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Research on Optimization of Agricultural Products Cold Chain Logistics Distribution System Based on Low Carbon Perspective

Chunrong Ni, Liaoning Vocational College of Light Industry, China
Katarzyna Dohn, Silesian University of Technology, Poland*

ABSTRACT

Based on thindiscussion of the traditional agricultural product distribution model, this article establishes a low-carbon perspective of urban agricultural product co-distribution model to reduce the level of agricultural product circulation and reduce the impact of distribution activities on the environment. By comprehensively considering the factors affecting carbon emissions in the vehicle delivery process, the fuel consumption and carbon emissions estimation models of delivery vehicles are analyzed and put forward. A mathematical model for the optimization of urban agricultural product cold chain distribution routes from a low-carbon perspective is established. This article takes a logistics center as an example, selects genetic algorithm as the model solution method, optimizes the distribution route, and obtains the corresponding result, thus verifying the rationality and feasibility of the model.

KEYWORDS

Agricultural Products, Cold Chain, Genetic Algorithm, Low Carbon, Path Optimization

INTRODUCTION

Agriculture plays a crucial role in national economic development, and the well-being of the agricultural sector and its related industries is closely tied to the overall economic progress and social stability of a country (Pan, 2021). In recent years, China has made significant adjustments to its agricultural industry structure, leading to continuous advancements and transformations in the agricultural economy. As a result, China has consistently ranked among the top producers of agricultural products worldwide. Moreover, there has been a shift in the consumption patterns of agricultural goods, moving away from traditional grain-based diets towards a diversified range of fresh vegetables, fruits, and meats (Bai, 2021). This evolution in dietary preferences has also raised expectations for higher product quality.

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In the search for ways to ensure product quality and minimize losses, cold chain logistics offers distinct advantages over conventional temperature-controlled transportation methods. By effectively managing temperatures throughout the supply chain, cold chain logistics helps to maintain the integrity and freshness of perishable products (Zhu, 2021). As the importance of maintaining a robust food cold chain has been recognized, there has been an unprecedented focus on and investment in cold chain logistics (Sheng, 2021). Despite the rapid development of the cold chain logistics industry, since China has been later than other countries to develop cold chain logistics, there is still a considerable gap in this regard between China and other developed countries. On the one hand, establishing the cold chain infrastructure is a difficult project (Behzadi, et al., 2013). Cold storage refrigerated trucks are widely distributed in eastern coastal areas, but less so in inland western areas. This uneven distribution leads to functional imbalance (Chen, 2021). The current network of facilities is far from meeting market demand. On the other hand, the cold chain circulation rate is not high (Gunasekaran & Ngai, 2012). Most agricultural products are kept at room temperature throughout the entire cold chain logistics link; the links from production to transportation to sales lack systemicity and continuity, and the "broken chain" phenomenon sometimes occurs, resulting in serious loss of agricultural product quality.

Logistics and supply chain operations, often referred to as the "third source of profit" for modern enterprises, are also responsible for significant fossil fuel consumption and carbon emissions (Hao et al., 2017). According to the Stern Report, the logistics industry contributes approximately one-seventh of total global greenhouse gas emissions, primarily through the production of carbon dioxide and other greenhouse gases. Unlike regular temperature-controlled logistics, cold chain logistics requires maintaining low temperatures throughout various stages, from raw material production and processing to transportation, sales, and final consumption. Consequently, cold chain logistics consumes more energy to ensure the quality and integrity of perishable goods (De La Fuente & Ros-McDonnell., 2013).

In the United Kingdom, for example, the food processing, retail, and catering industries collectively account for 3.7% of total greenhouse gas emissions. Within this category, the greenhouse gases produced by cold chain preservation alone contribute 2.5% of the country's emissions. This number highlights the significant environmental impact of cold chain logistics caused by its high energy consumption and carbon emissions. Therefore, it has become crucial to transform cold chain logistics from a big energy consumer to a low-carbon industry in order to align with the new era of low-carbon economic development. Optimizing transportation routes offers an effective approach to reducing carbon emissions (Montanari, 2008).

Some scholars have incorporated the perishability of fresh food and transportation time into cold chain distribution route optimization models. They have utilized methods such as taboo search to find the optimal solutions to these problems (Delice et al., 2009). Furthermore, researchers have developed mixed-integer linear programming (MILP) models to design optimal cold chain logistics distribution networks for various fresh agricultural products. They have employed hybrid optimization techniques to optimize the entire distribution network (Khezrimotlagh et al., 2013).

To establish sustainable fresh produce supply chain networks, scholars have analyzed two-layer path optimization problems considering time window constraints (Jin & Edmunds, 2015). They have also designed multi-objective optimization models (Pokharel, 2008) and proposed a hybrid optimization algorithm that combines variable domain search with a multi-objective particle swarm optimization algorithm (Yeh, 2005) to achieve the desired results. These research efforts aim to improve the efficiency and sustainability of cold chain logistics, reducing energy consumption and carbon emissions in the process.

Currently, there has been significant research conducted on both agricultural cold chain logistics and low-carbon vehicle routing. However, there remains a scarcity of literature that directly focuses on the integration of these two fields; there is also a lack of quantitative analysis of carbon emission calculations (Xu et al., 2015).

This paper aims to address this gap by focusing on the cold chain distribution system for agricultural products. It establishes an optimization model for cold chain logistics distribution under