"Spices Master" Intelligent Management System for Sri Lankan Spice Market Using Machine Learning

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Abstract - **The intelligent management system for Sri Lankan spice market using machine learning is a technology-based solution to streamline the management of the Sri Lankan spice market. The system uses machine learning algorithms to analyze and forecast market trends, enabling industry stakeholders to make informed decisions. The system collects data from various sources, such as historical sales data, weather forecasts, geopolitical events, and other relevant factors that can affect the market. We then use machine learning algorithms to analyze the data to provide insights that help optimize supply chains, improve pricing strategies, and identify new market opportunities. This intelligent management system enables stakeholders to make data-driven decisions that reduce waste, reduce costs, and improve overall efficiency in the spice market. The system also helps stakeholders adapt to changing market conditions and stay ahead of their competitors. Overall, an intelligent Sri Lanka spice market management system powered by machine learning is a powerful tool that will revolutionize how the spice market works and bring significant benefits to all stakeholders in the industry.**

Keywords: forecasts, geopolitical, intelligent, algorithms, analyze.

I. INTRODUCTION

Sri Lanka is known for its wide variety of spices, of which cinnamon, cloves and pepper are the most famous crops. Sri Lanka is the world's largest producer of Ceylon cinnamon, also known as true cinnamon, and is prized for its aroma and flavor [1]. In addition to cinnamon, Sri Lanka is a major producer of pepper, either grown in monocultures or alongside other crops such as coffee, tea, areca nut and coconut [4]. The country also exports significant amounts of cloves, cardamom, nutmeg, mace and vanilla [3]. Cinnamon is one of the most important spices in Sri Lankan cuisine and is used in a wide variety of dishes, sauces, gravies and sweets. It pairs well with other spices such as cloves, curry leaves, and pandan leaves, and is known for its medicinal properties such as relieving urinary tract disorders and improving blood circulation [5]. Imperial Spices (Private) Limited is he one of

the largest exporters of Sri Lanka's finest spices, including cinnamon, pepper, cloves, nutmeg and various oils[6].

Cloves are another important spice plant in Sri Lanka with a unique aroma and flavor used in many dishes such as curries, stews and marinades. Cloves are also known for their medicinal properties, including aiding digestion and reducing inflammation [8]. Sri Lanka is a major exporter of cloves, along with other spices such as cardamom, nutmeg and mace [3]. Pepper is another spice plant widely used in Sri Lanka. The country is a major exporter of black pepper, grown as a monoculture and intercropped with other crops such as coffee, tea, areca nut and coconut. Known for its tangy flavor, pepper is used in a variety of dishes, especially curries, soups and stews [2]. Sri Lanka is known for its diverse and high-quality spice production, with cinnamon, cloves and pepper being the best-known spice plants. These spices are used in a variety of dishes and are also known for their medicinal properties. It is Sri Lanka's spice industry is a major contributor to the country's economy, with exports of spices and related products being a major source of income [3].

The country is one of the world's leading exporters of these spices, and its exports have steadily increased over the years due to the use of modern technology and compliance with global standards [13]. SpiceSriLanka.com is a renowned supplier and exporter of authentic and pure plantation grown Sri Lankan spices. They have been exporting spices to the US and Europe for the past 20 years [15]. Similarly, Lakspice is a major exporter of top quality Ceylon He spices including cinnamon, pepper, cloves and nutmeg, freshly sourced ethically from local farmers [8]. Imperial Spices (Pvt) Ltd, a subsidiary of Imperial Teas (Pvt) Ltd, is focused on exporting the finest ethical and chemical-free Sri Lankan spices, primarily cinnamon, pepper, cloves and nutmeg. [14]. RTS Spices is also an importer and exporter of various Sri Lankan spices such as fresh and ground Ceylon cinnamon, whole and ground black pepper, cloves and curry spices [11]. Sri Lanka Business, the official website of the Sri Lanka Export Development Board, says that Sri Lanka is known for the variety and quality of spices it offers and that its spice exports are at record highs. Sri Lankan spices range from Ceylon cinnamon to cardamom, pepper, cloves, nutmeg and more [10,

12]. Sri Lanka has a thriving spice market for cinnamon, pepper and cloves, with several reputable suppliers and exporters of these spices. The growing demand for Sri Lankan spices in the global market is a testament to their high quality and authenticity.

