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Research Article

Optimization of Meat and Poultry Farm Inventory Stock Using Data Analytics for Green Supply Chain Network

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The traditional meat and poultry farms use a fixed quantity of supply, which creates an imbalance between demand and supply. Due to this imbalance, a huge amount is spent on balancing the requirements. There is an inequality among demand and supply since typical meat and poultry farms use a fixed amount of supply. A lot of money is spent trying to balance the requirements because of this mismatch. In addition, when connecting and building the meat and poultry farm system, the procedure ignores the impact on the environment. The owner's primary goals are to retain massive profits and raise reliability. The classical method neglects the effect on the environment while linking and designing the meat and poultry farm system. The main aim of the owner is to increase the quality and maintain the maximum profit. This paper deals with the meat and poultry farms in two folds. In the first step, the IoT based system is implemented for the traceability and demand-supply monitoring. The second steps include optimization of the supply network to reduce the carbon emission from the transportation. Both steps take data analytics as an input to process the final result for the farm to run and optimize. Effective inventory optimization algorithms have been shown to be able to evaluate a significant portion of previous sales data and anticipate inventory future demand by taking seasonality and lead times into account. Revenue, productivity, and customer satisfaction are just a few of the business variables that these strategies may affect. Finally, the comparison is done with the traditional farm and supply chain on the points of demand-supply balance, cost, carbon emission, and wastage. It is found that the farms using data analytics to optimize the overall system perform better and with 37% more efficient than the traditional systems.

1. Introduction

In the 21st century, the world has become competitive. Quality, quantity, services, environmental effects, and cost play a major role in all kinds of industries. But still, all industries have their own constraints which must be focused. Meat and Poultry Farm (MPF) are one of the most active sectors after vegetable farming which always faced problems related to demand-supply management (DSM) and have a huge carbon footprint [1]. The carbon footprint of a product is the quantity of carbon dioxide released across the supply chain for a single unit of that product. The focus of supply chain management is on managing a network of links that enables for the most efficient delivery of goods or services to clients. It enables businesses to collect data on how efficiently each link in the supply chain supports social and environmental responsibility within a sustainability framework. The phrase “poultry management” frequently refers to husbandry practices or production strategies that improve production efficiency. Sound management techniques are critical for maximizing production [2, 3]. The purpose of scientific poultry management is to maximize profitability while investing as little as possible. It is a sort of animal husbandry in which domesticated birds, such as chickens, ducks, turkeys, and geese, are reared for their meat or eggs [4, 5]. For food, numerous flocks of fowl, particularly chickens, are produced. More than 60 billion chickens are slaughtered for food each year. However, some illegal practices are carried out on farms. The animals' bodies are injected for speedy reproduction, which disrupts their life cycles. Furthermore, it contributes to the spread of unhealthy food in the market. To be successful, the pre-, during-, and postplacement stages of broiler production require carefully defined insecurity policies. Effective insecurity may assist a farm's hygiene, vermin and pest control, and disease transmission within and between barns. The selection of disease-free and compatible breeds, the supply of suitable and secure farm circumstances are critical components of poultry farm management [6, 7]. A variety of factors, including chicken resilience, health, and productivity, are impeding the poultry industry's future growth. Consumer confidence, product quality and safety, product types, and the introduction and re-emergence of diseases will continue to be major barriers to the sector's current position and strategic future. Poultry is intricately linked to both zoonotic and food-borne diseases. These concepts are critical components of threat analysis, which also covers risk management and the evaluation, selection, and execution of potential courses of action. These rules should be followed when communicating about risks with all parties involved. First, fewer medications and antibiotics are used, endurance is improved, zoonotic viruses are minimised, and animal and product traceability is ensured. Second, the cleanliness of the processing methods is checked, as are the products and materials that may come into contact with the food. Although, these MPFs using the latest technology such as automated breeding system, automated slaughtering systems, etc., but still there is a huge gap in the DSM and which leads to more carbon emission [8]. A number of sensing devices have been used to monitor the operation of the poultry house, and the network platform has access to a wide range of reliable details about the chicken house. Based on the present status of the chicken house, the automatic control systems and intelligent reproducing vehicles in the chicken house have been operated remotely to handle the necessary difficulties. Many domestic and international experts are currently conducting a study on the food supply chain. The majority of them look at the qualitative aspects of the food supply chain and the regulatory systems that govern it [9]. The food industry is critical in providing the principles and necessities for supporting a variety of human behaviours. Once produced or harvested, food must be maintained, distributed, and retailed in order to reach the final customers by the due date [10, 11]. According to reports, one-third of all food produced each year is wasted or abandoned. A billion million tons of food are lost each year owing to supply chain challenges such as harvesting, shipping, and storing [12, 13]. Take, for example, fruits and vegetables. In 2011, 492 million tonnes of such fresh produce were wasted globally due to inefficient and poor food supply chain management. As a result, FSCM is critical for food conservation [14, 15].

