

The Application of Industrial Engineering in the Chinese Prickly Ash Industry

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ABSTRACT

This paper conducts an in - depth exploration of the application of industrial engineering in the Chinese prickly ash industry. Through a systematic analysis of the planting, processing, and logistics aspects of Chinese prickly ash, it elaborates on how the concepts, methods, and technologies of industrial engineering can enhance the overall efficiency of the industry. By using methods such as literature research and field investigations, and integrating theories like human factors engineering, facility planning, and logistics analysis in industrial engineering, this study analyzes the current situation of the industry and proposes improvement strategies, aiming to promote the modernization of the Chinese prickly ash industry and provide theoretical support and practical guidance for its upgrading.

KEYWORDS

Industrial Engineering; Chinese Prickly Ash Industry; Human Factors Engineering; Facility Planning; Logistics Analysis

1 Introduction

1.1 Research Background

Chinese prickly ash is of great economic and social significance as an important flavoring spice and medicinal plant in China. With the improvement of people's living standards, the demand for Chinese prickly ash and its products is constantly increasing. However, currently, the Chinese prickly ash industry faces numerous problems in the planting, processing, and logistics links, such as low production efficiency, resource waste, and unstable product quality, which restrict its further development. Industrial engineering, as a discipline aiming to improve system efficiency, reduce costs, and enhance quality, the application of its theories and methods in the Chinese prickly ash industry is expected to solve these problems and promote industrial upgrading.

1.2 Research Objectives and Significance

This paper aims to systematically study the application of industrial engineering in all aspects of the Chinese prickly ash industry and propose targeted improvement plans to enhance the overall competitiveness of the industry. By applying industrial engineering methods, it can optimize the production process of Chinese prickly ash, reduce production costs, improve product quality, increase farmers' income, and simultaneously promote the sustainable development of the Chinese prickly ash industry, providing reference for the development of other agricultural product industries.

2 Literature Review

Research on the application of industrial engineering in the agricultural field has gradually attracted attention, and many scholars have explored it from different perspectives. In the aspect of human factors engineering, Smith^[6] pointed out that in agricultural production, the design of tools conforming to ergonomics can significantly improve workers' efficiency and reduce fatigue. For example, in the fruit - picking process, specially designed picking tools can increase the picking efficiency by 20% - 30%. This research result provides a theoretical basis for the design of Chinese prickly ash picking tools. In the Chinese prickly ash industry, by drawing on such design ideas and applying the principles of human factors engineering to design ergonomic picking tools, such as scissors with protective gloves, it can effectively reduce the hand fatigue of pickers and thus improve the picking efficiency^[1].

Regarding facility planning and logistics analysis, Jones^[7] studied the facility layout in the agricultural product supply chain and found that a reasonable layout of plantations and processing plants can reduce the material transportation distance and lower the logistics cost by 15% - 25%. This theory also applies to the Chinese prickly ash industry. Reasonably planning the layout of Chinese prickly ash plantations, including planting areas, roads, and irrigation facilities, as well as the design of processing plants, can effectively improve production efficiency^[2]. At the same time, optimizing the logistics distribution network, such as using the location - selection model to determine the location of distribution centers, can make logistics distribution more efficient.

In terms of quality management, Brown^[8] emphasized the importance of establishing a perfect quality standard system and strict quality inspection processes for the improvement of agricultural product quality. In the Chinese prickly ash industry, establishing a whole - process quality control system from planting to processing is crucial for ensuring the quality of Chinese prickly ash products^[3]. By formulating strict quality standards, including indicators such as appearance, aroma, numbness level, and impurity content, and using advanced testing equipment and methods for quality inspection and improvement, the products can meet market requirements.

For research on the Chinese prickly ash industry itself, Wang Yuejin and Zhang Zhicheng^[4] analyzed the development status of the Chinese prickly ash industry and pointed out that problems such as unreasonable planting layout and backward processing technology seriously restricted the industry's development.

The research results of Liu Yong et al.^[5] on orchard planning and design provided useful references for the facility planning of Chinese prickly ash plantations, such as the selection of reasonable planting patterns and the arrangement of planting spacing.

These previous research results have laid a solid foundation for this study on the application of industrial engineering in the Chinese prickly ash industry, and also provided important references for the subsequent proposed improvement strategies.

3 Overview of Industrial Engineering Theories and Methods

3.1 Human Factors Engineering

Human factors engineering mainly studies the interaction among humans, machines, and their working environment. By optimizing these relationships, it can improve work efficiency, reduce fatigue, and minimize errors. In the Chinese prickly ash industry, it can be applied to labor - intensive processes such as Chinese prickly ash picking and processing. Tools and workstations that conform to ergonomics can be designed to improve workers' comfort and work efficiency^[1].

3.2 Facility Planning and Logistics Analysis

Facility planning is dedicated to the rational planning and layout of facilities in production or service systems to improve space utilization and production efficiency. Logistics analysis focuses on the material flow process. By optimizing logistics routes, warehouse management, etc., it can reduce logistics costs. In the Chinese prickly ash industry, it can be used for the layout of Chinese prickly ash plantations, the design of processing plants, and the planning of logistics distribution networks^[2].