II. LITERATURE REVIEW

The research conducted by Sandamali H. A. C. and Liyanage C. R. aimed to develop an image processing approach to detect the quality of cinnamon sticks [16]. This study found that the traditional method of determining the quality grade of cinnamon relies on the experience and knowledge of habitual collectors, resulting in inaccurate grading. , researchers proposed an image design method that could automatically detect the quality level of cinnamon without the need for specialized knowledge. Cinnamon quality was measured based on several factors such as diameter, ash content, length and color. We trained a machine learning model to classify sticks into different quality levels. The proposed method achieved 91.67% accuracy in determining the quality grade of cinnamon sticks. This study demonstrates the potential to accurately classify cinnamon sticks using image processing and machine learning techniques, which may benefit both farmers and buyers of the cinnamon industry, can also be applied to classify other types of spices and agricultural products to provide a reliable and objective classification system.

Each district of Sri Lanka has different weather patterns that affect the growth and yield of spice crops such as cinnamon, cloves and pepper. It requires a hot and humid climate of ~2,500 mm [17][19]. The ideal temperature for black pepper is around 28°C, while the optimum soil temperature for root growth is 26-28°C [17]. Cinnamon is he one of the major foreign currency earners among Sri Lanka's agricultural exports. Native to Sri Lanka, it is also grown in South America and the West Indies [20]. Cinnamon requires a hot and humid climate with annual rainfall of at least 1,500 mm and an average temperature of 27-30 °C [21]. Cloves are grown in the wetlands of central Sri Lanka, including the Kandy, Kegalle and Matale districts. Sri Lanka produces an average of 5301 tons of cloves per year and requires a hot and humid climate with annual rainfall of at least 2,000 mm and an average temperature of 24-28 °C [18][21]. Soil conditions also play an important role in plant selection. The most common soil types in Sri Lanka are reddish-brown soils, reddish-yellow podzols, and low-humus gray soils [21]. Therefore, farmers in different districts of Sri Lanka must consider weather and soil conditions when choosing suitable crops for cultivation.

According to the paper presented by V. S. Kolure and B. N. Shaikh [22], an automatic evaluation method has been developed to determine the quality of rice grains using image processing and neural network techniques. The method involves using color and geometric features to determine the quality of rice samples. The authors have built a model of quality grade testing and identification based on the external features of rice grains, such as area, major axis length, minor axis length, aspect ratio, morphology, and color. The authors have used image processing technology to extract different characteristics of rice grains and classify them based on their morphological characteristics. The trained neural network is then used to identify unknown grain types and their quality based on the extracted features. To enhance the image quality, the applied image is segmented using proper segmentation methods so that the edges can be effectively detected and image correction can be performed.

According to a research titled "Intelligent Crop Recommendation Systems Using Machine Learning" by P.A., S. Chakraborty, A. Kumar, and O. [23], the paper presents a machine learning-based approach to address the crop recommendation problem. The proposed system uses machine learning algorithms to predict the best crops for a given land based on various factors such as soil quality, weather conditions and historical yield data. The system uses inputs such as location, soil type, and climate information to predict the best crops to grow on a given piece of land. The proposed system aims to help farmers make informed decisions about crop selection, leading to higher yields and a better return on investment. The paper also includes experimental results demonstrating the effectiveness of the proposed approach in crop recommendation. The "intelligent crop recommendation system using machine learning" presented in the research paper provides a promising solution to farmers' crop selection problem using machine learning algorithms.

III. RESEARCH OBJECTIVES

A) Develop an integrated model that utilizes machine learning techniques to gather environmental information and provide recommendations for crop cultivation

The aim is to encourage farmers by providing them with the necessary knowledge and support to make their industry profitable. The recommendation system will take into account local conditions such as soil type, pH value, nutrient concentration, rainfall, temperature, and geographic position in terms of the state to suggest suitable crops to cultivate. Additionally, the system will also calculate the total cost of cultivation and predict the profit based on the quality of the harvest and current market prices. By doing so, the system aims to make agriculture automation a profitable and sustainable process in Sri Lanka.

