UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

Faculty of Engineering

Exposé for a case study for the

attainment of the degree of

Master of Science in Logistics Engineering

on the Topic

Implementing the Digital Twin model in the Lentil Food Supply chain to reduce wastage.

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Introduction of the Case Study

Nowadays a variety of technologies have been implemented to improve the efficiency of the food supply chain (FSC`s). Due to high demand in the market, regulations, and cost-effectiveness, new challenges are arising that require innovative and efficient solutions. As a result, increasing efficiency through effective, integrated smart technologies and approaches like digital twins (DTs) has been actively addressed in recent years. A Digital Twin is a digital representation of an asset that provides better insight into its dynamics by combining *a priori* knowledge of the system through mathematical models with online data acquired from sensors and instruments deployed in or at the physical asset.

This proposal focuses on using Digital Twin technology to model the lentil supply chain, from farm-level production to processing and distribution, focusing on improving sustainability, optimizing facility locations, and reducing waste. Lentils are a high-protein, low environmental-impact food source, one of the oldest cultivated crops. Understanding how to optimize lentil supply chains using Digital Twins could have significant benefits for reducing food waste, improving logistics, and enhancing the resilience of the supply chain as an essential consideration in today's fast-paced global trade environment.

Background

Minimizing post-harvest losses in lentils is crucial due to issues such microbial infection, inadequate temperature and moisture control, and deteriorating seed quality. Lentils that contain more than 14% humidity are especially prone to deterioration, browning, and nutritional loss. By optimizing storage conditions including temperature, relative humidity (RH), and aeration, researchers aim to maintain seed quality.

Better drying methods are crucial since the increased heat from conventional mechanical drying frequently deteriorates quality. Energy-efficient, temperature-

controlled drying techniques preserve nutritional value and reduce microbial activity. Shelf life can be increased and discoloration can be prevented with controlled storage at low relative humidity and moderate temperatures.

For minimizing waste and enhance the quality of lentils, modern technologies like automated drying and environmental sensors are being developed to track and adjust circumstances in real time. In the lentil supply chain, improved handling, better storage facilities, and efficient temperature management are essential for lowering post-harvest losses.

Problem Statement

Current Food supply chain models do not adequately address issues such as resource optimization, waste reduction, or sustainability, and there is a significant gap in the use of advanced technologies like Digital Twins to monitor and optimize the supply chain.

The lentil supply chain as an increasing plant-based foo movement, which is affected by inefficiencies such as an inadequate storage condition, and a lack of integration across the various stages of production, processing, and distribution. The lack of efficient network design and real-time data integration further

contributes to waste, increased carbon footprint, and suboptimal logistical planning.

The aim of this study is to address these issues by exploring the application of Digital Twin technology in the lentil supply chain to create a model that enhances sustainability, storage capabilities, optimal network design, and waste reduction.

Objectives of the Study

Creating a Digital Twin Model Focused on Post-Harvest Waste Reduction and Spoilage Prevention

- Simulating the post-harvest supply chain for lentils using the Digital Twin model. The main focus is on storage and transportation to monitor, identify and reduce food waste. Enabling real-time monitoring of conditions (e.g. temperature) to proactively intervene and prevent spoilage.

Optimize Temperature Management in Storage and Transportation and analyse Environmental Impacts

- Integrate temperature control into the digital twin model. This optimises storage and transport conditions, preventing spoilage and minimising waste. Assess the energy consumption and carbon footprint of temperature management. Look for sustainable methods that reduce waste and maintain quality.

Methodology

Data Collection

- Primary data to be collected to learn more about the temperature, humidity, and moisture levels at various stages during supply chain.
- Use case studies, research articles, and other industrial reports to understand the Digital Twin model.

Modeling and Optimization

- In order to enhance temperature and moisture management, minimize spoilage, and save energy, a modeling tool is used to create a digital twin of the lentil supply chain.

Results Analysis

- An organized method for evaluating and contrasting the results of several tests, or situations for an comparative overview.

Expected outcomes

Acquiring information through the simulation of this Digital Twin focusing on Lentil supply chain to enhance Storage conditions, improving Transportation and waste reduction. This Digital Twin model provides us with the beforehand information (Forecasting, locations of facilities, etc) to provide efficient ways for a sustainable lentil food supply chain.

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