IoT devices might be attached to specific storage containers, raw materials, or completed items. The Internet of Things device will communicate its location, which GPS satellites can receive and use to track product movement. Suppliers, producers, and distribution centres may prepare for the delivery of items, which reduces handling times and ensures that resources are handled swiftly. Food supply chain management is critical in meeting the growing demand for food. A good MPF product supply chain network must have a cost-effective design that aids strategic and tactical decisions about the locations and allocation of relevant facilities in the network, as well as the optimal quantities of products transported in each echelon of the network, in order to be effective [16]. Always there has been a focus on demand-supply meet with the right time so that there must be minimal waste. Maximizing the demand-supply directly hits the logistic supply chain network [17, 18]. If the system is not optimized then there will be a such case where the logistic supply vehicle is underloaded and trying to match demand supply with loss in terms of fuel. Maximum capacity utilization is the aim of all MPF industry [19]. The management of inventory at Indian Meat Company is the subject of the study. Essentially, the organization's flawless operation depends on three different forms of inventories. They consist of unfinished products, function properly, and raw materials. Finished goods are products that have completed the manufacturing process but have not been dispersed or sold to the final consumer yet. Inventory refers to a store of finished items in accounting terms.

The carbon footprint reduction and other environment related concerns are the second most that should be included in the MPF system for making a green supply chain network [20]. The main reason for focusing on carbon footprints is due to different government rules and regulation. As the urbanization process accelerates, the demand for meat will increase, and because food is perishable and regional, the food supply chain will be required to meet the increased demand in a timely manner, with high efficiency and low cost [21–23]. A carbon footprint study can reveal a company's energy and raw material usage waste or inefficiencies. In view of growing energy costs and anticipated limitations of water and other natural resources, this information is critical for a business to ensure that informed decisions can be made to overcome such challenges [24, 25]. A big global firm with no carbon footprint is becoming more difficult to find. The GHG protocol is a global standard for measuring carbon footprints. It has developed a global standard for regulating, measuring, and revealing greenhouse gas emissions [26, 27]. Under the agreement issued by the association, companies must declare scope 1 and scope 2 emissions, and pressure is mounting on them to report scope 3 (indirect) emissions too though [28, 29].

Tracking and monitoring are two of the major aims for IoT adoption in supply chain management. Technology allows warehouse and fleet managers to keep track of their inventory and freight. One of the most typical IoT supply chain systems, for example, collects data on vehicle temperature, pressure, humidity, and other elements that might affect the product's integrity and prompts automated condition correction [30, 31]. It is critical to handle uncertainty in addition to the relevance of food supply chain management, capacity utilization, and environmental considerations [32]. Because uncertainty is unavoidable in the real world, decision-makers can better address real-world issues by understanding its influence. Various uncertainties exist in the meat industry that should be considered for a more thorough examination [33]. By utilising IoT in supply chain management, logistics partners may collect and use data for enhanced inventory management, transportation, and incident response. These capabilities open the door for the development of sophisticated, responsive supply management solutions that use IOT models for anticipate bottlenecks, save money and effort, and accelerate the emergency response. The MPF products require less stocking density than fisheries, one strategy for enhancing productivity is to buy and transport too many day-old chicks at the start of the breeding period. The weight and, as a result, the stocking density of MPF products increases over time as they grow older [34]. Finally, before total stocking densities surpass production capacity, a portion of the animals are removed and sent to a slaughterhouse for killing. Some criteria, including as mortality rate, the potential of disease conflict, feed, and vaccine consumption, are closely related to the weight and age of broilers and have a direct impact on this strategy [35].

To our knowledge, this article is the first to consider the aforementioned objectives in an MPF product supply chain management focused on meat logistics network optimization while lowering carbon footprints.