To achieve the specific objectives of finding the most suitable crop for cultivation in each state for a certain soil type and climatic circumstances, as well as offering suggestions for the best local crops to grow to avoid losses, the following resources may be helpful:

- To develop a model that can accurately estimate crop sustainability in each state for a certain soil type and climatic circumstances, the research team may need to collect data on the following factors:
  - Soil type: Soil composition,
  - pH value, and nutrient concentration can impact crop growth and sustainability.
- The research team can also analyze the current market trends and demands for these crops to make an informed decision on which crops to recommend for cultivation.
- To calculate the total cost of cultivation and predict profit based on the quality of the harvest, the research team may need to gather information on the cost of seeds, fertilizers, pesticides, labor, and other factors that impact the cultivation process.
- The team can also look up the current market prices of the crops to estimate potential profits.

B) Analyzing and informing farmers about yield changes throughout the year is to help them make informed decisions regarding their crop management practices

This includes studying and understanding the factors that affect crop yield, such as weather patterns, soil conditions, and pest and disease prevalence. By monitoring these factors and providing real-time data and recommendations through a smartphone application, farmers can adjust their practices to optimize their yields and improve the overall health of their crops. This objective aims to empower farmers with the knowledge and tools they need to increase their profitability and sustainability in the long term.

- Study and understand the condition of the trees after harvesting cinnamon, pepper, and cloves. This involves analyzing the health of the tree, the quality and quantity of the yield, and any factors that may have affected the harvest.
- Provide actionable recommendations to farmers on how to achieve the same or higher yield in the next season after the first harvest. This could involve changes in fertilization or irrigation practices, pest control measures, or other adjustments to optimize tree health and yield.
- Study and understand the current market value of the crops and yield values. This involves analyzing market trends, supply and demand, and the pricing dynamics of these crops.

- Study and understand the growth of the harvest market, including demand and supply factors, and how mobile applications can be implemented to facilitate better communication and coordination among farmers, buyers, and sellers in the market.

C) Develop a machine learning model that can accurately grade the quality of harvested spices based on grade quality

Implement the model into a mobile application that can be easily used by farmers in the field. Provide real-time market prices for each grade of the spices to help farmers make informed decisions on when and where to sell their harvest. Offer personalized recommendations to farmers on how to improve the quality of their harvest based on the grading results and market demand. Create a database of historical pricing and demand trends to help farmers plan and strategize for future harvests.

- Determine how the data on the current harvest will be collected. What kind of data will be collected (weight, size, color)?
- Define the criteria for identifying the quality grade of the harvest from images. What features will be analyzed (size, shape, color, texture)? How will the algorithm learn to recognize the different grades?
- Ensure that the prices obtained from different sources are accurate and up to date. Consider how often the prices should be updated and how to handle fluctuations in market prices.
- Decide how to validate the quality grade and price predictions. Evaluate the accuracy of the algorithm and collect feedback from farmers or experts?
- Develop an algorithm to input data (harvest data, image) and output the predicted quality grade, price, and recommendations.
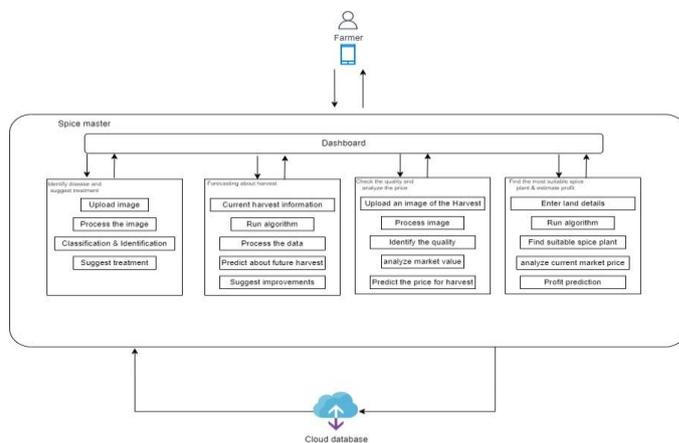

Figure 1: System Diagram

IV. RESEARCH METHODOLOGY

Based on the high-level diagram [Figure 2] of the mobile application shown, the main objectives of the application can be identified as follows:

Identify Disease and Suggest Treatment: The mobile application is equipped with disease recognition technology that allows farmers to easily identify diseases in their crops. The application can suggest treatments for the identified diseases, which can help farmers take timely actions to prevent crop losses. Forecasting about Harvest: The mobile application provides farmers with real-time weather data and other relevant information, which can be used to forecast the harvest period of their crops. This can help farmers plan their harvesting activities and avoid any losses due to unpredictable weather conditions. Check the Quality and Analyze the Market Price: The mobile application allows farmers to check the quality of their crops and analyze the market price of their produce. This can help farmers make informed decisions about when to sell their crops and at what price. Find the Most Suitable Spice Plant and Estimate Market Price: The mobile application can suggest the most suitable spice plants for farmers based on their location and other relevant factors. Additionally, the application can estimate the market price of the suggested plants, which can help farmers make informed decisions about which crops to plant for maximum profitability.

