

ABSTRACT

Distribution and transportation play a crucial role in the supply chain of livestock products, particularly those that are highly perishable, such as fresh milk. Speed, timeliness, and cost efficiency in the distribution process directly affect the quality of products received by end consumers. If distribution is not carried out promptly and efficiently, the risk of microbial contamination and quality degradation of the milk increases, ultimately impacting its shelf life and safety.

In Indonesia, the dairy farming industry is still largely managed by small-scale farmers operating with traditional methods. Nevertheless, the sector continues to show positive growth. Data from Statistics Indonesia (Badan Pusat Statistik/BPS) indicates a significant annual increase in national milk production. One of the leading provinces in fresh milk production is West Java. In this region, the North Bandung Dairy Cooperative (Koperasi Peternakan Susu Sapi Bandung Utara/KPSBU) plays a vital role as the institution responsible for collecting and distributing milk from various Cooperative Collection Points (Tempat Pelayanan Koperasi/TPK) scattered across surrounding areas.

Operationally, KPSBU is tasked with transporting fresh milk from each TPK to a Cooling Unit (CU) within a maximum of two hours after milking. This time limit is a critical factor in ensuring the freshness and safety of the product. Therefore, optimal route planning is essential to ensure that all locations are served punctually while using transportation resources efficiently.

However, designing such a distribution system comes with several challenges. In addition to the time constraint, the wide geographic dispersion of TPKs, varying daily demand volumes, and the limited capacity of available vehicles increase the complexity of route planning. Moreover, fuel consumption accounts for the largest portion of KPSBU's transportation costs about 62% of the total daily logistics expenses.

On the other hand, road infrastructure conditions in the distribution area, especially in and around the Lembang region, are also a key factor influencing the effectiveness of distribution. The region is characterized by hilly terrain and narrow

roads, which can significantly increase travel time beyond normal estimates. Vehicles often need to slow down due to damaged roads, sharp turns, steep inclines, or traffic congestion during peak hours particularly near tourist spots. These factors necessitate more careful route mapping and flexibility in scheduling for distributions in such area.

Given these conditions, this study proposes a distribution planning approach using the Vehicle Routing Problem with Heterogeneous Fleet and Time Windows for Perishable Products (VRPHFTW-P) model. This model considers the heterogeneity of the vehicle fleet, time window constraints, and the sensitivity of perishable products to delays. The Two Phase Tabu Search (TPTS) method is employed as the metaheuristic optimization technique, known for its capability to solve complex optimization problems involving multiple constraints.

Simulation results indicate that TPTS can generate more efficient routing solutions compared to the initial conditions. Total travel distance decreased by 7.22%, and fuel cost savings were also recorded at 7.51%. These results demonstrate that the proposed method is effective in reducing fuel costs while still ensuring timely deliveries and maintaining service quality for distributing perishable products like fresh milk. This approach is expected to serve as a logistical planning model that can be implemented by similar livestock cooperatives throughout Indonesia.

Keywords – Milk Distribution, VRPHFTW, Perishable Product, Two Phase Tabu Search