In order to construct a sustained medical supply chain network, [36] used a production-distribution-inventory-allocation-location problem and three hybrid meta-heuristic algorithms, such as ant colony optimization, fish swarm algorithm, and firefly algorithm. By using the GA to resolve their model, [37] investigated an SCLSCN with different levels, different products, and various periods. Sahebjamnia et al. [38] proposed four new hybrid meta-heuristic algorithms to shorten computing time and enhance the quality of results, with the SCLSCN being evaluated to minimise total expenditures, as well as the ecological impact of the facility, and to optimize the social implications.

Momenitabar et al. [39] proposed a fuzzy multiobjective mixed-integer linear programming model to design an efficient Sustainable Closed-Loop Supply Chain Network (SCLSCN) resiliently. Their findings confirmed that taking into account the idea of lateral resupply and a backup supplier might significantly lower overall costs and lessen shortages on the intended SCLSCN. Suffian et al. [40] has analysed the life cycle of broiler chicken production from the cradle-to-gate perspective and have found that improving all the input and output system will increase the level of productivity and the cost of the production. In order to get the first results of the model, Safaei et al. [41] proposed suggested the GAMS software, which is used for small and medium-sized problems. For large-size problems, the genetic algorithm is also implemented. According to numerical findings, the proposed model is more accurate and may provide a reasonable answer in terms of service level and scarcity. Kalhor et al. [42] in their work has found that the broiler production stage was the main source of environmental impacts in the life cycle of chicken meat production, primarily due to feed production and transportation and on-farm emissions.

2. Current Situation of MPF Inventory Stock Management

Meat and poultry demands are increasing day by day, so it is important to maintain the inventory stock to supply the demands when required [43]. This section will highlight the current scenario of the MPF inventory stock.

2.1. Large Investment on Logistics. As traditional system did not adopt optimization in the inventory management, due to which logistic consumes more of the investment. When there is no real time data then the logistic totally depends on the requirement when needed [44]. Due to which more transport facilities and more rounds of logistic is required. This increases the overall cost as it includes fuel cost, toll tax, and many more. As shown in Figure 1, it is clear that for time (T1) the demand is small so the logistic capacity will be very low. Similarly, if we compare for T2 and T3 time we can see that the logistic capacity is not much utilize. As there is no real time feedback system is present which can give the exact requirements.

2.2. No Demand Forecast is Included. Most of the time the supply is depend on the phone call from the demand side team to full fill the customer demand. In a traditional inventory system, just a few amounts of MPF product is present and as per the demand needed the stock is increased for the supply [45]. The major drawback in this case is the increase of time span which directly affect the customer satisfaction leading to a loss in income [46, 47]. The MPF product value chain is a highly complex industrial system, with billions of manufacturing combinations available at any given time. Every day, vital decisions must be taken in order to meet current and future demand using animals. It has been impossible to make optimal selections due to the complexity of the value chain, which is primarily driven by possible cutting and processing combinations [48–50].

2.3. Increased Carbon Footprints. Carbon dioxide and other greenhouse gas concentrations in the atmosphere have increased since the beginning of the industrial epoch. Human actions are mostly to blame for this expansion. The indicators in other volumes of this research highlight a number of these changes, which influence individuals, society, and

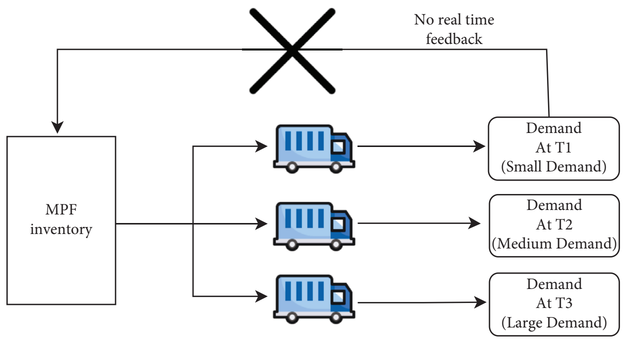

Figure 1: Traditional MPF inventory and supply chain.