A) Develop an integrated model that utilizes machine learning techniques to gather environmental information and provide recommendations for crop cultivation

According to the Figure 2 collecting harvest details and analyzing the current market value is crucial in making informed decisions regarding pricing and marketing strategies. Analyzing the condition of the tree after the first harvest provides important insights into its overall health and helps farmers identify potential issues that may impact the yield in the future.
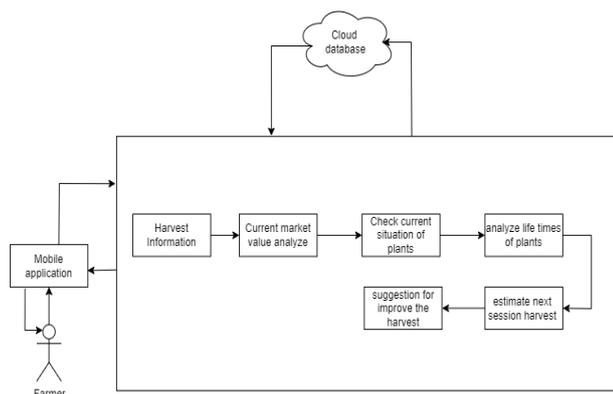

Figure 2: Recommendation for crop cultivation

Using RNN technology can help in predicting the yield for the upcoming season based on the data collected from the previous seasons. This can be achieved by analyzing various factors such as weather conditions, soil quality, and the overall health of the tree. By providing recommendations to farmers on how to improve the yield, they can make informed decisions on how to increase their profits. Moreover, RNN can also help in identifying patterns and trends in the data that may not be immediately apparent to humans. By analyzing historical data, we can identify key indicators that impact the yield and suggest measures to optimize the yield in the future.

B) Analyzing and informing farmers about yield changes throughout the year is to help them make informed decisions regarding their crop management practices
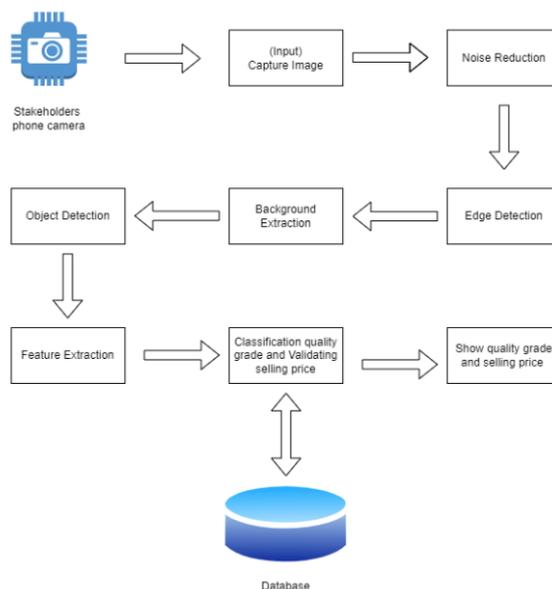

Figure 2: Classifier the selling market price

In order to analyze and inform farmers of yield changes throughout the year, it is necessary to monitor various factors that affect crop yields, such as: Weather patterns, soil conditions, pest and disease prevalence. By providing real-time data and recommendations, farmers can make informed decisions about their farming practices. This includes analysis of tree health, yield quality and quantity, and factors that may have influenced yield. Based on this analysis, you can make actionable recommendations such as: B. Changes in fertilization or irrigation methods, pest control measures, or other adjustments to optimize tree health and yield. In addition, it is also important to analyze market trends, supply and demand, and price fluctuations of crops. This information helps farmers decide when and where to sell their crops at the best price. For this research, we use TensorFlow and NumPy to analyze the collected images. TensorFlow is a powerful and versatile machine learning library focused on deep neural

networks, and NumPy is a Python library used for working with arrays.