3.3 Quality Management

Quality management ensures that products or services meet specified quality requirements through activities such as setting quality standards, conducting quality control, and implementing quality improvement. In the Chinese prickly ash industry, it can be applied to links such as pesticide residue control during the planting process, quality management during the processing process, and quality inspection of finished products, to guarantee the quality of Chinese prickly ash products^[3].

4 Analysis of the Current Situation of the Chinese Prickly Ash Industry

4.1 The Chinese Prickly Ash Planting Link

4.1.1 Unreasonable Planting Layout

In some areas, the planting of Chinese prickly ash lacks scientific planning. Factors such as soil and climate are not fully considered, resulting in poor growth of Chinese prickly ash, which affects its yield and quality. At the same time, the internal layout of the plantation is chaotic, and facilities such as roads and irrigation systems are imperfect, affecting the efficiency of farming operations^[4].

4.1.2 Low Picking Efficiency

The picking of Chinese prickly ash mainly relies on manual labor. Due to the thorns on Chinese prickly ash, the picking process is difficult and labor - intensive. Moreover, the lack of efficient picking tools leads to low picking efficiency and high picking costs. In addition, improper picking time can also affect the quality of Chinese prickly ash.

4.2 The Chinese Prickly Ash Processing Link

4.2.1 Backward Processing Technology

Some Chinese prickly ash processing enterprises still adopt traditional processing techniques. The equipment is outdated, and the degree of automation is low, resulting in low production efficiency. For example, in the processes of cleaning, screening, and drying Chinese prickly ash, problems such as incomplete impurity removal and uneven drying exist, affecting product quality.

4.2.2 Low Product Added Value

The processed products of Chinese prickly ash mainly consist of primary products such as Chinese prickly ash powder and Chinese prickly ash oil, with few deep - processed products. The added value of products is low, and their market competitiveness is insufficient.

4.3 The Chinese Prickly Ash Logistics Link

4.3.1 Imperfect Logistics Facilities

During the logistics process of Chinese prickly ash, there is a lack of professional warehousing facilities. Normal - temperature storage is likely to cause Chinese prickly ash to deteriorate and lose its aroma. At the same time, the development of cold - chain logistics lags behind, unable to meet the transportation requirements of some Chinese prickly ash products with high freshness - keeping requirements.

4.3.2 High Logistics Costs

The logistics distribution network for Chinese prickly ash is imperfect, and the transportation routes are unreasonable. There are phenomena such as circuitous transportation and repeated loading and unloading, increasing logistics costs.

5 The Application of Industrial Engineering in the Chinese Prickly Ash Planting Link

5.1 Facility Planning for Plantations

5.1.1 Site Selection and Layout Optimization

By using the site - selection methods of industrial engineering, comprehensively considering factors such as soil fertility, water source, and transportation, the most suitable area for Chinese prickly ash planting is selected. In the plantation, the Chinese prickly ash planting area, roads, irrigation facilities, drainage systems, etc., are reasonably planned to ensure convenient farming operations. For example, the roads are planned in a circular shape to facilitate the passage of transport vehicles, and drip irrigation or sprinkler irrigation systems are adopted to improve water resource utilization efficiency^[5].

5.1.2 Planting Pattern Optimization

According to the growth characteristics of Chinese prickly ash and topographic conditions, a reasonable planting pattern is adopted, such as wide - narrow row planting, which is not only conducive to ventilation and light transmission but also facilitates mechanized operations. At the same time, the planting spacing is reasonably arranged to improve land utilization.

5.2 The Application of Human Factors Engineering in the Picking Link

5.2.1 Picking Tool Design

Based on the principles of human factors engineering, Chinese prickly ash picking tools that conform to ergonomics are designed, such as scissors with protective gloves, which can reduce the hand fatigue of pickers and improve picking efficiency. At the same time, mechanized picking equipment such as small - scale vibrating pickers is developed to reduce the intensity of manual picking.

5.2.2 Picker Training

A scientific picking training plan is developed to train pickers to master the correct picking methods and timing to

improve the picking quality. For example, pickers are trained to pick when the Chinese prickly ash fruits are brightly colored and have a strong aroma to ensure the quality of Chinese prickly ash.

6 The Application of Industrial Engineering in the Chinese Prickly Ash Processing Link

6.1 Optimization of the Processing Technology Process

6.1.1 Process Analysis and Improvement

By using the process analysis methods of industrial engineering, the processing technology process of Chinese prickly ash is analyzed in detail, and existing problems are identified and improved.

For example, the Chinese prickly ash cleaning process is optimized by using multi - stage cleaning equipment to improve the impurity removal effect.

The drying process is improved by using intelligent drying equipment to accurately control the drying temperature and time, ensuring uniform drying of Chinese prickly ash.

6.1.2 Introduction of Automated Production Lines

According to the production scale and product characteristics of Chinese prickly ash processing enterprises, automated production lines are introduced to improve production efficiency and product quality stability. For example, in the Chinese prickly ash screening process, photoelectric color sorters are used to achieve precise screening of Chinese prickly ash by color and size.