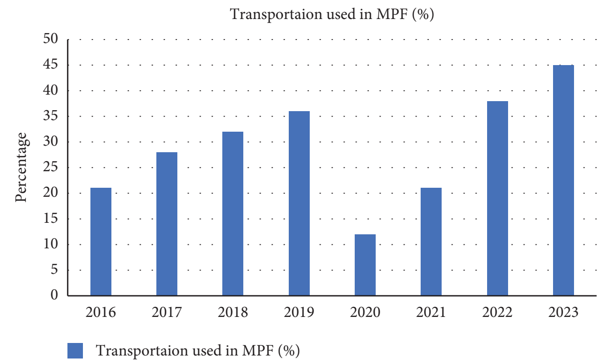

Figure 2: Use of logistic/transportation in MPF.

the environment, notably plants and animals in both positive and negative ways. Corporate organisations, Industries, e-commerce businesses, and supply chain businesses are all key contributors to rising greenhouse gas and carbon emissions. Transportation is the leading source of carbon emissions in the United States, according to the US Energy Information Administration [51]. Many industry sectors' supply chains account for more than three-quarters of their greenhouse gas (GHG) emissions. Transportation emits 1.9 billion tonnes of CO2 per year, which includes traffic from vehicles, planes trucks, trains, and ships [52]. Due to paperless data management, paperless offices, and paperless based transactions, the MPF industry uses fewer paper resources, but it still relies significantly on an energy and pollution-intensive transportation infrastructure.

Figure 2, shows the use of transportation for MPF worldwide. It can be noticed that every year there is a significant increase [53].

3. Optimization Solution for MPF Inventory Supply Chain Sector

Compare to other industrial sectors MPF products are influenced by the environmental factors, food processing factors, and many more. MPF supply chain and inventory need a regular and proper monitoring for an effective efficient system. This section deals with the problem statements and possible solution in optimization and reducing carbon footprints.

3.1. Problem Statement. Considering an MPF with limited inventory and stocks with an aim to provide the maximum supply to the local markets with constraints of low fuel consumption and inventory waste. It is a never-ending challenge to make the most use of resources and run efficient processes throughout the value chain [54]. From slaughtering the optimal number of animals required by completed product demand to executing the proper production cuttings, processing recipes, and manufacturing strategies in order to meet market demand. All without causing unnecessarily high CO2 emissions, overproduction of unwanted goods and waste, nonoptimal inventories, extra purchase expenses, inferior product quality, or excessive purchasing costs [55, 56]. It is critical to use resources wisely in order to meet the demand for finished goods while optimizing profits throughout the value chain. There are four points to be fulfilled for the proper inventory management in MPF:

(1) The value chain is a constantly shifting collection of gears, with individual decisions having upstream and downstream implications. With billions of possible combinations created by variables and factors at any given time, it is critical to have a system that can comprehend the complexity while also providing a clear knowledge and visibility of the implications.
(2) Based on company constraints, business laws, animal availability, and market demand, determining the correct quantity of animals and how to best utilize them through cutting and processing.
(3) Forecasts are inherently unreliable and mistakes have a significant impact on the efficiency and profitability of production. At the same time, the value chain is always changing due to demand, animal inbounds, and cutting and processing options, posing a high danger of stockpiling unwanted meat when meeting short- and long-term need.
(4) Reducing the carbon footprints by maximizing the transportation logistic with full capacity load every time with low numbers of round.

3.2. Optimization Model Using Data Analytics. As competition and performance pressure rise, more Advanced Analytics and Artificial Intelligence tools and techniques are necessary. These tools aid decision-making at any point in the value chain and at any time [57]. The first step in our approach for providing this help is to explore and exploit the customer's data, which is a valuable resource and the basis for the rest of the components in this hierarchy [58]. Iterating with the data can be used to derive information about how materials and processes are connected. Figure 3, shows the steps which is applied in the data analytics for every optimization techniques. It has 5 basic steps which are stated as follows:

(1) Data: large data are required especially historical and real time.
(2) Information extraction: using the data basic information is gathered like questionaries with when,