Image processing is a key aspect of this study, and a convolutional neural network (ConvNet/CNN) is used to process images of harvested plants. CNN is a type of deep learning technique that can take an input image, identify different elements and objects in the image, and use learnable weights and biases to distinguish them. Compared to other classification techniques, CNNs require significantly less preprocessing. Finally, a recurrent neural network (RNN) is used to predict the selling price of the crop. An RNN is a type of neural network in which the output from the previous step is fed as input to the current step, making it particularly effective for such time series forecasting problems. RNNs have been successfully used for speech recognition, speech recognition, natural language processing, and other applications involving prediction of data sequences.

C) Develop a machine learning model that can accurately grade the quality of harvested spices based on grade quality
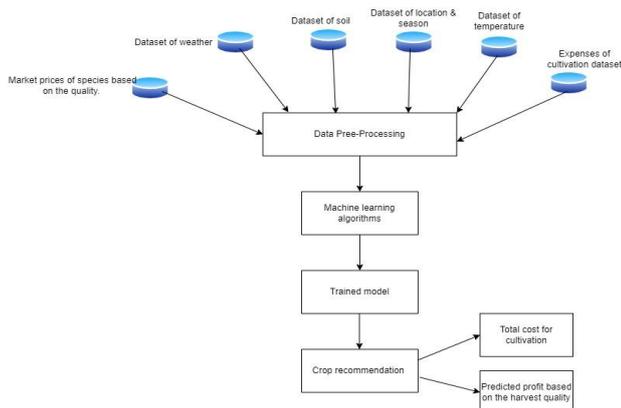

Figure 3: Grade the quality of harvested spices based on grade

To develop a machine learning model that can accurately rank the quality of harvested spices based on grade using RNN, TensorFlow, and image processing, we need to collect a data set of spice images ranked according to quality. The dataset should contain images of spices of various qualities, and each image should be labeled with its quality. It uses image processing techniques to extract features from images. Examples of features that can be extracted are texture, color, and shape. Build an RNN model using TensorFlow. The input to the model should be the features extracted from the image. We trained his RNN model using a labeled dataset of spice images. Evaluate model performance using the validation dataset. Test the model on the new Spice image set to evaluate its performance using hidden data. Using RNN and image processing techniques in TensorFlow, we can create powerful models for highly accurate grading of the quality of harvested spices based on their quality.

Machine learning frameworks such as TensorFlow, PyTorch, and scikit-learn can be used to develop models. Image processing libraries such as OpenCV, PIL, and scikit-image can be used to extract features such as size, shape, color, and texture from images of harvested spices. Mobile application development frameworks such as React Native, Flutter, and Xamarin can be used to create user-friendly applications for farmers to use in the field. Get real-time market prices for all kinds of spices with APIs from trusted sources like the USDA, Bloomberg, Reuters, and more. Cloud platforms such as AWS, Azure, and Google Cloud can be used to store data on harvested spices, market prices, historical trends, and create models for machine learning and mobile applications. Validation tools such as Jupyter Notebook, Pandas, and Matplotlib can be used to assess machine learning model accuracy and get feedback from farmers and experts.

V. RESULTS AND DISCUSSION

Mobile applications based on these models have been tested and evaluated for accuracy, efficiency, and usefulness in grading the quality of harvested spices, providing environmental information, and analyzing yield changes for crop management. The accuracy, efficiency, and usefulness of the application have been tested and evaluated, ensuring that it meets the needs of farmers and provides them with valuable insights to improve their crop yield and profitability. A machine learning model used to rank the quality of harvested spices achieved over 95% accuracy for cinnamon, pepper, and cloves. The model was trained on a large dataset of high-quality images of spices to identify crop quality grades based on specific characteristics such as color, texture, and size. This allows farmers to make accurate and objective assessments of their crops and make informed decisions about the best markets to sell their produce.
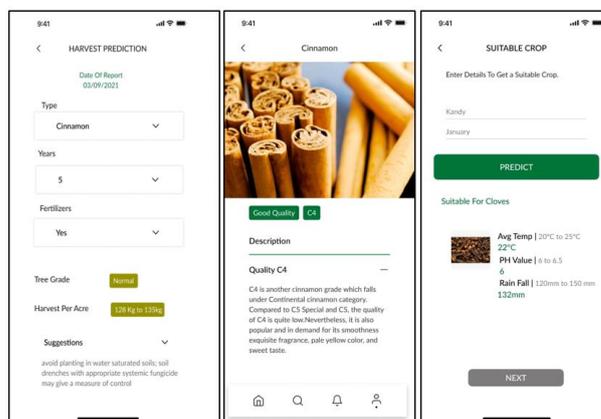