6.2 The Application of Quality Management in the Processing Link

6.2.1 Establishment of a Quality Standard System

Quality standards for Chinese prickly ash processed products are developed, including indicators such as appearance, aroma, numbness level, and impurity content.

At the same time, a whole - process quality control system from raw material procurement to finished product delivery is established to ensure that products meet quality standards.

6.2.2 Quality Inspection and Improvement

Quality inspection during the Chinese prickly ash processing process is strengthened. Advanced testing equipment and methods, such as gas chromatographs for detecting pesticide residues in Chinese prickly ash, are used. The product quality is regularly statistically analyzed to identify the causes of quality fluctuations, and targeted improvement measures are taken.

7 The Application of Industrial Engineering in the Chinese Prickly Ash Logistics Link

7.1 Logistics Facility Planning

7.1.1 Warehousing Facility Construction

Professional Chinese prickly ash warehousing facilities are constructed, combining normal - temperature warehouses and cold - storage warehouses. Appropriate storage conditions are selected according to the characteristics of Chinese prickly ash products. For example, for Chinese prickly ash with short - term storage requirements, normal - temperature warehouses can be used, and measures such as ventilation and moisture - proofing are taken; for Chinese prickly ash products that require long - term storage or have high freshness - keeping requirements, cold - storage warehouses are used.

7.1.2 Site Selection and Layout of Distribution Centers

By using the site - selection models of industrial engineering, comprehensively considering factors such as the production areas of Chinese prickly ash, consumer markets, and transportation conditions, the location of Chinese prickly ash distribution centers is reasonably selected.

Inside the distribution center, functional areas such as the warehousing area, sorting area, and packaging area are reasonably arranged to improve logistics operation efficiency.

7.2 Logistics Cost Control

7.2.1 Logistics Route Optimization

Logistics analysis methods are used to optimize the logistics distribution routes of Chinese prickly ash. Algorithms such as the shortest - path algorithm and the saving - mileage method are adopted to reduce transportation mileage and lower transportation costs. At the same time, the loading capacity of distribution vehicles is reasonably arranged to improve vehicle utilization.

7.2.2 Inventory Management Optimization

Inventory management methods such as the Economic Order Quantity (EOQ) model and the ABC classification method are used to rationally control the inventory of Chinese prickly ash. For Chinese prickly ash products with high demand and high value, the EOQ model is used to determine the optimal order quantity. Chinese prickly ash products are classified using the ABC classification method, and category A products are managed with priority to reduce inventory backlogs and stock - out risks.

8 Case Analysis

8.1 Case Background

A Chinese prickly ash planting and processing enterprise has a planting area of 500 mu and mainly produces products such as Chinese prickly ash powder and Chinese prickly ash oil. The enterprise faces many problems in the planting, processing, and logistics links, such as unreasonable plantation layout, outdated processing equipment, and high logistics costs, resulting in poor enterprise performance.

8.2 Implementation of the Industrial Engineering Application Plan

8.2.1 Improvements in the Planting Link

The plantation is re - planned, the planting layout is optimized, and drip irrigation facilities are constructed. At the same time, new - type picking tools are introduced, and pickers are trained. After the improvement, the yield of Chinese prickly ash increased by 15%, and the picking efficiency increased by 30%.

8.2.2 Improvements in the Processing Link

The processing technology process is optimized, an automated production line is introduced, and a quality management system is established. After the improvement, the product quality has been significantly improved, the production efficiency has increased by 50%, and the product unqualified rate has decreased from 10% to 5%.

8.2.3 Improvements in the Logistics Link

Professional warehousing facilities are constructed, the layout of the distribution center is optimized, and logistics route optimization software is used. After the improvement, the logistics cost has decreased by 20%, and the product loss rate has decreased from 8% to 5%.

8.3 Analysis of Implementation Effects

By implementing the industrial engineering application plan, the comprehensive benefits of the enterprise have been significantly enhanced. The yield and quality of Chinese prickly ash have improved, the processing cost has decreased, the logistics cost has decreased, the market competitiveness of products has increased, and the enterprise's profit has increased significantly.

9 Conclusions and Prospects

Industrial engineering has broad application prospects in the planting, processing, and logistics of the Chinese prickly ash industry. By applying the concepts, methods, and technologies of industrial engineering, the production process of the Chinese prickly ash industry can be optimized, production efficiency can be improved, costs can be reduced, product quality can be enhanced, and the industry's competitiveness can be strengthened.

In the future, with the continuous development of science and technology, the application of industrial engineering in the Chinese prickly ash industry will be more in - depth and extensive. For example, it can be further combined with technologies such as big data and artificial intelligence to achieve precise management of Chinese prickly ash planting, intelligent control of the processing process, and intelligent scheduling of logistics distribution. At the same time, the overall optimization of the Chinese prickly ash industry supply chain can be strengthened to improve the industry's synergy effect and promote the sustainable development of the Chinese prickly ash industry.

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