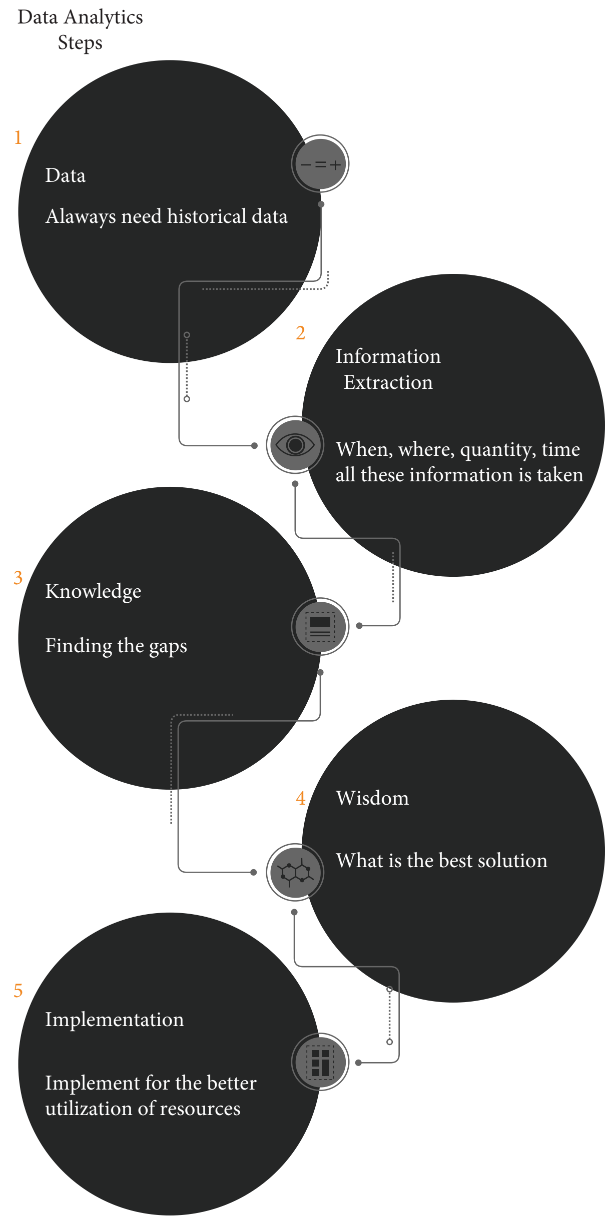

FIGURE 3: Data analytics steps.

where, timing, so that maximum details can be obtained for future purpose.

(3) Knowledge: using the data and information extraction the gap is identified for the better solution

(4) Wisdom: finding the best solution among different options.

(5) Implementation: It is a final stage where implementation is done for results validations and verification.

Now, the overall process used by the data analytics to optimize the MPF is shown in the flow chart in Figure 4. The process will undergo various stages before the carbon footprint has been released. The IOT system will analyze the data for the optimized stock. Both steps take data analytics as an input to process the final result for the farm to run and optimize. First, the data analytics helps to keep the data clean and useable for the process. Then the data is sent through the IoT to the inventory which helps to reduce the overall inventory loss and help to achieve the carbon foot print reduction. The feedback is obtained from the final retailers for the upcoming requirements.

4. Result and Discussion

Using the data analytics and IoT as a part for MPF supply chain inventory optimization, the results show that there is lot of scope to be achieved. Figure 5 shows the demand-supply optimization in MPF products. The data is analysed for six consecutive days and it was found that a very few error is present. It is clear from the bar diagram that by utilising IoT in supply chain management, logistics partners

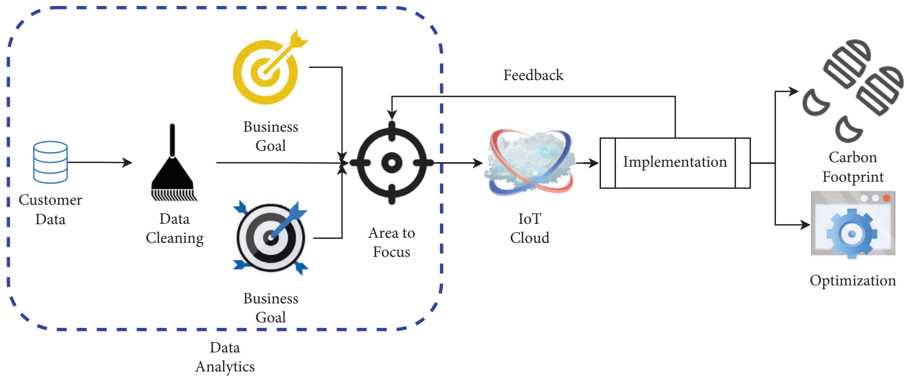

FIGURE 4: Data analytics for MPF inventory and carbon footprint.