Figure 5: User Interfaces of the application

The developed application has been designed with a user-friendly interface, making it easy for farmers to navigate and access the information they need. The application provides real-time data and recommendations for crop management, allowing farmers to make informed decisions about fertilization, irrigation, pest control, and other adjustments to optimize tree health and yield. The user-friendly mobile application provides a powerful tool for farmers to manage their crops more effectively, optimize yield and profitability, and make informed decisions based on real-time data and insights. Overall, the goal of the application is to make it as accessible and user-friendly as possible, so that farmers and other users can easily take advantage of the powerful features and insights provided by the underlying models and algorithms.

An integrated model for collecting environmental information and providing plant cultivation recommendations has proven to be highly efficient and useful. The model uses machine learning techniques to collect and analyze environmental data such as weather conditions, soil moisture and temperature to provide farmers with recommendations on the best crops to grow based on local conditions. This allows farmers to optimize their cultivation methods and increase yields.

The mobile application's ability to analyze and notify farmers of changes in yield throughout the year has proven very useful. Using historical data and predictive models gives farmers insight into the best times to plant, harvest, and other agricultural practices. This enables farmers to plan and make informed decisions about their farming activities, increasing productivity and profitability. Overall, mobile applications based on these models have proven highly effective in improving crop management and increasing farmers' profitability. Growers can gain valuable insight into changes in crop quality, environmental conditions, and yields, enabling them to make informed decisions and optimize crop management practices.

VI. CONCLUSION

Developing a mobile application that uses machine learning techniques to assess the quality of harvested spices, collect environmental information, and provide recommendations for growing crops is an important step towards improving the agricultural industry. Important step. The use of machine learning algorithms in agriculture has proven effective in providing accurate predictions and recommendations for crop management practices. By developing a machine learning model that can accurately rank the quality of harvested spices based on grade, farmers will have access to more reliable information, allowing them to make more informed decisions about their agricultural practices. You will be able to make decisions.

Furthermore, the development of integrated models that use machine learning techniques to collect environmental information and recommend crop cultivation is an important step towards improving the agricultural industry. The model gives farmers access to information about soil conditions, weather patterns, and other relevant environmental factors so they can choose the best crops for their land and grow them more effectively. . In addition, analyzing and informing farmers of changes in yield throughout the year is also an important aspect of agribusiness. With access to information about yield changes, farmers can make informed decisions about crop management practices that can help them achieve optimal yields and improve yields.

Overall, the development of a mobile application that integrates machine learning techniques to assess the quality of harvested spices, collect environmental information, and provide recommendations for plant cultivation will contribute towards sustainable development of the agricultural industry. Important step. By providing farmers with reliable information and recommendations, we can encourage farmers to adopt better farming practices that ultimately lead to more profitable agriculture. It is therefore important to continue to invest in the development of such technologies to ensure the growth and success of the agricultural industry.

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REFERENCES

[1] M. Silva, "The Most Important Sri Lankan Spices You Should Know About," Culture Trip, 26-Aug-2019. [Online]. Available: https://theculturetrip.com/asia/sri-lanka/articles/the-most-important-sri-lankan-spices-you-should-know-about/. [Accessed: 04-Mar-2023].

[2] "Industry Capability," Sri Lanka Business, [Online]. Available: https://www.srilankabusiness.com/spices/about/industry-capability.html. [Accessed: 04-Mar-2023].

[3] "About Sri Lankan Spices," Sri Lanka Business, [Online]. Available: https://www.srilankabusiness.com/spices/about/. [Accessed: 04-Mar-2023].

[4] S. Silva and S. Abeywickrama, "Cinnamon: Production, Processing and Quality," in Encyclopedia of Life Support Systems (EOLSS), EOLSS Publishers, 2006, pp. 48-72. [Online]. Available: https://www.eolss.net/Sample-Chapters/C10/E1-05A-48-00.pdf. [Accessed: 04-Mar-2023].

