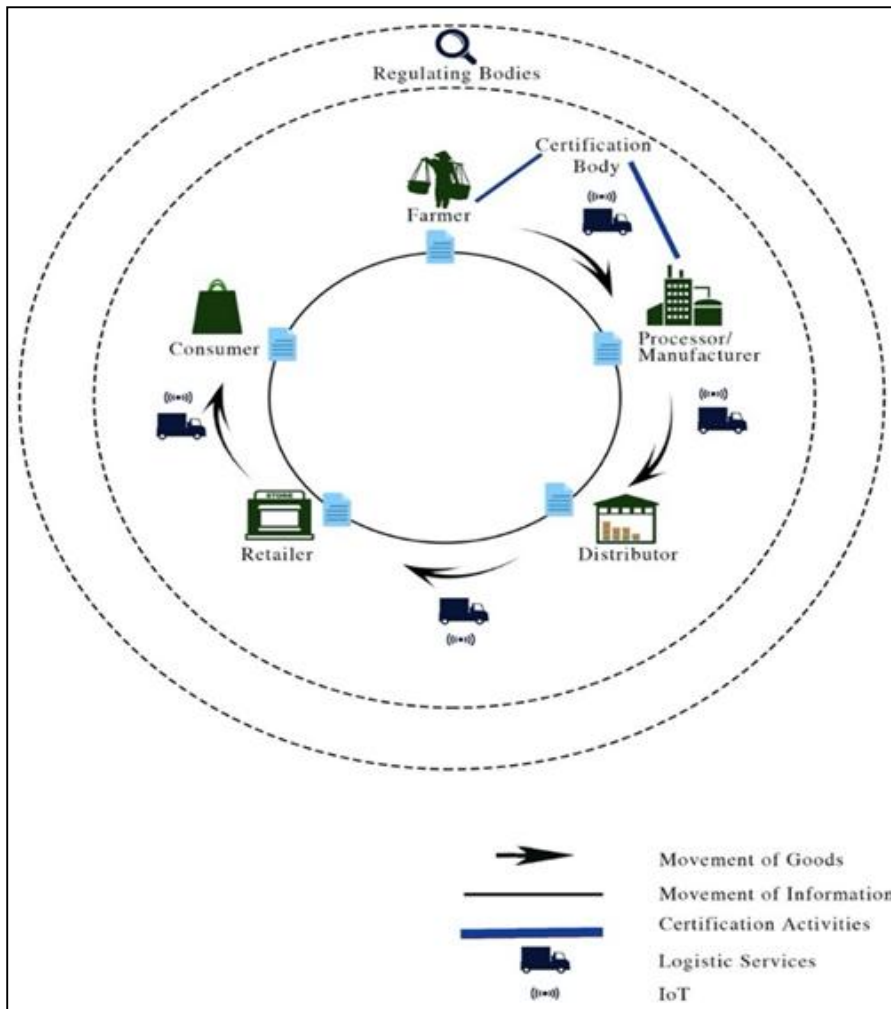

Fig. 1. Blockchain based dairy supply chain system

6. BENEFIT OF USING BLOCKCHAIN-BASED SUPPLY CHAIN SYSTEM TO THE DAIRY INDUSTRY

There are various advantages of the application of Blockchain technology in the dairy supply chain to the dairy industry. The major benefits are discussed below:

6.1 Improvement in Dairy Food Safety

With the application of the Blockchain technology, one can check and validate every information given with the food item with cent per cent certainty in very less time. Similarly, in case of some foodborne disease outbreak, one can trace the entire history of the particular food item to find the cause of the problem. Moreover, that particular lot or batch of the products can be recalled rapidly.

6.2 Prevent the Counterfeiting of Dairy Products

As the information stored in the Blockchain platform cannot be altered, food items with Blockchain-based information dissemination can stand noticeable from its alternatives. If someone tries to tamper or mishandle the food items, they can easily be pinpointed by other members in the Blockchain platform. Similarly, the confidence of consumers will be high for a food product with Blockchain-based information attached to it, ultimately not falling for counterfeit food products.

6.3 Establishing Trust in the Dairy Industry

Validating the correct information on food ingredient is often a daunting task for manufacturers and processors of the food. If they have to gain trust from consumers, they must be able to give every information on the food they have prepared. Blockchain provides a web-of-trust system, which will enable every participant of the food supply chain system to check and validate every information given in it. Hence, the consumer now can trust the food they are consuming.

7. CONCLUSION

Although there are various anticipated benefits of using Blockchain-based dairy supply chain system, there exist multiple challenges in the application of it. Blockchain technology being the new technology, business owners are unaware whether they get higher payments for the increased cost of using it. Similarly, in many countries like India, the government has no proper plan for its use, and debate is still over its applicability. Another major constraint lies in the dairy production system in the developing world, where dairy farming is a non-commercial and fragmented. A large number of farmers are engaged in it, but they have a small herd size. There exist challenges in integrating those farmers into the Blockchain-based dairy supply chain system. Hence, there is a need for in-depth research on these issues to apply the Blockchain technology to the dairy sector.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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