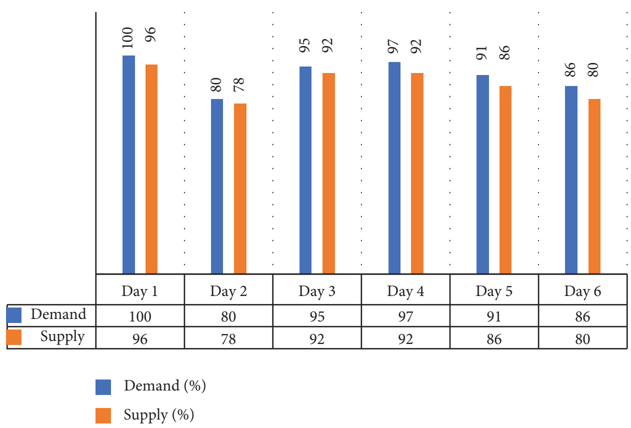

FIGURE 5: Demand supply optimization.

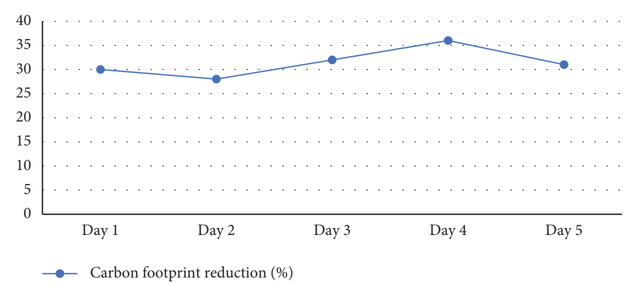

FIGURE 6: Reduction in carbon footprints.

may collect and use data for enhanced inventory management, transportation, and incident response.

For this data analysis open source excel and online data is used of the local market. As there is minimum error in the supply and demand so the logistic under-load is eliminated due to which there is an overall reduction in carbon emission in the environment. So the carbon footprints are reduced as shown in Figure 6. This shows a great upsurge in the supply chain network. Reduction in the carbon foot prints reveals the growth of the market and thus provides the maximum supply to the local markets with constraints of low fuel consumption and inventory waste. The application of data-driven techniques for MPF business patterns and performance is known as big data and analytics for retail. Big data or data science in retail, on a higher level, is the application of business analytics techniques in the retail sector.

By factoring in seasonality and lead times, effective inventory optimization tools can assess a large chunk of historical sales and forecast inventory future demand. Furthermore, inventory optimization approaches can provide insights into client preferences, product performance, and channel performance in the age of big data. The big data analytics, Industrial Internet of Things (IIoT), automation, and other related technologies are assisting in supply chain optimization all around the world. Manufacturers have never had such high levels of visibility into their supply chain processes as they do now. You may come up with strategies that have a major influence on your supply chain if you collect reliable data and ask strategic questions during your study. These tactics can have an impact on a variety of business metrics, including revenue, productivity, and customer happiness.

5. Conclusion

The capacity to easily collect and combine data on your items and their movement is one benefit of digitizing your supply chain. This information is useful to you as a producer or maker, but it is also useful to others. Other parties, such as your raw materials supplier and shipping partner, will be able to use this information to improve their supply chain processes, which will help your operations. The goal is to find metrics to assess and challenges to tackle by collaborating across departments and with important suppliers. Each department may have its own information needs and a unique viewpoint on how different data types affect its operations. Engineers would want to look for patterns that forecast system problems, sales managers might want to check how well a new product sells in a certain store, and customer care teams might want to track item returns. The killing, processing, packing, and distribution of animals like poultry, cattle, sheep, and other livestock are all handled by the meat business. Unlike veggies, which must go through a preparatory blanching procedure to deactivate enzymes, which results in a significant loss of moisture nutrients, meat is frozen without any prior treatment. Therefore, aside from vitamin E, there is little to no nutrient loss during the freezing process and, as far as trustworthy evidence is concerned, during frozen storage. While being frozen, proteins stay the same, but lipids might get rancid. Meat products, as a special commodity, have cross-industry and cross-region features. As a result, the supply chain for beef products is more stringent. However, due to the current state of the global logistics supply chain, the hidden danger of meat food safety has increased. As a result, it is critical to integrate the food supply chain process, achieve vertical supply chain integration, optimize the process of the entire food supply chain, and reduce supply time. So the data analytics can provide a better opportunity to tackle both problems i.e., the optimization and reduction of carbon footprints.Quality-controlled logistics for perishable commodities that take into consideration supplier decisions to send out alternative shipments, engineers to make changes, and the possibility of customers seeking an alternative provider.

Data Availability

The data is available on request to the corresponding author.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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