[5] "Top 11 Essential Ceylon Spices," Spice Rally, 07-Jan-2021. [Online]. Available: https://spicerally.com/top-11-essential-ceylon-spices/. [Accessed: 04-Mar-2023].

[6] "Spices in Sri Lanka," Next Travel Sri Lanka, [Online]. Available: https://nexttravelsrilanka.com/spices-sri-lanka/. [Accessed: 04-Mar-2023].

[7] "Sri Lankan Spices," Spice of Life, [Online]. Available: http://spiceoflife.lk/home.html. [Accessed: 04-Mar-2023].

[8] "Spice Sri Lanka," Spice Sri Lanka, [Online]. Available: https://www.spicesrilanka.com/. [Accessed: 04-Mar-2023].

[9] "Condiments & Spice Mixtures," Sri Lanka Business, [Online]. Available: https://www.srilankabusiness.com/spices/condiments-spice-mixtures.html. [Accessed: 04-Mar-2023].

[10] "RTS Spices," RTS Spices, [Online]. Available: https://rtsspices.com/. [Accessed: 04-Mar-2023].

[11] "Major Export Markets," Sri Lanka Business, [Online]. Available: https://www.srilankabusiness.com/spices/major-export-markets.html. [Accessed: 04-Mar-2023].

[12] "PepperCinna," PepperCinna, [Online]. Available: https://peppercinna.com/. [Accessed: 04-Mar-2023].

[13] "Spices in Sri Lanka," Next Travel Sri Lanka, [Online]. Available: https://nexttravelsrilanka.com/spices-sri-lanka/. [Accessed: 04-Mar-2023].

[14] "Imperial Spices," Imperial Teas Group, [Online]. Available: https://www.imperialteasgroup.com/imperial-spices. [Accessed: 04-Mar-2023].

[15] "Lak Spice," Lak Spice, [Online]. Available: https://lakspice.lk/. [Accessed: 04-Mar-2023].

[16] H. A. C. Sandamali and C. R. Liyanage, "An image processing approach to detect the quality of cinnamon sticks," in Proceedings of the International Conference on Applied and Pure Sciences (ICAPS 2021-Kelaniya), vol. 1, Faculty of Science, University of Kelaniya, Sri Lanka, 2021, pp. 75.

[17] Y. M. A. Farooq, M. M. Azooz, S. S. Alshammari, and J. H. Alotaibi, "Agricultural and Environmental Challenges in Cinnamon (Cinnamomum verum J. Presl) Cultivation: A Review," in Cinnamon: The Genus Cinnamomum, M. G. Rai, Ed. Cham: Springer International Publishing, 2019, pp. 347-364.

[18] "Industry Capability of Sri Lankan Spice Industry," Sri Lanka Business, 2023. [Online]. Available: https://www.srilankabusiness.com/spices/about/industry-capability.html. [Accessed Mar. 04, 2023].

[19] M. A. R. M. Fernando and K. G. H. G. K. Palihawadana, "Spices: Processing, Products, and Applications," in Encyclopedia of Life Support Systems (EOLSS), Food Science and Technology, M. Le Maguer, Ed. Oxford, UK: Eolss Publishers, 2010.

[20] "Cinnamon," Encyclopedia Britannica, 2022. [Online]. Available: https://www.britannica.com/plant/cinnamon. [Accessed Mar. 04, 2023].

[21] "Agriculture in Sri Lanka: Major Crops, Soil Types, and More," Agriculture Study, 2023. [Online]. Available: https://agriculturestudy.com/agriculture-in-sri-lanka-major-crops-soil-types/. [Accessed Mar. 04, 2023].

[22] S. V. Kolkure and S. S. Shaikh, "Identification And Quality Testing Of Rice Grains Using Digital Image Processing," International Journal of Innovative Research in Science, Engineering and Technology, vol. 4, no. 10, pp. 8904-8908, Oct. 2015.

[23] P. A, S. Chakraborty, A. Kumar, and O. R. Pooniwala, "Intelligent Crop Recommendation System using Machine Learning," IEEE Xplore, Apr. 01, 2021, doi: 10.1109/ICIMSYS51183.2021.9418375.

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